UNIVERSITÀ DEGLI STUDI DI PADOVA

Université de Lille

UNIVERSITÉ DE LILLE

École Doctorale Sciences de L'Homme et de la Société

CECILLE – EA 4074:

'Centre d'Études en Civilisations, Langues et Lettres Étrangères'

&

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Dipartimento di Filosofia, Sociologia, Pedagogia e Psicologia Applicata (FiSPPA)

Corso di Dottorato di Ricerca in Scienze Pedagogiche, dell'Educazione e della Formazione

(XXX Ciclo)

Promoting Outdoor Cultural Heritage Education with Mobile Mixed-Reality Learning Tools:

Two Case Studies in Italy and Great Britain

THÈSE - TESI

pour obtenir le grade de - per ottenere il diploma di

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DOTTORE DI RICERCA DELL'UNIVERSITÀ DI PADOVA

DANIELE AGOSTINI

sous la supervision de – sotto la supervisione di

Professeur Laurent Châtel

et - e

Professor Corrado Petrucco

Mars 2019

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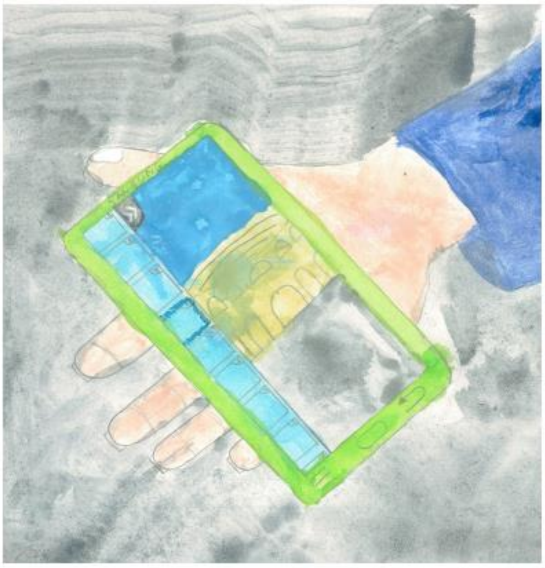


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Foreword

In the eighties and nineties, I was fascinated by films showing people doing fantastic things with computers and their imagination. They were able to live wonderful adventures and embody their dreams. Such an idealised view of the computer is what led me on to learn computing technologies by myself, and be guided studies in computer science, as well as my first eight years of work as a network engineer. Both at school and at work, I quickly realised that, except for a few exceptions, the aura and magic of computers were lost. The computer was undoubtedly useful and sometimes vital but was far from being the passport to great adventures. In parallel, I have kept my passion for adventure and developed a taste for education thanks to an experience with the AGESCI (Italian Association of Catholic Scouts), the civil service and many summer camps as a manager for my parish. I ended up deciding that I would rather be a teacher than a network engineer, so I began university, and passed the M.Ed in Primary Education Sciences, working meanwhile for a private primary school. In my dissertation, as throughout my university years, I tried to use technology as a medium to rekindle the wonder, exploration and understanding. Then, I had the opportunity to collaborate with the University of Padua in the person of Dr Manlio Piva using educational technologies in school and *in situ* for the education of heritage related with the Great War on the Austro-Italian front. This experience, called ‘Geolocalising the Great War’, involved several secondary school in Veneto and raised my awareness of the potential of the use of cultural heritage as a catalyst for projects between schools and communities. With this doctoral experience, I have the opportunity to create research which synthesises my interests and in which I can use my previous skills and competencies at best in order to bring back that sense of wonder and discovery in children’s learning experiences.

Introduction

«Nihil est in intellectu quod prius non fuerit in sensu»
(Lat.All., Thomas Aquinas, Locke)

«nisi ipse intellectus»
(Leibniz)

The axiom *'Nihil est in intellectu quod prius non fuerit in sensu'* (Nothing is in the intellect that was not first in the senses) recurred more than once over the centuries. Thomas Aquinas borrowed it in his *De veritate* from the Greek Peripatetic School funded by Aristotele. In late 17th Century, in England, Locke used it to support his empiricist view of the human mind as a *tabula rasa* in his *An Essay Concerning Human Understanding,* thus, causing contemporaries to reflect ever since. It was a compelling statement because, although perception was understood and accepted, to state that everything must first come from outside - including the categories we use to analyse and perceive the world -, was not straightforward. That idea was refused especially by contemporary philosophers in continental Europe, whom were basing their works on Descartes' ideas that the knowledge is innate, and just requires the right experiences to be discovered. Leibniz, of the rational school, took the time to think about it and to write the *New Essays on Human Understanding* to explain his view, inclusive of a thorough criticism on the work of Locke. The German philosopher, though, found his own original point of balance embracing the general idea but adding a – substantial – condition: *'nisi ipse intellectus'* the mind itself must be already there. The understanding, the mind and its activities precede the experience. This is a first step in the direction that would later be pursued by Kant on perception and thought (Reale & Antiseri, 1991). The postulate, with its clause, challenges people today just as it used to challenge them in the seventeenth and eighteenth centuries. Notably, one class of people which may feel most involved in its implications is teachers, educators, trainers and, in general, all the educational practitioners. Of course, we have now more than three hundred years of thinking on educational matters and established sciences like Medicine, Psychology, Sociology and Pedagogy could give us many answers on human development and cognition. This thesis itself is based on a constructivist epistemology[1] more than an empiricist or rationalist one, but still, in educational practices, especially in school contexts, the issue is not adequately addressed and often ignored.

This thesis considers this challenge, fostering the debate on the new means at our disposal to set up meaningful learning experiences (Johnassen, 2008). Our focus will be on primary school students of the fifth year which are the subjects of the research and of the teaching intervention, and the practices employed to make them aware of cultural heritage as the object, the matter of the intervention. When cultural heritage is the object of a study, it also becomes the mediator of knowledge. To facilitate this mediation between the students and the heritage, there will be human guides, and technological tools able to present the visual and iconographical information in a different way thanks to technologies of mixed reality.

As a corollary of the quote above, I could say that if people do not know about heritage, they will not preserve it. If heritage is not discussed and shown, they will not know about it.

The Position of the Thesis

A primary school laboratory

Observation of school contexts highlights that the most practised teaching method in Italian primary schools is the ‘traditional’ one, i.e. lecturing. It has several limitations, particularly in the face of new educational challenges presented by new generations of students, as the growing phenomenon of

[1] Constructivist epistemology was formalised in a first place from Jean Piaget. In general, it takes into account that a person has a background of knowledge and other internal structures like culture and language. That interacts with the environment and information coming from the environments through processes of mediation to be internalised. Constructivism comes with a strong ontological stand and with a great variety of practices. Other authors that influenced constructivism are: John Dewey, Maria Montessori, Lev Vygotsky, Jerome Bruner, Mikhail Bakhtin, Jean Lave, Etienne Wenger and Seymour Papert.

learning disabilities (Cisotto, 2009). They used to be presented as digital natives (Prensky, 2001) and as ‘millennials’ (Howe & Strauss, 2009) and their peculiarity are to have learning styles that are very different from former generations. The reason is that every generation has a preferred type of medium with which it interacts since early childhood. If for the previous generation it was television, after 1982 it became computer and the Internet (Oblinger, 2003; Dede, 2005). In the last decades, computer, internet and mobile technologies have been more and more pervasive in the life of new generations modelling learning styles and cognitive patterns. Lately, concepts such as ‘millennials’ or ‘digital natives’ have been reconsidered from many researchers in order to leave no room for misinterpretations leading to think of them as ‘generation with an innate knowledge of how to use new technologies’ (Kirschner & De Bruyckere, 2017). Because of all these evidences, we consider the possibility that new generations would actually need a different way of teaching. In case in school contexts we continue to use a channel of communication that is not their preferred one, our communication will not be effective. There is also the possibility that they are listening to more than one channel as their preferred mode, and so, to utilise only one channel, say, the auditive one, could bring them to be distracted from what’s happening on other channels. In that case, to use a multi-media approach can be better. But if we presume that they are also used to multi-modal, interactive, approach, the usual way of lecturing would have another disadvantage. We do not mean to say that classic lecture and writing should not be used, in fact, we think that classical skills are essential along with the capacity of focussing and increasing the attention span. The suggestion is that, probably, educators should use as the primary means of communication channels and modalities which are cognitively the pupils preferred. This, in order to facilitate the learning process. The learning contexts represent a second challenge. If historically schools, universities and libraries were the physical places were to access the knowledge, today this is no more the case. Information is available everywhere at any time thanks to the Internet, computers and mobile devices. The kind of society in which we live is often called ‘Information Society’ (Castells, 1996). In this scenario, educational institutions need to provide students with the instruments to verify information and to recognise authoritative, trustworthy sources. In fact, on Internet, often, one would find both a point of view and its contrary[2]. To address this issue, researchers have come up with a set of skills needed from a person in the Twenty-first Century society, especially for young people that needs to work and face very different professional requirements than in the past. They called them ‘21st Century Skills’ (Trilling & Fadel, 2009). This situation has been remarked upon by institutions and several frameworks have been created with the aim of spreading those skills. The European Union started drafting the ‘Strategy of Lisbon’ (in 2001) and several competence framework programmes followed after it. This strategy, at the moment, seems to work partially (Dede, 2010; Copeland, 2012). Having this as the background, let us think about what the schools can do about everything the students learn outside school, in non-formal and informal contexts, especially when they learn things connected with school curricula. The school needs to be aware of them and let the students bring to school that information. It would be up to the teacher to mediate, connect and help to create shared meanings and, ultimately, an authoritative knowledge. Informal and formal learning contexts should not be parallel, never-touching lines, but very tangled ones. On a similar note, we find developed methodologies such the Flipped Classroom (Lage et al., 2000), the WebQuest (Dodge, 1995) and Project Based Learning (Bell, 2010).

My contribution to this debate relies on the use of new mobile technologies as mediators of teaching and learning and as a link between different learning contexts. However, to do that, I needed an experimental context which could help to involve students connect school curricula formal learning with informal and non-formal learning. As regards the choice of primary school pupils as subjects of the research, as mentioned earlier, I had the opportunity and the knowledge of curricula and contexts where research could help. In the next sub-chapter, it is explained why the heritage was chosen as the object of our educational research.

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[2] Sometimes the information is wilfully made to be wrong, to misinform the Internet reader. In many countries, at this moment, it is ongoing a wide debate on the so called ‘fake news’ and several of the greatest hi-tech players committed to oppose this phenomenon.

Highlighting Cultural Heritage

Recently the final report of an extensive research project was published, funded by the EU Culture Programme 2007-2013: 'Cultural Heritage Counts for Europe (CHCfE). Towards a European Index for Cultural Heritage' (CHCfE Consortium, 2015). It considers the cultural heritage in a holistic dimension, aims to collect and analyse empirical research and case studies relating to economic, social, cultural and environmental aspects of cultural heritage. The research was conducted in several European countries and highlighted the full range of benefits that investing in cultural heritage could bring. It helps the innovation and the development of new ideas and solutions to problems. Technologies like digitisation virtual reality technologies are growing thanks to it, with the aim of making historical environments and assets accessible to the public. Education and lifelong learning are at the centre of cultural heritage development. Thanks to it, the understanding of history, feelings of belonging, co-operation and personal development could be improved. Hence, it is also a way for Europe to be more united and integrated thanks to the awareness of our common roots.

Cultural heritage education is a relatively new field. Dating back to the eighties, has so far lacked a specific didactic and guidelines from and for educational institutions are missing. Much was left to the skills of teachers, associations and local institutions. Education and training related to cultural heritage was carried out in accordance with criteria developed by cultural practitioners with the basis of their filed experience but very often not formalised and not necessarily outcomes of a pedagogical reflection. In the anglophone world, things have been partly better thanks to the concept of interpretation of the heritage (Tilden, 2009) which is guided by principles enunciated by Freeman Tilden in 1957 and it can be considered as on-site teaching or transmission of the heritage. In Europe and Italy this situation has begun to change since the end of the Nineties with recommendation by the European Council, but in recent years it had new impulse, and in Italy in December 2015 the first 'National Plan for Heritage Education' has been drafted by the Ministry of Education and the Ministry of Cultural Properties and Activities. Every year it has been updated with the aim to institutionalise cultural heritage education, provide guidelines, identify good practices and create collaborations. From those documents emerges the idea of a cultural heritage that is both an educational objective and a tool. It can be used to learn about a specific heritage and developing knowledge in other subjects as well as transversal skills, like the 21st Century's. Heritage education can be carried out in both formal and informal contexts acting as a bridge between the two. This explains the choice to utilise such potential in this research. It seemed the ideal field for every pedagogical purpose and interest I had when this investigation started.

Mobile Mixed Reality

In recent years, thanks to the rapid development of mobile technology, we have at our disposal portable devices which combine the great ability to manipulate data along with many sensors which allow us to interact with the environment. Augmented and Mixed Reality technology allows to overlap our sensory perception of reality with one generated by a fixed or mobile device. In the most common understanding of the term, Augmented Reality (AR) provides a virtual layer of contextual information, pictures or 3D models which interact with environments or real objects. AR takes place within a continuum lying between two opposite poles: Real Environment and Virtual Environment (Milgram et al., 1994) and the applications within this interval are part of Mixed Reality (MR). A general classification recognises two main types of AR: location-aware and vision-based. Location-aware AR presents artefacts to learners as they move with a GPS-enabled mobile device. This type of medium helps augment the visible - and sometimes also auditory - reality with extra information that is (directly or indirectly) relevant to the place. Vision-based AR presents digital media to learners after they point the camera in their mobile device as an object (Dunleavy & Dede, 2014). The ability of AR and MR to link the virtual and the real, and its potential in the field of education, has increasingly attracted the attention of researchers. They foresee for this promising pedagogical instrument a fundamental role in the school of the future (Dede, 2008). While they used to be costly technologies, now they are flexible, available and affordable enough to be adopted in educational settings. In particular, we see much potential in the synergy between AR and MR used as an extension of the mobile learning paradigm (Sharples et al., 2010), which helps crossing the boundaries between formal and informal contexts. At the moment in which this research was begun, the literature on experiences and experiments involving AR and MR for educational purposes was extremely limited. In the last two or three years, thanks to the quick refining of those technologies, a dramatic increase has been experienced with this kind of researches. Early meta-analyses on the researches already show the positive impact that AR technologies have on learning (Tekedere & Göke, 2016). Nonetheless, this research presents some unique features to be presented in the next sub-chapter.

My research did not simply realy on already existing technological tools, but was a test case for designing and crafting two 'applications' (apps) from scratch, keeping in mind our aims and trying to follow pedagogical principles along with suggestions from the guides that would have used those apps with children. To do that, studying the cultural heritage involved was not optional.

Research questions, context and contribution

Initial motivations at the onset of research turned into broader questions and epistemological considerations that can be said to crystallise in the following thesis agenda:

- What is the relevance of mixed reality technologies for the understanding of a cultural site? Do they enhance engagement, recall and appropriation?
- The use of different tool affects differently the cognitive processes that are activated (Vygotsky, 1978). What are the cognitive processes with the use of mixed reality technologies for cultural heritage education, in out-of-the-classroom contexts? Which are the relations between student - technology - teacher?
- Are such technology and methodology transferable to other cultural contexts? Does their effectiveness change?

To answer this kind of questions, a mixed-method quanti-qualitative research design was drafted. In fact, if quantitative data can help us assess different factors, feedback and results, we would need qualitative tools to register unexpected outcomes, inputs and feedback.

But designing research always requires finding contexts which grant the opportunity to carry it out adequately. The choice of contexts is already limited from temporal and research constraints. This research needed primary school contexts which made it possible to have experimental and control classes[3] involved in a cultural heritage education experience. A specific type of cultural heritage had to be identified as the object of the research as well as experts of that heritage. For these reasons, we started a collaboration with Quartiere Attivo, an association for the promotion of the historical, artistic and natural heritage of Verona that was active for some years and which works mainly with primary and lower secondary schools. One of their main expertise is in the Roman history of Verona and educational visits with schools. Thanks to their co-operation, we involved in the research seven classes of the fifth year of three different primary schools in research. Because of our research questions, which were developed after observation in school contexts and a review of bibliography as specified in the previous sub-chapters, we also needed a second context, possibly in another European Union country, where to ensure the transferability of the methodology and educational technology for the cultural heritage education into another cultural context and heritage. Hence, our research for the second context in EU with an open-air heritage that could be interesting for local 5th-year primary school classes. A summit of the Immersive Education Initiative was held in Paris hosted at Paris-Sorbonne University by Prof. Martinet and Prof. Châtel who have been pioneers in the use of technology for the education to the 18th Century English heritage, in particular with the creation of an interactive CD-ROM and subsequently a website about Georgian cities[4] (Gallet-Blanchard & Martinet, 2000; CSTI, 2013). During an extensive exchange with them we found that

[3] A control group is a group of people that is kept in the same situation of the experimental group, except for what concerns the experimental factor. In this research, there are experimental and control classes which will have the same experience, except for the use of MR technology. This is useful to compare results and understand the impact of the experimental factor.

[4] The website, created in 2013 by the Research Centre « Cultures, Sociétés et Technologies de l'Information » CSTI of Paris-Sorbonne University represents one of the most complete and authoritative open-access resource on the topic, and can be reached at the address http://www.18thc-cities.paris-sorbonne.fr

English 18th Century landscape gardens, while remaining a very different context from Roman Verona, have a solid link with the Italian heritage and landscape. Also, they are regularly visited by local primary schools' classes. In fact, English 18th Century landscape gardens were often based on the ideal Italian landscape found in famous paintings and drawings from travels in Italy like *capricci* and italianate. Roman remains are regularly on the background of those illustrations, reflected in gardens as can be found also in Britain with Roman alike statues and Palladian-style buildings (Martinet & Châtel, 2001). In addition, being an open-air type of heritage, it was possible for us to use the same kind of technology and methodology. Thank to prof. Châtel's collaboration I chose Hestercombe as the best English garden that could lend itself to an experimentation period and the building up of research material, with the involvement of two primary schools in the area of Taunton.

Turning now to the major contributions of this dissertation, I would like to highlight the following aspects:

1. While many researches use augmented and mixed reality, few studies concentrate on the real impact of this technology, and its reliable models of use (Pribeanu, Balog & Iordache, 2016). This dissertation add to the debate on the benefits of using new technology.
2. The dissertation took into account the level of familiarity of pupils with mobile technology and cultural heritage inside and outside school contexts in order to avoid any bias.
3. Drawings from children from experimental and control groups were used to understand the appropriation of concepts through the images mediated by MR or simple booklets.
4. To the best of our knowledge, this dissertation stands out in its use of mobile MR app for heritage education not as a substitute of the guide, but as a more powerful mediator at guide's disposition. Furthermore, the app was developed following historians and guides suggestion and after the

already existing visit format. So, it is the technology which was adapted to education, and not the contrary.

5. This thesis formalises a way of interaction and mediation between students, guide, technology and heritage that can be applied to other contexts.
6. The research tested the same technology and methodology in two completely different cultural environments and heritage to understand its transferability.
7. This research wants to be a first step towards the use of new MR technologies to allow pupils from different European countries to share their heritage and recognise common roots as a motive of cohesion for all European citizens.

Structure of the thesis

The thesis is divided into two main parts, which are Part 1 'Outdoor Heritage and Mixed Reality: Conceptual Framework and Theory' and Part 2 'Ancient Verona and Georgian Hestercombe Augmented: Research Methodology and Development'. Chapter 1 presents a brief historiography about the cultural heritage as a subject and the education to it in order to understand best practices and use them as a starting point. Chapter 2 develops the Activity Theory which underlies my two case studies and which constitutes the major prism through which are interpreted and analysed the interactions between the subjects, the objects, the mediators and the outcomes of my research. Chapter 3 highlights the specificity of MR mobile technologies which were used and provides a classification of them. It also contains the theoretical and methodological aspects of the use of MR mobile technology for education. Chapter 4 provides a review of all the research experiments similar to this one, that is an MR outdoor experience for heritage education. Chapter 5 is dedicated to research design, research questions and tools of analysis. In Part 2, the Roman Verona Study is introduced and analysed in detail in Chapter 6 while Hestercombe is discussed in Chapter 7. In Chapter 8, some elements of the two case studies are compared. Then, all elements are brought together in order to understand the outcome of the research as well as its implications, limitations and future developments. Finally, the conclusion is followed by a general bibliography organised by subject and by author in alphabetical order. For the reader’s convenience, bibliographical references can be found at the end of each chapter.

PART I -

Outdoor Heritage and ‘Mixed Reality’:

Conceptual Framework and Theory

The first part of this dissertation addresses the theoretical framework and conceptual basis which lie behind the two case studies in Italy and Britain. A condensed cohistoriography of European cultural heritage as a subject is presented in Chapter 1, as well as a retrospective study of the ways and means of heritage education. Most recent documents and best practices are also presented as starting points for this study. Chapter 2 introduces the Activity Theory starting with its genesis in the first half of the twentieth-century up to the most recent contributions. Activity Theory was used throughout this research as a tool for the microanalyses of the case studies. Chapter 3 studies and categorises Augmented and Mixed Reality technology. Theoretical and methodological aspects of the use of Mixed Reality mobile technology for education are also addressed. The most important MR outdoor experiences for heritage education are reviewed in Chapter 4. In Chapter 5, I start clarifying the three main questions the research builds on and the pedagogical motives that guided me, which were based on the question of the impact of new technology on teaching. It follows a description of the design, which includes explanations on the chosen research methodology, setting and population. Subsequently, the detailed diagram of all the phases of the research is presented in both the cases of Verona and Hestercombe, specifying the contexts and the people who took part in the experimentation.

CHAPTER 1
Interpretation and Education of Cultural Heritage in Europe: A Historiographical Approach

1.1 The concept of cultural heritage in the 20th and 21st Centuries

1.1.1 Before the 20th Century

Before studying the education and the interpretation of heritage, we need in the first place to understand what ‘cultural heritage’ means. It is clear that the concept of cultural heritage is neither new, nor a recent emanation of contemporary institutions and countries. Naturally the idea evolved continuously to reach the modern conception.

We can find the first trace of it in our common Roman roots. It is in Roman Law, notably in the concept of *legato* at *patriam* or *dicatio at patriam,* whereby if a private citizen built on a public area (e.g. the front of a building), that building was, partially, considered as *res populi romani* (thing of the Roman people) (Settis, 2011).

Later, in the Middle Ages, kingdoms began to be aware of value of artistic productions of previous high civilisations like Romans, Greeks and Etruscans and began to issue laws to protect them and to avoid destruction and illegal appropriation of those artefacts.

In the constitution of Siena (1309), the beauty of the city was considered of the uttermost importance for two main reasons: to let the visitors have fun and be happy and to preserve the honour, prosperity and improvement of the city and its citizens. For this reason, the city had various regulations aimed at safeguarding art, architecture and general decorum.

In Rome, because of the high number of antiquities in public areas, after 1162 the Papal States protected them with several laws in the 13th and 15th and 16th Century. The ‘Albani Edict’ in 1733 expressed a more sophisticated sense of safeguarding heritage mentioning the ‘public decorum’ and the ‘benefit for the public and of the private good’. At the same time, in 1734, Pope Clemente XII acquired a great collection of antiquities and created the Museo Capitolino, the first public museum of art in Europe and the second public museum after the Ashmolean Museum in Oxford (1683) (Paul, 2012).

In the eighteenth century, another idea joined the pre-existent nucleus: the preservation of cultural heritage in the context of its original creation. One early example of this new approach is Florence. In 1737, during the passage from the Medici dynasty to that of the Lorena, the two families signed a convention that retains for Florence all the collections made in its territory. Those collections are nowadays the core of the Uffizi. Later, the Kingdom of Naples adopted a similar resolution as well as many other Italian kingdoms in the nineteenth century.

1.1.2 The French beginnings

France is the leading European state in which the modern notion of cultural heritage was developed. We have a precursor in François Roger de Gaignières (1642-1715) who in 1703 had the opportunity to present to King Louis XIV a project for the constitution of a royal office for listing and protecting monuments[5]. The king was interested, but the Spanish war of succession drained too many resources from the royal finances to follow up with the project. In between the Revolution and the Restoration, the modern ‘cultural heritage’ concept finally developed. Just after the Revolution the idea of *patrimoine*, or *patrimoine national*, grew up on the fundamental innovation which was to give to the Nation, and thus to the people and the community, a juridical identity. Cultural heritage

[5] Before that work and the one of Bernard de Montfaucon ‘Monuments de la Monarchie française (1724 - 1733)’ the word monument was not in use (Desvallées, 1995).

on that scenario was of fundamental importance to create the Nation, national culture and national character. This process saw as one of the most important actors the Abbé Grégoire (Henri Grégoire). Amidst the distruction and the vandalism caused by the Revolution, he created a project for the protection of cultural heritage and moved the consciences to follow his advice. In 1794 the revolutionary government asked him to answer a proposal to destroy all Latin inscriptions on monuments. This was the first of a series of reports and articles where he explained the importance of art and monuments, expecially in republic that were emerging, starting from the basis (Sax, 1989). From the third decade of the 20th Century, France substantially contributed to integrating the idea of *patrimoine* in the cultural dimension of international institutions. Euripides Foundoukidis, born in Greece and educated at the Institut des Hautes Etudes Internationales and the Ecole des Hautes Etudes Sociales in Paris, coined the expression 'artistic heritage' at the Athens Conference in 1931 and soon it became commonly used in international documents. While the French translations of those documents used the word *patrimoine*, the English ones used the word 'property' and in the Italian *bene culturale*, but we will discuss such diversity in the next chapter. (Desvallée, 1995; Vecco, 2010)

1.1.3 In the United Kingdom

In the United Kingdom, the discussion about the act of listing and protection of cultural heritage begun in the second half of the nineteenth century. In 1873 a member of the Parliament, Sir John Lubbock, inspired by the deeds of the Abbé Gregoire in France, presented to the House of Commons 'A Bill to Provide for the Preservation of Ancient National Monuments'. The idea was to avoid the loss of Roman and prehistoric antiquities, primarily due to the re-use of stones and demolitions for housing development.

The Bill was long discussed and gave birth to the first law which recognised the existence of artefacts from the past that need to be protected. It is known as the 'Ancient Monuments Protection Act' of 1882. It listed twenty-nine monuments in England and Wales, twenty-one in Scotland and eighteen in Ireland which must be protected. In 1900 an amendment to the law was enacted. Its goal was to extend the protection to medieval castles and to extend the authority of the Commissioners of Public Works still; it was always limited to those buildings or sites that were important enough for the government to accept financial liability for them (Halfin, 1995). Also, the government was still unable to mandatorily purchase properties in order to protect them. This last point was reached thirteen years later with the *Ancient Monuments Consolidation and Amendment Act* of 1913. The Act gave the Commissioners of Works the job to publish a new list of monuments with the help of the Ancient Monuments Boards for England, Wales and Scotland, which was established in the same year. It is interesting to note that the definition of 'monument' evolved. While in the first 1882 Act there was nothing more specific than '*ancient monument*', in the 1900 Consolidation and Amendment a monument was defined as '*any structure, erection or monument of architectural or historical interest*'. Subsequently, in 1913, the definition was extended specifying that an 'ancient monument' is what was contained in the 1882 list or similar to what is listed; any monument the preservation of which is in the public interest by virtue or its particular historic, architectural, traditional, artistic or archaeological interest, or the site of any such monuments or its remains. All the land required for its preservation or the access is part of the monument. By 1931 more than three thousand monuments were listed. In the 1931 Ancient Monuments Act, the definition of monument changed to '*any building, structure or other work, above or below the surface, and any cave or excavation*' (s.15, 1931 Act). The attention and interest in protecting cultural heritage rose dramatically during and after the Second World War. During the war, England suffered massive bombing by German airforce, and many monuments were destroyed while very many were damaged. After the war, it was clear that a law to protect them from destruction was not enough. There was the urgency of law with a proactive approach to conserve and restore monuments. It was provided in 1953 under the name of 'Historic Building and Ancient Monument Act' and gave to the Minister of Works the authorisation to create monetary grants to repair and maintain monuments. From that moment on, the UK contributed to the international discussion about the protection of the heritage, that developed from 1954 on, as we will see in the following sub-chapter (Sax, 1990; Halfin, 1995; Mynors, 2006).

1.1.4 The Italian and wider European situations

In the Italian Republic, cultural heritage was introduced in 1948 in the Constitution. In article number nine, one can read the concept of *patrimonio storico e artistico della nazione* (historical and artistic patrimony of the nation), but the term *beni culturali* has in fact been used for a long time, translatable as 'cultural goods'. The reason is the history of the concept in the peninsula and the juxtaposition with another term by which it has been derived: *beni naturali* and *beni paesaggistici,* or, sometimes, *beni ambientali* that are 'natural goods' and 'landscape goods' or 'environmental goods'[6]. The first time *beni culturali* appeared in official documents, in the Italian translation, was the 'Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict' signed in 1954; so *beni* was here a translation for property. The equivalence between *bene* and 'property' is something that could be taken into account. As a matter of fact, the Hague convention was adopted because of the massive destruction of cultural property during the Second World War. For that reason, it is also an essential document at the European and global levels, and the first to refer to and define a cultural property. There is in this document, in its first article, a definition of cultural property:

> *a) moveable or immoveable property of great importance to cultural heritage of every people, such as monuments of architecture, art or history, whether religious or secular; archaeological sites; groups of buildings which, as a whole, are of historical or artistic interest; works of art; manuscripts, books and other objects of artistic, historical or archaeological interest; as well as scientific collections and important collections of books or archives or of reproductions of the property defined above;*

[6] It is possible here to use the word 'heritage' instead of 'goods', as it is more palatable, but it seems to me not quite the same thing in this specific context. In fact, one would translate heritage with *eredità* while normally good is translated with *bene*.

b) buildings whose main and effective purpose is to preserve or exhibit the moveable cultural property defined in sub-paragraph (a) such as museums, large libraries and depositories of archives, and refuges intended to shelter, in the event of armed conflict, the moveable cultural property defined in sub-paragraph (a);

c) centres containing a large amount of cultural property as defined in sub-paragraphs (a) and (b), to be known as `centres containing monuments'.

The Hague Convention of 1954 substantially expanded what was stated in the conventions of 1899 and 1907 in the fifty-sixth article and in the Washington Pact of 1935 where it was not clear what constituted cultural property, but it employed wording like ‘art’, ‘artistic work’ and ‘monument’.

From 1954 on, in Italy, the phrase used has always been cultural good and environmental - or landscape - good. The first attempt at creating a definition was made in 1966 from the Franceschini commission. It says that cultural or environmental goods are things that constitute a material proof of an earlier civilisation and conveys their values to subsequent ones.

In 1998 there was a second, broader, attempt (art. 148 of D.Lgs. 31st March 1998 n. 112): cultural goods form the historical, artistic, monumental, demo-ethnic-anthropological, archaeological, archivist and book heritage, and others are establishing a proof with a value of civilisation and identified by the law. Environmental goods are identified by the law as meaningful proof of the environment in its natural or cultural value.

A definition of cultural heritage comes in 2004 in the *Code of cultural goods and landscape* made by the Italian Ministry of Cultural Goods and Activities. It integrates both ‘goods’ and ‘heritage’ stating that:

1. Cultural heritage is formed by cultural goods and landscape goods.
2. Cultural goods are all the moveable and non-moveable things that are property of the State, the regions, other public institutions, no-profit private

persons and institutions with an artistic, historical, archaeological, ethnoanthropological, archivist and bibliographical interest[7].

Currently, in French and Italian the words we use for heritage (in cultural context) are respectively *patrimoine* and *patrimonio*. The common root is from the Latin *patrimònium* that is composed of the two words *patris* and *munus*. *Patris* means 'of the father' while *munus* have many meanings which one can summarise in two main semantic fields: duty and gift. The English term 'heritage', through the Middle and Old French, comes from the Latin *hereditas*, that is both the act of inheriting and the thing inherited. We think that the word *patrimònium* is more interesting because it brings the concepts of gift and inheritance together with duty and responsibility for it. Of course, we could use the English word 'patrimony' and 'cultural patrimony'. It could be a proposal for institutions, but, as at the moment all the European documents in English refer to cultural heritage. The very same expression will be kept here, being aware nonetheless of the responsibility that comes with it.

As it happens for the words referring to it, the whole concept of cultural heritage is centuries old. It is the product of a process begun with a list of physical objects of extraordinary historical or artistic value followed by an amalgam of material and immaterial evidences which are display of an entire culture (Bortolotti et al., 2008).

According to Nuzzaci (2011), unlike the familiar or personal heritage, the cultural one must be passed on as the memory of the past to future generations. There is a responsibility to identify, protect, safeguard and add to it. It is heritage which brings continuity between the past, present and future, and strengthens the relationship between single persons and the community from a local to a global scale. It is the provider of at least seven different kinds of value:

- an original value, that is often ancient;
- a scientific value, which is the authentic one.
- a sentimental value, outlet of emotions and feelings;

[7] Additional specifications in the article 10 and 11 of the Code

- a symbolic value, in relation to the present;
- an educational value, that is the educational potential of heritage as a tool and as a subject;
- a social value, provider of identity;
- a collective value, extending from local to global scale.

(Nuzzaci, 2011, p.20)

As just reported, in the most recent international documents we have the officialisation of an evolution of the concept of heritage. Traditions, languages, rituals, festivals, practices and representations of knowledge and skills are regarded by people and communities as part of their own cultural heritage. Therefore, the evolution consists in the expansion of cultural heritage into four polarities or continuums: objectual - non-objectual, tangible - intangible, visible - invisible, usual - unusual.

In the last years, another significant change of cultural practice relates to cultural experience time quality. Thanks also to European policies, it is no longer just a time of recreation but an opportunity for the user to recognise himself in cultural identity and through the relationship with heritage and the community to create a sense of belonging (Nuzzaci, 2011).

1.1.5 Protection of Cultural Landscapes and Historic Gardens

The International Council on Monuments and Sites (ICOMOS), together with the already cited UNESCO and Council of Europe, had a leading role in protecting the European (and global) cultural heritage and notably landscapes and gardens. Within it, in 1971 the 'International Committee on Historic Gardens and Sites' was born. The committee was formed from members of ICOMOS and IFLA (International Federation of Landscape Architects).

One of the most important documents developed by the ICOMOS-IFLA International Committee for Historic Gardens (now ISCCL) is the Charter of Florence. It dates from 1981 but was adopted by ICOMOS in 1982 to address the needs of historic gardens, a specific category of cultural property which was not adequately represented in the 1964 Charter of Venice[8]. The Florence Charter on Historic Gardens was a breakthrough in conservation practices for the specialists were asked to identify historic gardens and, unlike anything done before with buildings and monuments, to

> *'manage a process in a place whose character was defined by living organisms with a defined life and death cycles. It was probably the first approach to the conservation of the combined works of man and nature' (Gustavo Araoz, president of ICOMOS).*

It provided definitions of historic gardens as well in order to clarify what should be considered a historic garden. The first one was

> *'an architectural and horticultural composition of interest to the public from the historical or artistic point of view'. As such, it is to be considered as a monument.*

Then, in the second article of the Charter there is another definition, which already provides a philosophical approach to the conservation of an historic garden:

> *'The historic garden is an architectural composition whose constituents are primarily vegetal and therefore living, which means that they are perishable and renewable.' Thus, its appearance reflects the perpetual balance between the cycle of the seasons, the growth and decay of nature and the desire of the artist and craftsman to keep it permanently unchanged. (ICOMOS-IFLA, 1981)*

Subsequently, in 1999, the committee changed its name to 'International Scientific Committee on Cultural Landscapes' (ISCCL) to reflect the change of focus from gardens to the broader area of 'cultural landscapes'. This definition was introduced in 1992 in the UNESCO's 'Operational Guidelines for the Implementation of the Word Heritage Convention' and it is described as cultural properties which represent both the works of nature and people. The three main categories of cultural landscape are:

[8] The Venice Charter for the Conservation and Restoration of Monuments and Sites is a set of internationally accepted guidelines for conservation and restoration of historic buildings. It took place in Venice in 1964 and was promoted by ICOMOS and the Second International Congress of Architects and Technicians of Historic Building.

1. designed landscapes and created intentionally by people; mainly parks and gardens.
2. Organically evolved landscapes that may be relict (or fossil)[9] or continuing.
3. Associative cultural landscapes[10].

(UNESCO-ISCCL, 2017).

1.2 Cultural Heritage Education[11]

The concept of Cultural Heritage Education has developed in Europe since the 1980s. The aim was to integrate into the school's curriculum cultural-heritage centred interdisciplinary projects. With the Recommendation No. R (98) 5, on the 17th of March 1998, the European Council recognised for the first time the Education to Cultural Heritage - often referred as Heritage Education - as a fundamental element for the European education policies.

It is a short text, but it brings several fundamental concepts:

1) A definition of 'cultural heritage': '*includes any material or non-material vestige of human endeavour and any trace of human activities in the natural environment*.'
2) A definition of 'heritage education': '*means a teaching approach based on cultural heritage, incorporating active educational methods, cross-curricular approaches, a partnership between the fields of education and culture and employing the widest variety of modes of communication and expression*.'

[9] Relict landscapes, or fossil landscape, are residual landform of —also called relict landform—, that escaped burial or destruction to remain as part of the present landscape. Relict landforms are developed by erosive processes (morphogeneticsystems) no longer operating, which means that in that area, a very long time ago, there used to be a different climate (The Editors of Encyclopaedia Britannica, 1998; Cotton, 1968)

[10] An 'associative cultural landscape' is a landscape with a powerful religious, artistic or cultural association of the natural element rather than material cultural evidence, which may be insignificant or even absent (UNESCO, 2018).

[11] The following chapter has its basis in the 'First national plan for the education to cultural heritage', a landmark document in the Italian panorama written in December 2015 by the Italian Ministry of cultural properties and activities and tourism.

3) Recognition of 'cultural' professionals, associations and organisation: '*as subjects working in cultural and environmental field, from heritage to contemporary creation*.'
4) Institution of 'European heritage classes': '*as an approach to heritage education, including international school exchanges based on a common project and themes related to cultural heritage; they form part of the curriculum but involve fieldwork outside the school; they allow young people at all levels and types of education to discover the richness of heritage in its context and to grasp its European dimension*.'

Heritage Education is then defined as inherently cross-curricular, and the directive is to promote it '*through the medium of different school subjects, at all levels and in all type of teachings*.'

All the initiatives in that sense, private and institutional, should be encouraged and facilitated, all the efforts supported, and there should be an evaluation of the results of each action with particular regards at the educational, cultural, organisational and financial levels.

The document recognises that teachers and cultural professionals need to be trained, as well as heritage institutions' staff. A link to the school's curricula is essential.

An administrative and financial effort should be made in order to facilitate those activities. Notably, the following statement is unequivocal and compelling: '*All young people, irrespective of their family or financial background, should be able to take part in heritage education activities*'.

A last paragraph of the Recommendation is about the documentation. Here it stresses the necessity of production of teaching material for heritage education and its dissemination. The most up-to-date information and communication technology should be used.

On the 20th of March 1998, in Italy, the Ministry of Cultural and Environmental Heritage and the Ministry of Public Education signed a framework agreement asserting that every citizen has the right to be educated towards greater heritage awareness, welfare and understanding. In order to achieve this primary goal both ministries pledged to provide structures, resources and activities. They envisaged a collaboration between the public schools and the public cultural institutions to develop projects lasting one or more years, featuring experimental educational models and printed, multimedia and electronic didactic materials. A focused training programme was suggested for teachers both from schools and from institutions.

Starting with this incentive from transnational and national policies, discussions and reflections on the role of heritage education in society gained momentum in Europe. In the report commissioned by the Council of Europe 'European democratic citizenship, heritage education and identity' (Copeland, 2005) heritage is the 'engine' of processes of education to heritage and to the citizenship in a synergy where the former provides a historical and cultural dimension for the latter. Citizenship education, on the other hand, identifies both rights and responsibilities to be developed in heritage education. Starting from the basis of 1998 Recommendation, Copeland updates and extends heritage education definition. Heritage Education is in his view a global education having both tangible and intangible heritage as an object, inherently multidisciplinary with its basis on active and participatory methodologies. It involves many institutions and individuals of the territory to collaborate throughout formal, non-formal and informal contexts of the citizen's life, throughout all the ages of life, in a lifelong learning perspective. The aim of heritage education is not to pass on information, but actively contribute towards the improvement of the life of individuals and society through culture (Bortolotti et al., 2008; MIBACT, 2015).

In the same year, the Council of Europe drew up the 'Framework Convention on the Value of Cultural Heritage for Society' emphasising the potential of heritage as a resource for sustainable development of quality of life in a constantly evolving society. Here, it is explained that every person has the right to engage with heritage and that everyone needs to be involved in the process of defining and managing heritage. Furthermore, they locate as the final goal of the conservation of and its sustainable use human development and quality of life. A new, wider definition of cultural heritage is put forward:

‘Cultural Heritage is a group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time.’

Another new concept is the one of ‘heritage community’, that is a group of people who think that a particular cultural heritage is essential. They wish to preserve it and to pass it on to future generations with the help of framework of public action.

The common European cultural heritage is regarded as a binding agent for European countries and a mean to understand the past in order to have a peaceful and society for the future.

Heritage education is present throughout the document, even if more implicitly than explicitly, and one may see it in three different forms:

1. Implicit: Rights that needs to be respected (requires action).
2. Implicit: Need of actors in contribution, enrichment, identification, protection, study, interpretation, presentation.
3. Explicit: affirmation of the need to integrate these approaches into all aspects of lifelong education and training, to raise the awareness of heritage value, the necessity of maintenance and preservation, and the benefits that can be derived from it.
4. Explicit: the whole article 13 regarding ‘Cultural heritage and knowledge’. The cultural heritage dimension should be included at all levels of education (not necessarily as a subject but as an aspect of other subjects); a link between heritage education and vocational training is needed; encouraging interdisciplinary research; constant professional training, exchange of knowledge and skills inside and outside the educational system.

The fourteenth article is entirely dedicated to the relationship between heritage and information society. New technologies are seen mainly as means to foster heritage education. They must be employed with the aim of enhancing the accessibility and usability of content and information about the heritage, in particular for educational use.

It worth mentioning the last subsection of the article:

> *The Parties recognise 'that the creation of digital contents related to heritage should not prejudice the conservation of the existing heritage'.*

The interpretation of this commitment is left to the Parties, but it could be understood in several different ways, of which two are the most likely:

1) If to produce digital content, it is needed to use techniques that may or will physically damage the artefact, then the creation of such content should be avoided (e.g. flash on old paintings, drill on statues, and lasers on sensitive surfaces).
2) If the fact of producing digital content somehow prevents the custodian of cultural heritage to adequately conserve heritage due to loss of income from visitors (direct loss or satellite activities loss), then the creation of this digital content should be avoided (e.g. a virtual visit perfectly shows a place, and potential visitors, after the experience of the tour, won't need to visit the real site for which they would have had to pay).

The UNESCO summit at Hangzhou, in the People's Republic of China, on the 17th of May 2013 produced a joint declaration 'Placing Culture at the Heart of Sustainable Development Policies' where it is asserted that culture is at the base of sustainable development and the concept is expanded in some original way. The declaration introduces the concept of 'mobilising culture' by means of educational, communication and artistic programmes. Another notion is the 'cultural literacy in school'. It should be an integral part of quality education as it will play a significant role in the creation of an inclusive and equitable society and the safeguard and promote.

Recently, the final report of an extensive research project was published, funded by the EU Culture Programme 2007-2013: *Cultural Heritage Counts for Europe (CHCfE). Towards a European Index for Cultural Heritage* (CHCfE Consortium, 2015). It considers cultural heritage in a holistic dimension, aiming to collect and analyse empirical research and case studies relating to economic, social, cultural and environmental aspects of cultural heritage. It provides precise information about the value, the benefits and impacts of cultural heritage, recognised by the EU Council of Ministers European 'strategic resource for a sustainable Europe' (Council of the European Union, 20 May 2014).

The analysis of the findings from research conducted in several European countries demonstrates the full range of benefits that may arise from the investment in cultural heritage. In the final report of CHCfC these are traced to 10 key findings including:

- *Cultural heritage is an important source of creativity and innovation, generating new ideas and solutions to problems, and creating innovative services — ranging from the digitisation of cultural assets to exploiting the cutting-edge virtual reality technologies — with the aim of interpreting historical environments and buildings and making them accessible to citizens and visitors.*
- *Cultural heritage provides an essential stimulus to education and lifelong learning, including a better understanding of history as well as feelings of civic pride and belonging, and fosters co-operation and personal development.*
- *Cultural heritage combines many of the above-mentioned positive impacts to build social capital and helps deliver social cohesion in communities across Europe, providing a framework for participation and engagement as well as fostering integration.*
(CHCfE Consortium, 2015, pp. 24-29)

In the findings of this research, we can read how heritage education has a positive impact on the three main development areas: cultural, social and economic, as was already theorised in the Hangzhou Declaration. The reason for economic development is that the education to cultural heritage could start a process where the knowledge and the skills of some people in a community are directed to improve and promote the local development. This is more likely since heritage education facilitates the creation of an identity and a feeling of belonging to the community. Looking at this document, the word ‘education’ is not limited to the acquisition of skills and knowledge regarding cultural heritage, but also seen as a competence, a basis to use cultural heritage to develop other competencies.

The First Italian National Plan for heritage Education built up a definition based on three pillars:

1) **Heritage is both an objective and educational tool**: education can be aimed at knowing a specific heritage or at developing knowledge in other subjects as well as cross-competences. More, it can be aimed at a broader understanding of the role of cultural heritage to foster its awareness, safeguard and value (Coperland, 2005; Bortolotti et al., 2008). Cultural heritage experiences and awareness contribute to developing a sense of belonging to one or more cultures; that fosters also the awareness of cultural identity and the sense of belonging of heritage to the community.
2) **Heritage education is carried out in both a formal and informal context**: in the former, it is a great tool to teach critical 21st Century skills while in the latter it would foster informal learning experiences through heritage.
3) **It is addressed to everyone**: that means that every age group at every moment of their lives can benefit from heritage education in the long perspective of lifelong learning. For this reason, a key challenge is to propose different projects, strategies and communication to engage a diversity of publics.

1.3 Heritage interpretation.

Heritage Interpretation is a concept with a dual birth both in American and English contexts, the first formalisation of which was made by Freeman Tilden in 1957 in its book ‘Interpreting our Heritage’. He defined heritage interpretation as

'*An educational activity which aims to reveal meaning and relationships through the use of original objects, by the first-hand experience, and by illustrative media, rather than simply to communicate factual information*' and established six principles of heritage interpretation:

> 1. *Any interpretation that does not somehow relate what is being displayed or described to something within the personality or experience of the visitor will be sterile.*
> 2. *Information, as such, is not interpretation. Interpretation is* revelation *based on the information. But they are entirely different things. However, all interpretation includes information.*
> 3. *Interpretation is an art, which combines many arts, whether materials presented are scientific, historical or architectural. Any art is in some degree teachable.*
> 4. *The chief aim of Interpretation is not instruction, but provocation.*
> 5. *Interpretation should aim to present a whole rather than a part and must address itself to the whole person rather than any phase.*
> 6. *Interpretation addressed to children (say up to the age of twelve) should not be a dilution of the presentation to adults, but should follow a fundamentally different approach. To be at its best, it will require a separate programme.*
>
> (Tilden, 2007, pp. 34-35)

Looking at those principles, we can affirm that interpretation is, in fact, education, or, at least, part of the education. This list seems to give didactical directives for an on-site education to heritage.

In the following years, the concept was widely adopted in the USA, Canada and the UK. Also, people interested in it created national associations for the interpretation of heritage. On the documents produced by interpretation associations one may find several slightly different definitions:

Multiple definitions of Interpretation

1. *'Heritage interpretation is any communication process designed to reveal meanings and relationships of cultural and natural heritage to the public, through first-hand involvement with an object, artefact, landscape or site.'* (Interpretation Canada, 1976 - Canada)

2. *'Interpretation is a mission-based communication process that forges emotional and intellectual connections between the interests of the audience and the meanings inherent in the resource.'* (The National Association for Interpretation, 1988 - USA)

3. *'Interpretation is primarily a communication process that helps people make sense of, and understand more about, your site, collection or event. It can:*

- *Bring meaning to your cultural or environmental resource, enhancing visitor appreciation and promoting better understanding. As a result, your visitors are more likely to care for what they identify as a precious resource.*
- *Enhance the visitor experience, resulting in longer stays and repeat visits. This will lead to increased income and create employment opportunities.*
- *Enable communities to better understand their heritage, and to express their own ideas and feelings about their home area. As a result, individuals may identify with lost values inherent in their culture.'*

(The Association for Heritage Interpretation, 1975 - UK)

4. *'Interpretation refers to the full range of potential activities intended to heighten public awareness and enhance understanding of [a] cultural heritage site [sic]. These can include print and electronic publications, public lectures, on-site and directly related off-site installations, educational programs, community activities, and ongoing research, training, and evaluation of the interpretation process itself.'* (ICOMOS Ename Charter for the Interpretation and Presentation of Cultural Heritage Sites, 2008)

Finally, the last definition tries to link it to the European tradition:

5. *'Mediation is the translation of the French médiation, which has the same general museum meaning as 'interpretation'. Mediation is defined as an action aimed at reconciling parties or bringing them to an agreement. In the context of the museum, it is the mediation between the museum public and what the museum gives its public to see.'* (Key Concepts of Museology, 2010, International Committee of Museums ICOM's International Committee of ICOM for Museology ICOFOM)

We have here another confirmation of the didactical level on which interpretation intrinsically belong. Indeed, the mediation between the subject (student or visitor) and the object (heritage) is essential and would be better explained in the chapter related to heritage education methodology.

It seems reasonable to affirm that concept of Heritage Interpretation should be part of, and substantially contribute to, heritage education.

1.4 New Challenges for Cultural Heritage Education

Since cultural heritage is a structural element for our living environment, it is there for everyone to be seen, lived, as a resource. It is the object of study for many but also a point of reference both spatial and temporal for the community. It allows us to understand the people of a place, their culture and their environment. For those reasons, it is vital as part of education. Through it, information and knowledge gain human and social meanings. But how to rightly integrate it into education? It is essential to avoid it to be just a spot digression into a broader discourse, or to make of it a separate lesson. It needs a comprehensive and articulated project with specific aims, strategies and contexts, both formal and informal which recognises cultural heritage as a tool and educational objective.

In order to pave the way for such an education, there are issues to be addressed in several important areas such as accessibility, participation and interdisciplinarity. As regards accessibility, cultural heritage should be in the first place a right. It is critical for the development of the single person and the community. Furthermore, it is imperative for the existence and the preservation of heritage itself. Only with the mutual exchange and interaction between people and heritage people can fully develop. Thus, they will preserve old heritage and create the new.

That's the reason why cultural heritage must be fully accessible from every point of view. It needs to be physically reachable, affordable and understandable for everyone, serviceable for people with sensory and motor-disabilities. Heritage education must take into account those principles, which are *condicio sine qua non* for it to be effective. On the other hand, it is directly responsible for the cognitive accessibility of heritage. It is thanks to educational projects that everyone might have the opportunity to understand and appreciate heritage. Participation is the second problem that must be addressed. The Framework Convention on the Value of Cultural Heritage for Society stresses how the dimension of participation is of the utmost importance in the process of the awareness and conservation of heritage. Educational projects will substantially contribute to engaging the community. From the smallest activity in class to the most advanced project involving schools, museums and associations, education engages people in heritage by letting them understand and become aware of its value. Finally, it would be reductive to approach cultural heritage from a single point of view that can be representative of a single school or research subject. Cultural heritage is inherently multidisciplinary and interdisciplinary as it is the object of the study of many disciplines and at the same time, not one of those can explain it by itself. That is because it is the crystallisation of the whole culture of an epoch and not just a part of it. It is the riches of heritage to be multi-faceted and to be a field where every aspect of the knowledge can grow and develop.

1.5 The importance of cultural heritage education for educational methodologies

All that constitutes cultural heritage is the result of natural processes, people and human societies moving in particular cultural contexts. They are the tangible results of beliefs, religions, visions of the world, crafts, relationships in the societies, technical evolutions, aesthetic preferences and many other variables. Of course, they are tightly connected with the place, its territory, morphology and climate (Bortolotti et al., 2008). During the process of the construction of knowledge, experts of every discipline transform those elements with research tools and link them to reach the best possible understanding of each one of them.

In the context of the formal education often we find part of this knowledge and heritage artificially presented as single elements to study. It is true that each discipline has at its basis a part of heritage, but it should not be divided from the others. That's why the integration of cultural heritage education in the school curricula may bring a remarkable pedagogical and didactical innovation. Here's how it could enhance the teaching-learning practice in schools:

- Providing an understanding of the methodologies at the basis of the construction of knowledge.
- Fostering the acquisition of skills like observation, analysis, production of information, critique, communication, inference and aesthetics.
- Explaining the reason for a specific discipline methodology.
- Fostering proficiency in applying the same methodology in other contexts.
- Triggering the comprehension of other cultures and heritages and therefore intercultural skills.
- As it happens for the production of knowledge by experts, the same process applied to a school class requires a socio-constructivist approach to teaching and learning practices.

An essential part of the methodology is didactics and the strategies employed to help students have a meaningul experience and learning. Thanks to the interaction with objects, students have access to a present and past reality that otherwise would be hidden.

An artefact[12] is the physical crystallisation of a specifc culture in a specific timeframe. In it, the physical dimension with all its features and the cultural, symbolical, dimension which engendered it are merged. A mediation is needed to obtain a good understanding of both those dimensions. Thus, in a didactic intervention, interaction between students and heritage, especially when it comes to an object-based experience, is paramount as well as the role of

[12] The word artefact comes from the Italian word *artefatto*, from the Latin *àrtis* (that we could now translate as art, profession, craft, skill, talent, proficency, ability, mastery) and *fàcere* (which means 'to do' or 'to make'). It is a product of man's craft.

mediation between them. The mediation, to be effective, needs to help the students (subjects) to connect to all the network of the relation of which the artefact (object) is part and has been part. Through storytelling, the communication should provide information and trigger the emotions as well as the engagement. Basically, completeness of information matters less than the overall experience as one should always be attention to reception over and above dissemination of every single aspect of a phenomenon. Finally, it is crucial to differentiate the educational offer for different needs, consolidate and apply what has been learned and put in place processes of testing and evaluation of learning (Nuzzaci, 2011).

1.6 ICT for Cultural Heritage Education

A UNESCO (2005) document reported that all developed countries had created open electronic archives containing vast collections and digital versions of part of their cultural heritage. Thirteen years later those collections have improved in quality and quantity, other nations followed the lead, and many different techniques of digitalisation of heritage have been employed. As an example, 3D models of artefacts, monuments and buildings are now both of better quality and much more comfortable to acquire. The result is a great availability of those digital representations of heritage.

In the European Union, the digitising of heritage is a strategy since 2000 (eEurope policy), and it is continuing now through the so-called ‘Digital Single Market’ in the policy ‘Digital Cultural Heritage’. In 2011 the European Commission issued a recommendation ‘on the digitisation and online accessibility of cultural material and digital preservation’ where it states that the European aim is to digitise and make publicly available as much as possible of European cultural heritage. One of the most considerable efforts on this front has been made with the creation of Europeana, a shared, open, European digital library containing artworks, artefacts, books, videos and sounds. It was inaugurated in 2008 and in October 2011 held more than seventeen million two hundred thousand contributions (European Commission, 2011). At present, it contains more than fifty-one million five hundred thousand contributions.

It is an example, but the number of open access heritage databases has grown as well, and we have the opportunity to see from the Internet the collections of many museums.

This means that the quantity of material available for an educational use is enormous. Teachers now having at their disposal the digital representation of heritage are able to use electronic means to conceive educational activities. This on the one hand may help in-depth study of single topics and, on the other, grant a better overall understanding of the context where they originated. In support of the former, images are nowadays not only in their usual bi-dimensional format but now also enable one to zoom into details, change the perspective with 3D techniques, rotate the view and see things which are very difficult to notice in the real world. Essentially, the representation of the artefact is now dynamic and interactive allowing the user to choose his viewpoint and ultimately to have a better understanding (Ott & Pozzi, 2011).

In support of a better understanding of the original and historical context, new technologies enable the user to move from the single object to the broader frame. This is possible thanks to 3D, immersive and virtual environments that can use current reality (e.g. thanks to spherical immersive imagery) or virtual reality (e.g. by means of virtual reconstructions of the past landscape and environment based on data and research) to give a context to heritage. In addition, virtual reality technologies enable users to have a real experience of the sites in ancient times, move around them and look inside at least for some of them (Barcelo' et at., 2000).

The contribution of new technologies to heritage teaching and learning practices can be described through the diverse possibilities it generates:

- Personalisation, inquiry-based learning:
  Since access to the information is open, it is sensible to let the students discover it for themselves. They can be active in the process of knowledge building and create their own learning path thanks to inquiry-based and project-based methodologies.

- Enriched situated learning:
  It stresses the relevance of cultural and social context where the teaching and learning processes take place. The context is tightly interlinked with the knowledge development process (Brown & Duguid, 1989). Thanks to the ubiquituous presence of mobile devices it is possible to adopt a more effective situated learning. The school is no longer the only place where learning takes place: one may have access to crucial information in situ, when needed. Similarly, one can be at school or at home and yet pretend to be in situation thanks to virtual reality technology.
- Interdisciplinarity:
  Cultural Heritage is inherently interdisciplinary, and more, one could say that the disciplines originate from cultural heritage. ICTs have the power to highlight and link those aspects of heritage with broader and more generic knowledge categorised in subjects and contexts. Of course, the reverse process is also possible. One could, for example, search for a particular argument regarding a subject and get links to all heritage that relates to it.
- Collaboration:
  ICTs offer a wide choice of collaborative tools for collaboration and co-construction of knowledge. They support peer-to-peer communication, data exchange and joint elaboration of information not only amongst local students but potentially involving far students and communities through the World Wide Web. Tools like wiki, blog and folksonomies allow students also to create shared artefacts (Sigala, 2007). Another possibility to use multi-user virtual environments like OpenSim or Minecraft to let students study, manipulate and represent heritage[13].
- From formal to informal:
  Informal learning indicates those learning processes which occurs spontaneously, outside a formal education setting (Livingstone, 2001) and

[13] One significant example is the work made at the Otero Junior College and La Junta High School in Colorado. They collaboratively re-built the local Bent's Old Fort National Historic Site (a 19th Century trading post) in Minecraft and now shared their work to let other students virtually visit the fort.

is not defined just from the context but also by the kind of activities and the processes involved. The ubiquitous presence of mobile devices through a student's contexts of life, allow him to deepen concepts already addressed in a formal environment and, and vice-versa, to bring in the formal environment information and detailed studies made in the informal context. Also, thanks to the use of ICTs, institutions like museums and monumental sites, where informal learning usually take place, have the opportunity to investigate how people use the ICTs provided, thus providing more exciting and meaningful experiences (Ott & Pozzi, 2011).

As already reported, another crucial challenge for heritage Education is the accessibility one. That has many faces, but ICTs can help addressing several of them, like to avoid or reduce cultural and disability barriers thanks to the use of specific technological tools (Ott, Pozzi, 2011) or a technology-oriented inclusive design approach. Another issue that the ICT allow to address is the one related to the physical inaccessibility of part of heritage, such as very ancient and delicate artefacts. They can be used as an example for creating digital copies or representations of objects, developing trails aimed to a better knowledge of heritage and creating specific experiences of the same heritage for different users and needs.

In other words, adopting those technologies is not a mere change of media, they actually provide a set of original possibilities which enable a powerful use in educational contexts:

- Side by side comparison between physically distant or nowadays no-more-existent artefacts.
- Recreate the original context in which heritage was placed.
- Retrace past events and lives.
- Show and propose current networks and links in the land and cultures of the past and the present.

By means of these functionalities students may respectively understand differences and similarities between artefacts and cultures, understand the reason for a particular heritage and its utility in the original context, conceive how heritage has been experienced by the people who fashoned it and by the people who found it in the following epochs, figure out how current and past cultures are connected at various levels (Bortolotti et al., 2008).

On a final note, what is right for the general technology-enhanced education is also true in the use of those technologies in heritage education: it is not the simple use of the technology that grants a meaningful learning experience or to elude accessibility barriers. In order to obtain those results, one needs to develop interactive experiences with active, experiential methodologies based on a 'design for all' or 'universal design' approach.

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CHAPTER 2
The Activity Theory and its relevance for a technological approach to heritage education

This chapter will now turn to the chosen research framework and its role as a powerful instrument, especially suited for the analysis of studies based on technological tools and Human-Computer Interaction (HCI). [14] I would like to present firstly the historiography of the concept of 'activity theory' as it has evolved since the 1990s. Activitiy theory designates a conceptual framework to better answer the classic questions '*who is doing what, why and how*' (Hasan & Kazlaukas, 2014, p. 9).. It provides powerful instruments for the interpretation of human activities. Three generations are examined in order to better explain the most updated versions that I employed throughout the research. The first one dates back to the first half of the twentieth century and was further developed until the eighties; the second and the third ones were developed respectively at the end of the eighties and at the end of the nineties. In 1993, Yrjö Engeström described the Activity Theory (AT) as 'the best kept secret of academia'. Although not very well known outside the social, pedagogical and Human-Technology Interaction sciences, nowadays it is no longer such a well kept secret. In fact, since the beginning of the Nineties the growth of researches about, or using, the AT has been exponential (Roth & Lee, 2007). It is a very sophisticated tool to enable better understanding of the complexity of human activity and to ask meaningful questions related to every action (Kaptelinin, Nardi

[14] In order to write this chapter, it was important to find guides in the complex and varied field of Activity Theory. The most influential among them were Engeström's (2009) article '*The future of activity theory: A rough draft. Learning and expanding with activity theory',* Roth and Lee's (2007) article '*Vygotsky's neglected legacy: Cultural-historical activity theory'* and Kaptelinin and Nardi's (2009) book *Acting with Technology*.

& Macaulay, 1999). Vygotskij[15] and his colleagues (notably, Aleksej Leont'ev e Aleksandr Lurija) created it on the basis that, unlike machines and animals, human activities are guided by a meaningful purpose and carried out by means of tools. They developed the triangle of artefact mediation of which the current AT model is an expansion. First Leont’ev and then Engeström worked on that expansion. Their works are similar in many aspects but not identical. Engeström, having worked at it subsequently, incorporated some of the work of Leont’ev in a new model. In 1999 he spoke of three generations of AT, which we will address in the next sub-chapter. In the last twenty years, other authors decided to work on the Leont'ev model rather than the Engeström one. Among them the most influential are arguably Bonnie Nardi, Kari Kuutti and Victor Kaptelinin who refined the AT to better be applied to informations systems. Given the complexity of the two case studies that are part of this research, we decided to use AT to describe and evaluate them. Also, the intercations between pupils and technology finds in the last versions of AT a great analysis tool.

2.1 The First Generation

The first generation model is very similar to the Vygotskij concept. The unit of analysis is mediated action. It can be visualised as a triangle with on one vertex the Subject, who can be an individual, a dyad or a group, on the other one the Mediational Means, which are tools such as writing, speaking, technology, etc and on the third one the Object, in other words, the Motive which leads to an Outcome.

[15] Lev Semyonovich Vygotsky (1896 - 1934) was a Russian psychologist. He is considered the father of what is now called the ‘cultural-historical’ school of psychology. The peculiarity of this school is to indissolubly bound the human mind with the society and culture it belongs. He greatly influenced world’s psychology and pedagogy. In Russia his students Luria and Leont’ev developed the Cultural-Historical Activity Theory (CHAT) (Roth & Lee, 2007) while in Europe and US, from the seventies on, his theories have influenced social-constructivist theories, complementing Piaget constructivism (Daniels, 2005).

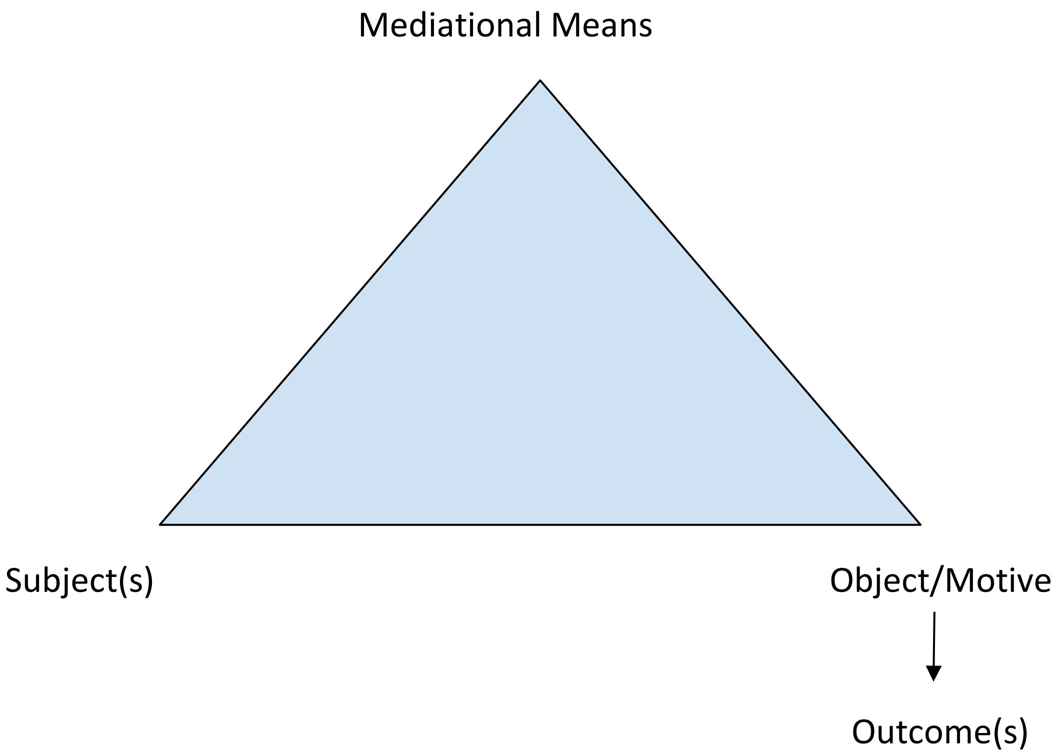

Figure 1: Representation of the first generation of Activity Theory.

This triangle represents the way in which Vygotskij brought together cultural artefacts with human actions in order to avoid the dualism between individuals and society (Figure 1). During that period, the focus of the theory was on individuals.The fundamental concept is that tools or signs, which are culturally defined or created, mediate every human activity. The subject interacts with a tool to achieve an outcome. During this external interaction with the tool, the internal mind of the individual is transformed (Aboulafia, Gould & Spyrou, 1995). This is a crucial concept for AT and this research as well, and the reason is that the tools that have been used in the human activity are themselves the result of a long process of cultural and evolutionary development. Since they are not neutral, the subject will be influenced by interaction with them, as will the object. Leont'ev called this phenomenon *ringstruktur* (ring structure) (Figure 2).

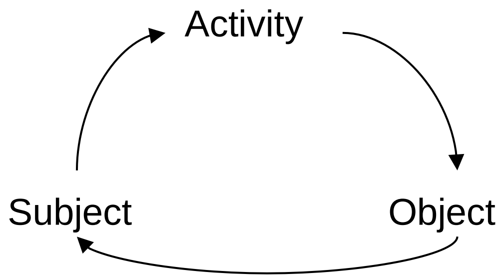

Figure 2: Leont'ev's Ringstruktur.

Subject, Activity and Object are on the same level, and the Object closes the circle influencing the Subject. In Leonte'vs thought, the activities are ordered in a hierarchical system (Figure 3) in which an activity comprises a series of actions and an action a series of operations. Take the example of the basic skill of executing a mathematical addition. The activity in that case is training in mathematical addition. An action is to solve an addition, and an operation is to sum one and one. Nevertheless, the activity has a motive, in this case, to give to children literacy in maths, the action has a goal, which is to get the result, and the operation has conditions which are to add the numbers correctly and to obtain a correct result for the numbers given. It is essential to highlight that the operation always takes place in the subject's mind.

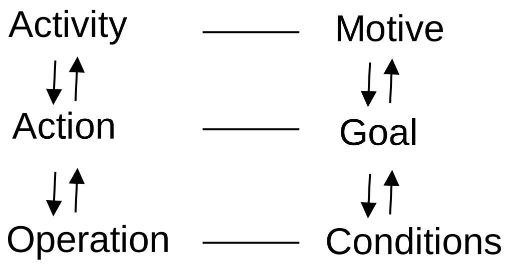

Figure 3: Hierarchical levels of activity.

2.2 The Second Generation

From Leont'ev's conception of activity system, Engeström developed the second generation (Figure 4 - The structure of a human activity system Engeström, [1987], p. 78)

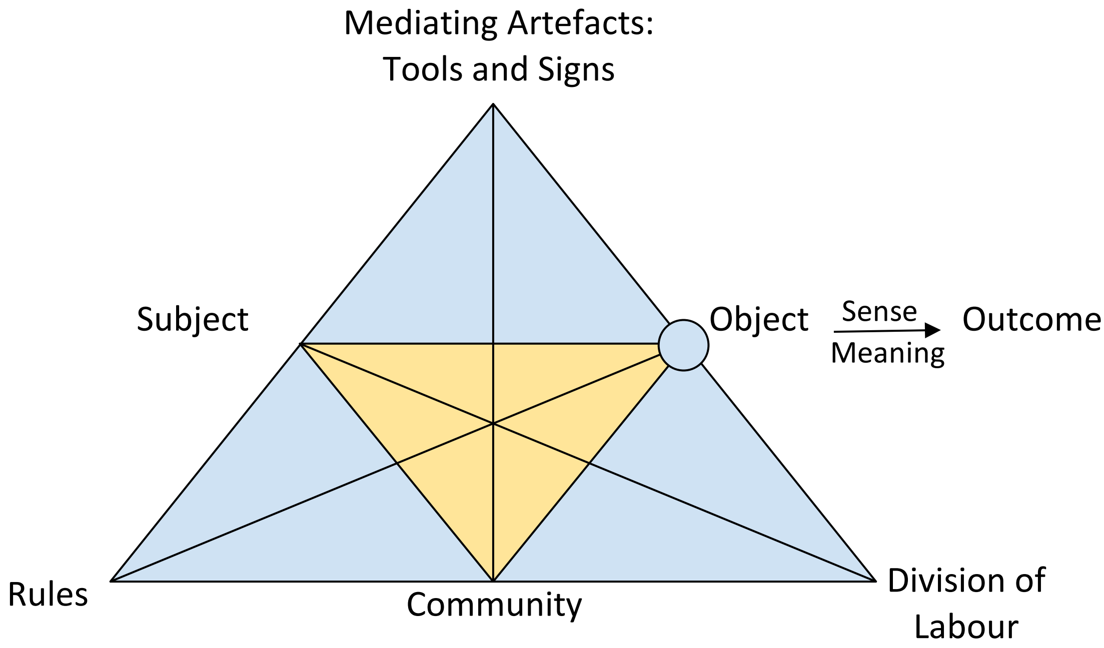

Figure 4: representation of the second generation activity theory. The process of attribution of sense and meaning to the object leads to the outcome.

It is based on the concept that artefacts are integral, inseparable components of the human being, but he focused on the relation between mediation and the other components of an activity system.

In order to progress the development of activity theory, Engeström expanded the original triangular representation of activity to make it possible to examine systems of activity at the macro level of the collective and the community rather than micro level concentration on the individual actor or agent operating with tools. The aim is to represent the social and collective elements in the activity system as they are regarded as fundamental to the transformation of an individual, the subject. The expansion has been made by adding the three elements of community, rules and division of labour, emphasising at the same time the importance of exploring their interactions with each other.

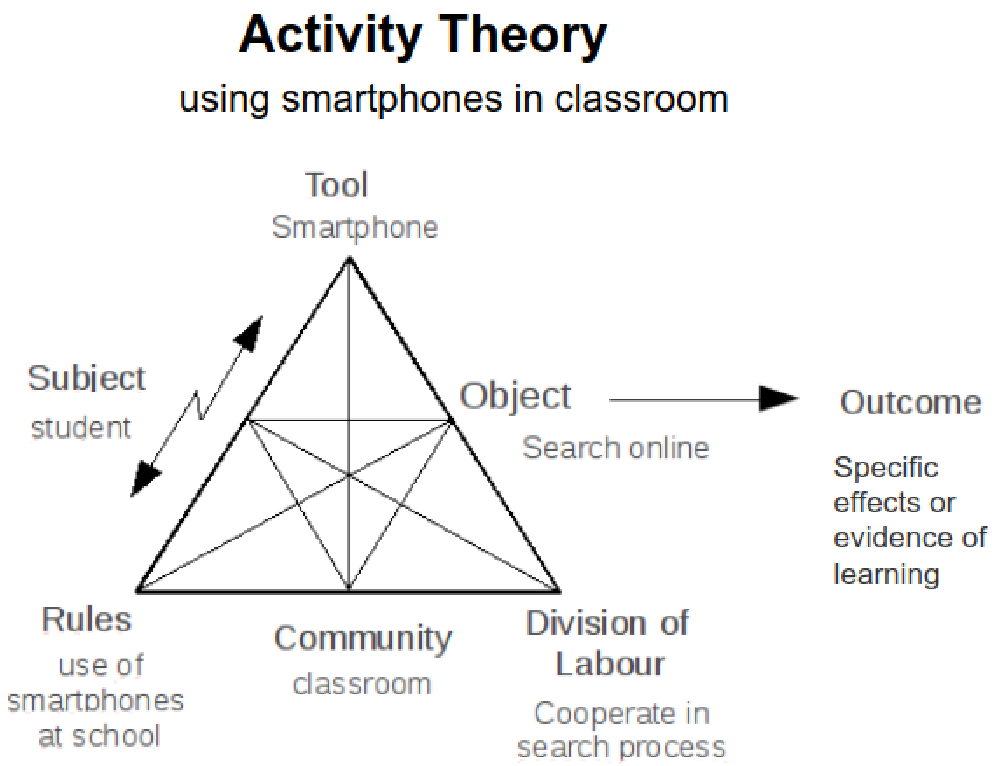

Figure 5: Possible contradictions between Students, Rules and Tools using smartphones in classroom.

The 'Community' represents people in the system other than the subject. 'Rules' are a mechanism, which can be formal or informal, explicit or implicit, and control how the system operates. The 'Division of Labour' has two dimensions: the vertical and the horizontal. The vertical related to power and status, i.e. the hierarchy, while the horizontal has to do with the division of tasks between the members of the community.

In this second generation of AT, sometimes, in the figure, the object is depicted as an oval indicating that object-oriented actions are always, explicitly or implicitly, characterised by ambiguity, surprise, interpretation, sense-making, and potential for change (Engeström, 1999). As is visible in Fugure 4, the six elements peculiarly interact with each other. These interactions produce 'tensions' or contradictions[16] within activity systems which are the driving force

[16] Patricia Collins et al. (2002) in their paper 'Activity Theroy ans system design: a view from the trenches' call them 'tensions' finding the word 'contradiction' too strong.

of change and thus development (Engeström, 1999; Ilyenkov, 1977). Often, the feedback from participants in a project focuses on contradictions within or between elements. To analyse these contradictions or tensions, can provide rich insights into system dynamics and opportunities for the evolution of the system (Collins, Shukla & Redmiles, 2002).

Tensions or Contradictions between two elements of the triangle can evidence problems in a system. It is important to note that the contradictions represent a real structural component of the system that affects all the elements. For example, the educational use of smartphones in classrooms can be considered useful and tolerated in order to keep students engaged in an online search for information about a specific learning topic. This is an interesting educational choice, but it can lead to contradictions between Rules and Subject (Students) and Tools because smartphones are also powerful devices that are sources of distraction (see Figure 5).

Inside every AT model there are four higher order functions originating from the relationship between the three vertexes of each triangle (Holt & Morris, 1993; Nardi, 1998) which represent different aspects of human activity:

- Production: is the creation of the object needed to reach the aims of the system.
- Distribution: divides the work into the community following the social laws.
- Exchange: records the social interaction produced by the activity.
- Consumption: is the function, that comes after the others, which realises the prefixed aims of the subject and the community.

2.3 The Third Generation

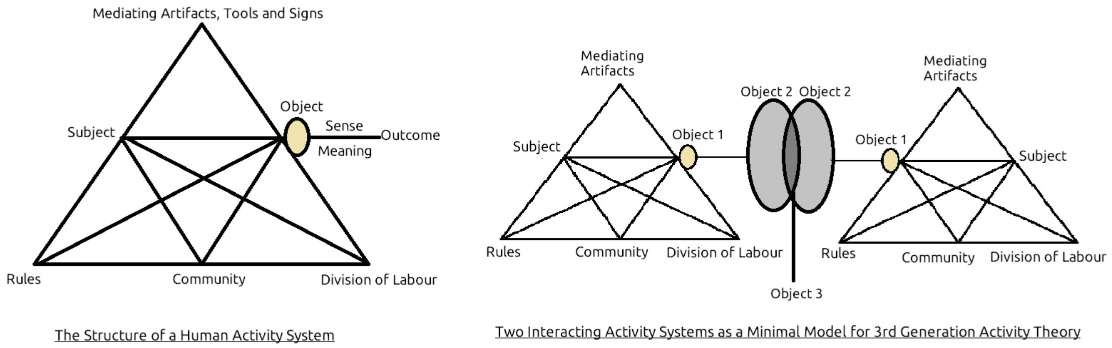

Figure 6: the scructure of a Human Activity System and two Interacting Activity Systems.

The third generation addresses the Engeström view of joint activity or practices as the unit of analysis for activity theory. The unit is not the individual activity. It is built on the idea of multiple interacting activity systems focused on partially shared object. The focus is on the process of social transformation and includes the structure of the social world in the analysis, taking into account the conflictive nature of social practice. He sees instability, (internal tensions) and contradiction as the 'motive force of change and development' (Engeström, 1999) and the transitions and reorganisations within and between activity systems as part of evolution. It is not only the subject but also the environment that is modified through mediated activity. He views the 'reflective appropriation of advanced models and tools' as 'ways out of internal contradictions' that result in new activity systems (Cole and Engeström, 1993).

The third generation of activity theory proposed by Engenstrom intends to develop conceptual tools to understand dialogues, multiple perspectives, and networks of interacting activity systems. He draws on ideas of dialogic and multivoicedness to expand the framework of the second generation. The design of networks of activity within which contradictions and struggles take place in the definition of the motives and object of the activity calls for an analysis of power and control within developing activity systems. The minimal representation in Figure 6 shows but two of what may be a myriad of systems exhibiting patterns of contradiction and tension.

Engenstrom (1999, pp. 397-402) suggests that AT may be summarised with the help of five principles. They stand as a manifesto of the current state of activity theory:

1) *A collective, artefact-mediated and object-oriented activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis. Goal-directed individual and group actions, as well as automatic operations, are relatively independent but subordinate units of analysis, eventually understandable only when interpreted against the background of entire activity systems. Activity systems realise and reproduce themselves by generating actions and operations.*
2) *The multi-voicedness of activity systems. An activity system is always a community of multiple points of view, traditions and interests. The division of labour in activity creates different positions for participants, the participants carry their diverse histories, and the activity system itself carries multiple layers and strands of history engraved in its artefacts, rules and conventions. The multi-voicedness is multiplied in networks of interacting activity systems. It is a source of trouble and a source of innovation, demanding actions of translation and negotiation.*
3) *Historicity. Active systems take shape and get transformed over lengthy periods of time. Their problems and potentials can only be understood against their history. History itself needs to be studied as a local history of the activity and its objects, and a history of the theoretical ideas and tools that have shaped the activity. Thus, medical work needs to be analysed against the history of the local organisation and the more global history of the medical concepts, procedures and tools employed and accumulated in the local activity.*
4) *The central role of contradictions as a source of change and development. Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between activity systems. The primary contradiction of activities in capitalism is that between the value and the exchange value of commodities. This central contradiction pervades all elements of our activity systems. Activities are open systems. When an activity system adopts a new element from the outside (for example, new technology or a new object), it often leads to an aggravated secondary contradiction where some old element (for example, the rules or the division of labour) collides with the new one. Such contradictions generate disturbances and conflicts, but also innovate attempts to change the activity.*
5) *The possibility of expansive transformations in activity systems. Activity systems move through relatively long cycles of qualitative alteration. As the contradictions of an activity system are aggravated, some individual participants begin to question and deviate from its established norms. In some cases, this escalates into collaborative envisioning and a deliberate collective change effort. An expansive transformation is accomplished when the object and motive of the activity are conceptualised to embrace a radically broader horizon of possibilities*

than in the previous mode of activity. A full cycle of expansive transformation may be understood as a collective journey through the zone of proximal development of the activity.

(Centre for Socio-Cultural and Activity Theory [CSAT] of the University of Bath, 2007, pp. 3-4)

Another achievement of Engeström has been to refine Wartofsky's mediating artefacts hierarchy (1979). The following table provides the classification, which is still open for discussion and different interpretations. (Collins, Shukla & Redmiles, 2002)

Table 1: Mediating Tools (Artefacts) Hierarchy

Tool Class	**Primary Characteristic**
What	Contributes a *means* of achieving the object
How	Contributes to *understanding how* to achieve the object
Why	*Motivates* achievement of the object
Where - To	Motivate *evolution* of all elements in the activity system

The mediating artefacts hierarchy is directly related to the activity system model, specifically identifying forms of mediation between the subjects and the object. The classification scheme enables to identify ways that are inadequate or missing but are needed by the subjects to achieve the object better. It allows one to look more closely at the artefacts and to understand the role of each within the activity system. It can be useful as a checklist against which one can determine missing or inadequate classes of artefacts. In Table 1, and throughout the dissertation, the name of this specific device was changed from 'mediating artefacts' to 'mediating tools' because the word artefact could be misleading in this particular case. In fact, artefact is used in this diessertation to indicate cultural heritage objects.

AT can contribute to the efficiency and the quality of the analysis. One map the data from the interviews and observation directly to the elements and relationships between elements in the model. The seven elements of the model (subject, mediating artefacts, object, rules, community, division of labour, outcome) were an efficient means of identifying fundamental parts of the activity system.

I will examine below the role of runaway and boundary objects which can be defined as follows: by runaway object one refers to an activity object that is under nobody's full-control and tends to be shared and spread increasingly; as for boundary objects, they designateactivity objects shared between two or more activity systems, but also scientific objects (physical or theoretical) which are at the present in two different social worlds or two different scientific fields.

2.4 Runaway objects

Activity theory is a theory concerning object-driven activities. Objects are concerns and generators of attention, motivation, effort and meaning. Through their activity people constantly change and create new objects. Those can also be unintentional and can be results of multiple activities. Runaway objects (Engeström, 2008) have the potential to escalate and expand up to the global scale of influence; they are inadequately under anybody's control and have far-reaching, unexpected effects. They are contested and generate opposition and controversy. They can be powerfully emancipatory objects that open radically new possibilities of development and well-being. One well-known example is the Linux Operating System[17]. They can start as marginal innovation, and their

[17] Linux is computer Operating System (OS), which was created in 1991 by the Finnish software engeneer Linus Trovalds. Frustrated by the licensing systems of the time, he created his own OS starting from the basis of the opensource code of UNIX OS. He released Linux as an opensource and free distributable software. From that moment on Linux have been increasingly adopted,

potential is difficult to be predicted and utilised. They can remain dormant, invisible or unseen, for a long time until they produce great breakthrough, or crises.

It is likely that a significative, hi-impact, runaway object is the focal object of two or more activity systems. Runaway objects tend to be pervasive, so boundaries are hard to draw. Also, the positions of the activity systems are ambiguous, and they often seem to be subsumed to the object rather than in control of it. Runaway objects often tend to be technological innovations.

Since user interest is not always a priority of the IT industry, it exists an immense underwood of activities aimed at creating home made soloutions for various unsolved problems. People are acting, creating communities and troubleshooting issues with software and hardware. There are communities that finds new creative uses of proprietary technologies.

These activities contribute to intermediate runaway objects, which are less spectacular and more inviting. Various social movements try to do just that: organic farming and Wikipedia, an open model of scientific research and publishing, are examples. Most of such attempts remain marginal, but there are some qualities and characteritists that lend the object a high appeal:

- Intrinsic property to transcend the limits of the utilitarian profit motive. A runway object is at the boundary between legitimate and illegitimate, sensible and crazy, work and leisure, technology and art.
- The object has to be continuously refined, with persistence and patience, and to find its place between those boundaries.
- The object must yield useful intermediate products, yet remain an incomplete project, always changing and improving.
- The object must be visible, accessible and cumulative, allowing participants to return repeatedly. There must be adequate feedback from, and exchange among, the participants acting on the object.

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expecially for server computers. The advent of Android OS (the smartphone OS which can be found in most of mobile phones), which is based on the Linux kernel, supercomputers and the Internet of Things (IoT) consacred it to be the overall most widespread OS in the world (Wikipedia contributors, 2018; Gartner, 2018).

2.5 Boundary objects

Boundary objects have been theorised in a first place by Susan Leigh Star and Griesemer at the end of the eighties. They were a way to solve the problem of joint representation in diverse intersecting social worlds (Star, 1989; Star & Griesemer, 1989) and to analyse the nature of cooperative work in the absence of consensus (Star, 2010).

In this first and original sense, the boundary object refers to those scientific objects, abstract or concrete, that are present and originated in two or more social worlds. A boundary object maintains its own identity in each different social world, but it is flexible enough to meet the specific, sectoral, definition of the field in which it is used. It can be both very strict in a determined use and unspecific in the everyday usage.

The concept of boundary object has then been borrowed from Engeström to be integrated into the activity theory. It should be noted that the meaning of ‘object’ in AT context is different from the Star’s definition. In AT an object is the motive and aim of activity while a boundary object is a mediating artefact (physical or abstract). One could argue that those two definitions have an intersection of shared meaning and so the object can be at the same time an AT and a boundary one. We agree, but we think it is essential to be aware of that difference. Looking at the Engeström work, for a first time, working at the 2nd generation of AT, he used the same Star’s conceptualisation (Engeström et al., 1995). On the other hand, in the 3rd generation, he changed the meaning moving it to the shared motive of two or more activity systems, the Object 3 in Figure 4, thus updating the role of the boundary object in AT from artefact to shared object.

In this research, we are going to use the boundary object concept in both the form, the augmented visit will be a boundary object, fully integrated into the 3rd generation of AT, but also the App will be a boundary object in Star’s sense.

2.6 The relevance of AT for this research

2.6.1 Relevant AT experiences

Since Leont'ev, and, in particular, after the first Engeström postulation, AT has been increasingly adopted in researches and notably in those fields of study where is necessary to analyse dynamics between participants, the activities are mediated by artefacts, and are object-oriented. In the following chapter, one can find a selection of AT-based research concerning augmented reality, mobile learning and computer-mediated activities, topics that we regard as very relevant to our research. Only a few researchers applied the third generation of activity theory. When they did, it was to address boundary-crossing and to have a shared object as the aim of more than one activity.

Since the beginning, Human-Computer Interaction and Computer-Mediated Activity have been amongst the main subjects of research that used AT as a framework. Victor Kaptelinin in 1995 and 1996 published some exemplary work on the theme in order to give theoretical support to the body of research. In the same year Bonnie Nardi edited the book 'Context and Consciousness: Activity Theory and Human-computer Interaction' with two chapters from the same Kaptelinin and other experiences of the use of AT in the HCI field (Nardi, Kaptelinin, Kuutti, Bellamy, Bødker, Christiansen, Raeithel and Velichkovsky, Holland and Reeves, Zinchenko, Engeström and Escalante).

Three years later Kaptelinin, Nardi and Macaulay (1999) propose five principles for AT together with a four-step Checklist aimed to evaluate computer-mediated activities (Table 2).

Table 2: Activity Theory Checklist.

Principle	**Checklist**
Object-Orientedness -->	Means and ends
Hierarchical Structure of Activity ->	Social and physical aspects of the

	environment
Internalisation and Externalisation ->	Learning, cognition and articulation
Mediation -->	(present throughout the checklist)
Development -->	Development

In the meantime, Jonassen and Roher-Murphy (1999) were adapting the Engenstrom's and Kuutti's work on activity theory for designing constructivist learning environments (CLEs - Jonassen, 1999). They created a six-step model to work as a guide in that process. The steps are as follows:

1. Clarify the Purpose of Activity System
2. Analyse the Activity System
3. Analyse the Activity Structure
4. Analyse Mediators
5. Analyse the Context
6. Analyse Activity System Dynamics

Each one of these steps has sub-steps to be followed with meaningful questions to help better understanding of what to analyse. They agree with Nardi (1996) in affirming that AT seems to be the best-provided framework to study the context in its wholeness.

Later on, AT has been used as theoretical framework for a project to develop an augmented reality-based system to enhance the group work (Fjeld, Lauche et al., 2002)

On their research towards a task model for Mobile Learning, Josie Taylor, Mike Sharples et al. (2006) regard AT as a powerful tool to analyse activity systems as classroom, workspaces and learning communities. They chose it as a foundation for their model, in parallel with Conversation Theory (Pask, 1976).

In the same year, Nardi and Kaptelinin wrote a book called 'Acting with Technology: Activity Theory and Interaction Design' where they analyse and give an order to all the interpretations and uses of AT to date. As a conclusion they give their own, trying to put the basis for a new, comprehensive, activity model.

They updated that book with a new publication six years later, in 2012 'Activity Theory in HCI: Fundamentals and Reflections' where they take into account the new challenges of the HCI, and integrate the latest research on AT.

Papadimitriou et al. (2007) asked students to collect information in a museum using PDAs. They reported that AT was handy for the researchers, enabling them to see how operations informed actions and to see the role of the facilitators as well as students and devices. They concluded saying that AT seems the ideal conceptual tool to use in the context of a technology-enhanced museum visit: it lets you see beyond outcomes, tool and context.

Lorda Uden in 2007 acknowledged the work done with AT in HCI. She used it in the design of mobile learning experiences and proposed a framework ad-hoc. She found three main limitations on three of AT's main strengths: the requirement for the researcher to really understand the activity system he is studying, the difficulty in unravelling activity systems, and the difficulty in distinguishing between the levels of activity, actions and operations. The benefits outweigh the limitations, though, providing a view of the whole learning system and describing all the interacting elements and their relationships. Another significant advantage is that AT looks at the activity system as something dynamic, evolving, regarding conflicts, breakdown and discontinuities as vital dynamics (Uden, 2007).

In 2010, Walker used the principles in Table 2 in order to analyse the activity of visitors in museums. They were asked to construct trails by means of mobile technology to understand how the people make meanings in such a context. Since he found AT ideal for investigating tool mediation but lacking a comprehensive description of the museum meaning-making context, he built a conceptual model for the design and analysis of trails. This draws theoretical basis from the Contextual Model of Learning (Falk, 1991; Falk and Dierking, 2000) and uses the methodology of AT.

The role of the guide, or the teacher, in mobile learning activities, has always been something not easy to define and difficult to analyse. Cowan and Butler (2013) address the issue with the help of AT, proposing a modification eventually to the Engeström triangular model. Examining the four higher functions and their interrelations they found tensions, of course, and imbalance between elements of AT, which affect the learning process negatively. They modified the AT prividing a three-dimensional representation, adding the teacher in the very centre of it with the role of control and balance between elements that is necessary for effective learning.

To understand the effectiveness of the use of WhatsApp in mobile learning, Barhoumi (2015) take advantage of AT in a quantitative study underlining how the three levels called Community, Individual and Technological influence, in fact, the online participation.

The interest in using activity theory to analyse and design learning experiences with the mediation of mobile technologies is growing. *Mobile Learning Design. Theories and Application* is a 2015 book where the editors selected papers on this subject. AT is used as a framework or as one of the foundations for the theoretical model in four of the twenty-four articles presented:

1. Churchill, Fox and King use it in their RASE (Resource, Activity, Support, Evaluation) learning design framework that aims to get advantage from the multiple affordances of the mobile learning technologies.
2. Burden and Kearney conceptualise the Authentic Mobile Learning providing a model of it. AT is present with its concepts of boundary and boundary objects in order to better understand the continuity between home and school, formal and informal, physical and virtual.
3. Rozario, Ortlieb and Rennie employ the six-step AT (Jonassen & Roher-Murphy, 1999) as primary tool, along with a case study design, to understand how and if the different pedagogies, professional learnings and mobile technologies support teachers to foster a learner-centred and interactive approach. They affirm that using AT as a lens provides an ideal position to better understand the relations between context, mobile technologies (both hardware and software) and the collaborative and interactive learning.
4. Cook and Santos describe three phases of the Mobile Learning, and they push forward the research with a project aimed at the development of a mobile platform for help-seeking for the healthcare in the UK. They use Vygotsky's cultural-historical approach in the logic engine of the Social

Semantic Server that relates people to data, people with people and data with data.

5. Khoo uses an app in order to let pre-school children view and represent addition and subtraction skills. That enabled them to acquire new strategies to learn and understand those operations. He employed AT as the primary framework of this research, to analyse and to categorise four dimensions: subject-tool-object, subject-community-object, subject-division of labour-object and subject-rules-object.

2.6.2 Heritage education and activity theory: a synthesis

Examining the studies reviewed above, one may argue that Activity Theory Literature provides one of the best frameworks for this dissertation. Our research work involves three different institutions with different subjects, communities and rules, which, nonetheless, have partially shared objects. These objects crystallise in the shared object, which is the augmented visit. The augmented visit is not 'just' a shared object, but it fulfils the criteria for being considered as a runaway object and a boundary object in the Engeström's sense. Three activity systems (plus one) per study case have a common shared object in the augmented visit (the main focus of this research), it is thus preferable to to opt for the Engeström's third generation of AT over other models.

As we think it is of great utility, for the analysis of the single activity system, we partially employed the Kapelinin and Nardis's (2009) Activity Checklist, adapting it to the 3rd Generation AT. Also, we will take into account that Jonassen, with reference to the Engeström work, highlights the nested nature of activity theory dynamics. So, a learner group could be the subject of an educational activity, but it could also have been the result (object) of a previous activity aimed at the constitution of the group. In this research, we have a nested activity system, which is the App development one. Its result is the Tool in each of the three interacting activity systems: Class, Guide and Research (Figure 7). Therefore, we are in front of a boundary object in Star's (2010) sense. It is a physical artefact that takes form from the dialogue between three different systems and serves as a link, a connection, a shared artefact that crosses the boundary of the three worlds. The analysis of the two experiences at Verona and Hestercombe, as well as the interpretation of the qualitative and quantitative data, will be done through the lens of AT.

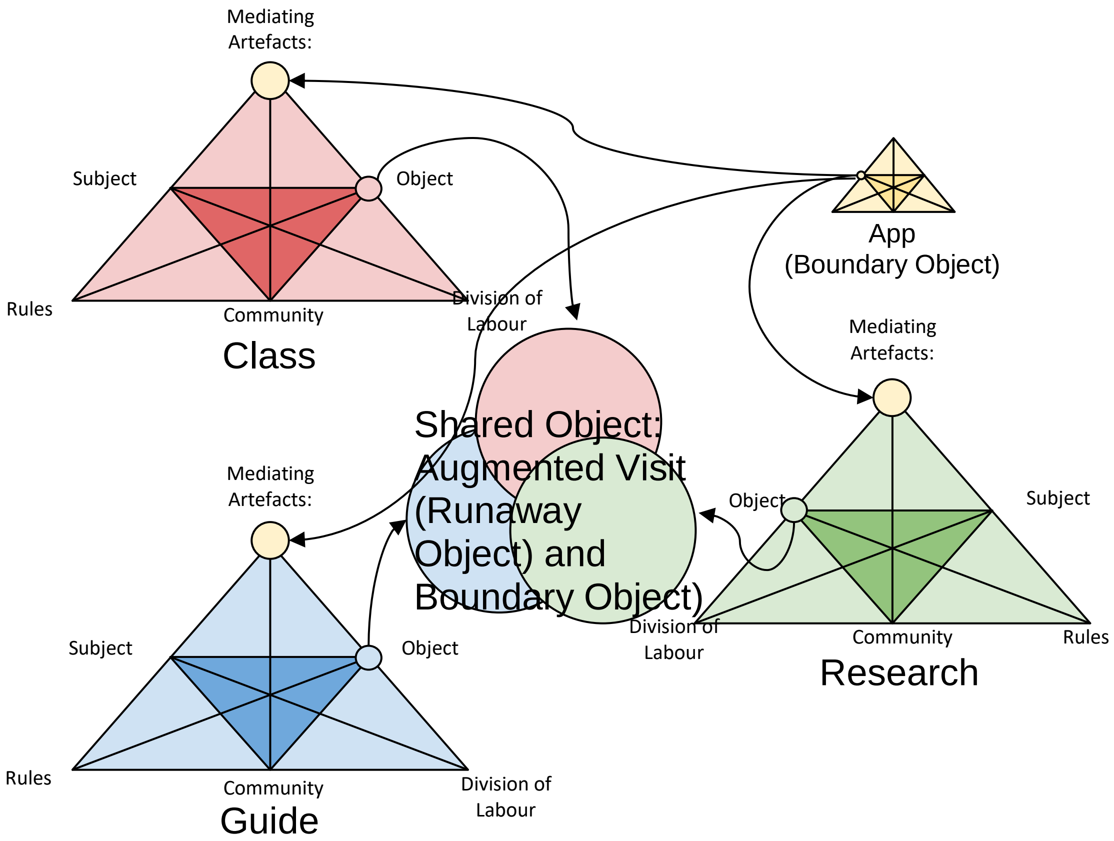

Figure 7: Activity Systems interactions in the field of heritage education. (Copyright Daniele Agostini 2018)

Chapter 2

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CHAPTER 3
Augmented and Mixed Reality Mobile Learning

This chapter will now turn to learning methods and the role that new technology may have in shaping the learning experience differently. Didactic and pedagogic theories have long considered attention span, quality of learning reception, and the benefits of ever-changing activities to keep interest stimulated. Augmented and mixed reality are technologies able to superimpose a layer of computer-generated information on the user perceptions. This unique feature might be able to improve not only motivation and attention, but the overall learning quality.

3.1 Augmented and Mixed Reality

Augmented Reality (AR) is a term coined by the Boeing researchers T. P. Caudell and D. W. Mizell. They created a heads-up (HUD), see-through, head-mounted display (HMD) enabled for head-position sensing and real-world registration. Using it, a worker could have his field of view augmented (Caudell & Mizell, 1992). This technology was thought to add a visual level over and above the user's sight by means of HMD. Nowadays, researchers often define AR in the same way, as just an augmentation of the sense of sight, with the difference that now it can be used with glasses, headsets or mobile device displays used as HUD. Nevertheless, we agree with the work of Schraffenberger and van der Heide (2016) who argue that AR is ordinarily multimodal and involves many other senses than that of sight.

Thus, our definition of AR is a technology which heightens our sensory perception of reality through the superimposition of a computer-generated layer to one or more of our senses. Another fundamental characteristic of this technology is that it implies an anchor with reality or, in other words, something that links the computer-generated layer with reality. It is most commonly used to heighten the sense of sight, providing the user with contextual information, three-dimensional images or models which interact with the environment and other real objects (Azuma et al., 2001). This feature is usually achieved by sensors. In most of the appliances, the sensors are GPS and the camera.

We must not forget that one of the most successful forms of AR relates to the sense of hearing: audio guides belong to this technology; in fact, they supply us with an additional and contextual layer of information artificially accompanying our sense of hearing.

Augmented Reality acts within a continuum with two polarities: the Real Environment and the Virtual Environment (Milgram et al., 1994) (see Figure 8). The areas which lie between these two poles are part of a so-called 'Mixed' Reality. AR acts within the Mixed Reality interval which is closer to the Real Environment, whilst Augmented Virtuality is closer to the Virtual Environment.

Figure 8: Reality-virtuality continuum by Milgram et al., 1994.

Thanks to its ability to link the virtual with the real, the potential of AR in the field of education is increasingly studied by researchers who now regard it as one of the next-generation media with a prominent role in future learning best practices (Dede, 2008).

Mixed Reality has been used since the beginning to broadly refer to technologies which are in the continuum but cannot be classified as 'just' AR or VR (Virtual Reality). In fact, one of the earliest definition of MR, from the 1st International Symposium on Mixed Reality, is *'the overlaying of virtual objects on the real world'* (Billinghurst & Kato, 1999; Pan et al., 2006) which is very similar to the current AR definition. It seems that the fact of having 'virtual objects' superimposed on a real environment, instead of plain textual information, was the discriminant to classify it as MR. Being in a continuum one cannot talk of boundaries and strict classifications, but with the latest AR technologies, such as

Apple AR Kit and Google AR Core, those categories become, if possible, more blurred than ever.

3.2 The range of AR and MR technology

In recent years, thanks mainly to progress in mobile technology, we have at our disposal a variety of affordable portable devices, featuring substantial computing power, and many sensors which allow a very wide use of AR and MR technology.

Initially, we used to make two kinds of distinction, the first being hardware/software: smartphones and tablets are ideally suited to the increasing use of AR/MR, and the major world producers of these are coming up with increasingly efficient means of putting AR/MR to use, i.e. through types of glasses. Some of these gadgets can be used by themselves since they have an integrated operative system (Google Glasses and Microsoft Hololens for example). Smartphones are on the other hand being increasingly used as computers which manage these glasses, thus allowing these devices to become more affordable, i.e. Sony, Epson, GlassUp are only a few of producers who are coming up with these solutions.

From a software point of view, the range of present applications available for mobile operative systems is widening. Some of these can be defined as 'general purpose' applications which allow us to use AR/MR with 3D images or models in various situations, Augment, Aurasma and ZappAR for example. The second kind of application is used within a specific environment or scope, for example in visiting a few well-known historical sites or catalogues (such as Ikea's).

After an in-deep study of the matter, we have found this kind of classification, though useful for a first glance at what is available, not so helpful for a better understanding of, and theoretical work on, the technology.

For this reason, we would like to propose an alternative classification of AR/MR, not making a distinction between hardware and software, but based on context and hardware-software technology as a whole. We call this a classification of AR/MR experiences. There are attempts to create taxonomies for this kind of technology, but we prefer to use the word 'classification' instead. In fact, while for some macro-categories one can easily distinguish a hierarchy (for example distinguishing between Fixed and Mobile or types of technology), for others it is hard to identify sub-categories and hierarchies that are not merely related to hardware. Therefore, we do not find ourselves in front of a taxonomic style tree like that of Darwinian evolutionary theory, but in front of an intricate bush-style diagram, more like the theory of punctuated equilibriums of Eldredge and Gould.

Within AR/MR technologies, we identify a variety of characteristics or dimensions, the combination of which delineates technologies, software and, above all, application contexts. The first dimension is the above mentioned Virtuality continuum, but not all the others are polarities of a continuum; several are part of a discrete succession:

- Portability Dimension:
  Static ←---portable ----- mobile -----→ Ubiquitous/wearable/pervasive
  Traxler (2005) made this dimension trying to classify e-Learning and m-Learning devices. This dimension is directly related to the hardware required to run a specific AR/MR appliance. An example of AR/MR fixed installations is the use of 3D mapping projectors which project layers of information and images on a real surface. They can be interactive or not. Another reason to have a fixed or a moveable device might be the need for great computing power to have a real-time rendering of a 3D scene, for example. In that case, one could use a powerful desktop or a powerful laptop, which is portable but not exactly pocket-sized. On the other polarity, we find the most common kind of AR/MR experiences involving smartphones, smart glasses and other wearables.

- Sensory range:

Range:	Visual	Auditive	Haptic	Olfactory	Gustative

AR/MR technology can add an informative computer-generated layer over one or more of our senses. Traditionally we reckon to have five senses: sight, hearing, taste, smell and touch. Each sense is enabled by a sense organ or sensor. In order to augment our senses, the AR/MR device needs a component to do that and, often, a sensor that let it acquire the same kind of information as our senses to give the right information at the right moment and in the right place. For example, one of the most common AR/MR involves the sense of sight. To add a computer-generated layer to our vision, the device needs to let us see that layer using a screen, a projector or a light emitter. At the same time, the device needs to know what we are seeing or where we are so it needs a sensor, like a camera or the GPS sensor, to give us the right information.

An example of visual AR/MR are those apps like Peak Finder that shows you through the screen of the phone or specific headsets the same panorama that you are looking at, but with all the names of the mountains around you. Pokémon Go is another example of visual AR/MR.

To have an example of an auditive AR/MR one can look at all that apps in the market which give you information through sounds or speech in relation with the place where you are or where you are heading to. Good examples are audio-guides, satnavs and soundwalks. Is it also possible to use 3D sounds thus adding the dimension of space to the sound.

Another example of an audio AR is Shazam: it is an app that can listen to the music one is hearing at, and tell you name, artist and album of that song, along with links to listen to the song.

There are other applications which use haptic feedback[18] to give us more information. It is mostly used in the fields of simulation and telesurgery, but one can find widespread uses such as the Google Maps navigator which provides you with tactile feedback while navigating in 'on foot'

[18] Haptic feedback includes tactile feedback and kinesthetic feedback, the former being what you can sense on the surface of your skin like touch, texture, pressure or vibration. The latter is given from sensors in joints, tendons and muscles and let you feel the approximate weight, size and the relative position to your body (Minamizawa et al., 2010).

mode. So, you know when to turn. Other examples are haptic clocks or an app that helps you taking level photos through haptic feedback. In regard to the other two traditional senses of smell and taste, we have some experiments and even commercial products. To enable that augmentation, it would be necessary to add a taste and smell peripheral to the device (Sardo et al., 2017). One of the latest examples is the oPhone Duo, a device connected to the smartphone that through a specific app allows one to send pictures with a primary and secondary note of scent.

All the capabilities mentioned above are directly connected to the sensors which the AR/MR device contains.

- Sensors range:

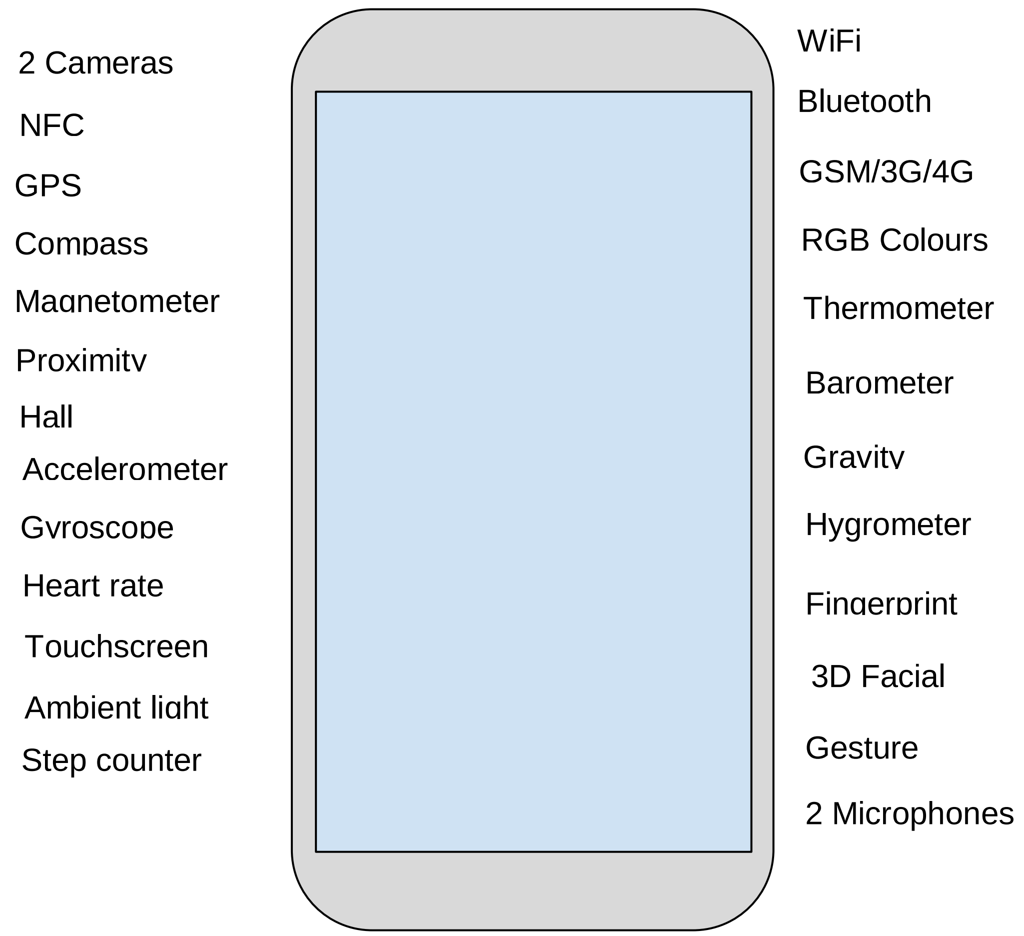

Figure 9: Sensors on a high-end smartphone.

A sensor is the electronic equivalent of a sensorial organ. To register information from reality, an electronic device needs sensors. Every sensor is a possible link with the reality. In Figure 9, one can see a list of sensors of which a modern high-end smartphone is equipped. From a combination of those sensors, the smartphone's Operating System (OS) is capable of being aware of more complex situations.

If the augmented reality needs anchors to connect the virtual world with the real one, the sensors are those anchors. Thus, the AR/MR experiences can be classified depending which sensor or cluster of sensors, the application uses. The two most commonly used are GPS[19] and the camera. The former is used in all the applications that trigger events based on your position, as an example Google Maps or the Google Assistant. The latter is adopted from the kind of apps with a vision-based AR that shows pictures or 3d models on the camera feedback. Examples include the Ikea catalogue app, the ZappAR which is used mainly for commercial communications and SnapChat's famous AR function that modifies people's faces. Pokémon GO, on the other hand, uses both of those sensors to deliver the AR experience. The GPS triggers the encounter with the Pokémon that you would be able to see through the camera.

More advanced AR framework like Apple ARKit and Google ARCore use a combination of sensors. They use camera, gyroscope and accelerometer together with machine learning algorithms to deliver the best possible AR experience.

A possible sub-division of the sensor options is the type of anchor, or marker that the AR/MR uses in order to link the real and the virtual.

We can categorise as *Location-triggered AR* all the AR experiences based on location sensors, but there is more than one possibility to achieve that:

[19] With GPS we actually mean a generic GNSS (Global Navigation Satellite System). In fact, current smartphones use not just the U.S. Navstar Global Positioning System (GPS), but also the Russian Global Navigation Satellite System (GLONASS), the Chinese BeiDou Navigation Satellite System (BDS), the Japanese Quasi-Zenith Satellite System (QZSS) - which is technically a regional satellite navigation system which augment the performance of the GPS in Asia and Oceania - and the European Galileo GNSS.

- GNSS based: this system uses as the link the location data provided from the GNSS sensor (mainly Latitude, Longitude and Altitude).
- A-GPS based: A-GPS stands for Assisted GPS, and it relies on more than one sensor to improve the accuracy of the GNSS location. It cross-references the data from GNSS sensor, cellular network when available (GSM/UMTS/LTE), visible Wi-Fi networks and, where available, barometer - used to give an approximate altitude - to provide quicker and more accurate GNSS position. This is the most common locative system for outdoor AR.
- Location services based: data from above-mentioned sensors, notably triangulating WiFi network signals, can also give an approximate position in the absence of a GNSS sensor or / in indoor situations.

A second category is *Proximity-triggered AR*, that is a technique based on sensors that need an electronic tag which they can recognise:

- Bluetooth Beacons based: this technology delivers a very accurate position system based on Bluetooth beacons, which are little devices that emits a Bluetooth wireless signal and need a power supply. They are used mainly in indoor settings where the GNSS signal cannot be received. Its maximum range is about 70 metres for regular beacons and 450 metres for long-range beacons.
- Near Field Communication (NFC) based: this is the same wireless technology used for Apple, Google and Samsung Pay contact-less platforms. Although it uses a specific NFC sensor, in AR experiences it can be used more or less like a more sophisticated and reliable QR (Quick response) Code (Miglino et al., 2014). To use it, it is sufficient to bring the device close to the NFC tag, which is a very thin and inexpensive piece of circuitry. Since it uses the principle of electromagnetic induction, the tag doesn't need a power source. NFC will also recognise other NFC sensors. The range of the most common sensors is usually less than 20 cm.

Finally, we can categorise as *Vision-triggered AR* all the experiences where one has to point the camera sensor towards the surrounding environment to trigger an augmentation of it. Here, too, there is more than one approach:

- QR Code-based: this approach uses the camera sensor with software capable of reading and decode QR codes, which are bi-dimensional barcodes. They contain data embedded and, usually, a link to a webpage, a web app or a smartphone function. They are common in both outdoor and indoor experiences to deliver highly contextualised information. E.g. in the QuizerRo experience they are used for location-based games to trigger riddles and other content that will bring the user to the next stop-over (Erenli, 2013)
- Marker-based: this is the most used type of vision-triggered AR. It is based on a so-called fiduciary marker, that is a picture or a pattern already stored in the system. The computer vision algorithm looks for that same marker in the camera feedback and, when it finds it, the AR is triggered.
- Marker-less: this is the rarest kind of AR technology because it requires the computer vision to recognise unknown features following models and categories rather than a well-known marker. This approach is however becoming more common lately thanks to machine learning and artificial intelligence (Zhou et al., 2008).

- The 'Virtual' Dimension:

  I have already addressed this kind of classification in the introduction to this chapter since it is the most used and generally accepted amongst the scientific community. I will use it as one of the dimensions of our classification, but, since I use the mixed reality concept, here I will be more specific and pinpoint significant kinds of MR in the continuum. In particular, I found two different and conventional ways of implementing AR: direct and indirect (Wither et al., 2011). Those techniques refer to a visual AR, but the same principle could be used for an auditive AR. In direct AR, the reality is captured and augmented in real-time from the smartphone sensors. As an example, applications like Ikea's and Aurasma use direct AR because they add a computer-generated layer on the real-time feed from the camera. On the other hand, indirect AR does not use real-time feed but information that has been previously stored in the correct format inside the device. Most of the open air AR/MR applications use that technique. It provides a series of technical advantages in respect of alignment issues, and, in particular, because of the difficulties in linking the virtual layer with the real one in contexts on which there is no control over contrast and light conditions (Wither et al., 2011). Other sensors like GPS, gyroscope and accelerometer link the indirect AR to reality.

We may say that indirect AR, from the user-experience point of view, is very similar to a traditional AR experience, but, from a technical point of view, is a space that is more virtual than real. For this reason, we see it as one of the most typical examples of MR.

This classification will be used in the literature review to analyse all the different experiences of Mixed Reality Mobile Learning (MRML) for Cultural Heritage Education. In the following chapter, we will address Mobile Learning (m-learning) and its different dimension in order to come up with a comprehensive classification of the whole MRML experience.

3.3 Mobile learning and Mixed Reality Mobile Learning

In the history of the educational use of technology, one has sometimes been convinced that this method improves the teaching-learning process. However recent in-depth studies based on hundreds of tests in the past 20 years (Hattie, 2009; Tamim, 2011) appear to demonstrate that technology in itself does not guarantee a significant improvement (Rushby & Seabrook, 2008). In fact, they seem to have a neutral or average impact and, in some instances, even negative effects due to overloading of the cognitive process, a problem underlined by Cognitive Load Theory (Sweller et al., 1998). All the research papers point to the fact that the most important measure of success in the use of technology in teaching is the choice of adequate methodologies appropriate to the context in which they are to be used (Kirschner et al., 2006; Calvani, 2014). From this point of view, mobile devices like smartphones are considered more disruptive than traditional devices used in school (i.e. computers, smartboards, etc.) principally because they are constantly in the students' possession in informal daily-life contexts. The teaching strategies which include the use of mobile devices have to take into account the setting of such a complex and cross-contextual learning experience.

Mobile Learning (m-learning) began in the eighties when portable computers (the 'in-thing' in those days) were first introduced into the classroom on an experimental basis (Kukulska-Hulme et al., 2008). It took off only in the late 1990s thanks to specific experimental educational programs aimed at exploring the didactical potential of PDAs (Personal Digital Assistant). From the mid-nineties to the present, we can pinpoint different phases revolving around three different focuses: tools, out-of-classroom learning, and student mobility (Sharples, 2006). The first phase is characterised by the search for the right tools or rather those best suited to the educational environment, to the learning and teaching processes, with a view to affordances[20]. E-books, learning aids and digital notepads were at the heart of this search, along with data logging and learning object software (Ranieri & Pieri, 2014).

The second phase focused on out-of-classroom learning, and extensive research was carried out on mobile devices which could be used on school trips and visits to museums. In this phase, the technology was still in an embryonic state and imposed considerable limitations on this line of approach (Kukulska-Hulme et al., 2008).

[20] The concept of affordance is of great importance in the field of educational technology (Osborne, 2014). It was coined in 1966 by the American psychologist James J. Gibson with reference to the complementarity between animals and the environment and what the environment can offer to the animal (Gibson, 1979). It was then implemented and finally applied by Donald A. Norman, American cognitive scientist, in the field of the human–machine interaction, in 1988. His definition of affordance is therefore a property or a function of an object that can be inferred from external features like, as an example, shape, size, weight and, in general, the design (Norman, 1999). Norman, later, changed the name with a more specific one: 'perceived affordance.'

In the third (and current) phase more attention is being paid to student mobility and consequently to the learning spaces (real and virtual) and the relation between formal and informal learning environments (Coyle et al., 2007).

Thanks to the interaction between the learner, the device and the environment, the learning experience can be context-specific. In this phase, m-Learning has some very peculiar affordance which has been made possible thanks to methodological and technological development. Pouezevara & Strigel (2012) propose four main classes of m-learning affordance: accessibility, immediacy, individualisation and intelligence. The first one is comprehensive of all the affordances that allow one to access learning opportunities, reference materials as well as experts, mentors and other learners. The second one includes on-demand learning, real-time communications, real-time data sharing and situated learning. In the individualisation, or, better, personalisation (the latter emphasising learner-centredness), makes it possible to use your own device or a familiar one and promotes active learning. ‘Bite-sized learning’ has a prominent role in this process because it is a concept that refers to tiny and highly contextualised pieces of information, provided at the precise moment when you need them to understand and not necessarily in a specific order. That also fits well with short timings that the informal learning requires (Omer, 2015). The last class is intelligence, that includes all those advanced features related to context-awareness, data capture and multimedia capabilities.

The third phase of m-Learning, even in regards to the abbreviation form, comes from e-Learning and one can recognise it by looking at those classes. They are partly the same as e-learning, but they also have some unique characteristics. While accessibility and personalisation are also under the e-Learning umbrella, everything related to concepts described as spontaneous, situated, portable, context-aware, lightweight, informal, personal and bite-sized are only part of m-Learning (Traxler, 2005).

Teaching strategies which include the use of mobile devices must take into account the context of such a complex learning experience which crosses the borders of formal and informal.

3.3.1 Mixed Reality Mobile Learning (MRML)

The research on the didactic potential of AR and MR is increasingly focused on the latter aspects as one of the main developments of the Mobile Learning third phase (Ranieri & Pieri, 2014). Multimedia augmented m-learning was an intermediate phase on the way to the current MRML. This deserves mentioning because of the challenges that were addressed during this transformation: mobile devices, networking, content heterogeneity, delivery and user requirement issues (Yousafzai et al., 2016). If some of them remain crucial, others have been significantly downsized, in particular, on the technological side. Mobile device issues like small screens, display resolution, codecs, OSs heterogeneity and limited memory have been addressed quite efficiently. Also, networking issues have been significantly diminished thanks to 4G, 4.5G and soon 5G networks. We are now at the next step, where the multimedia augmented m-learning become augmented and mixed reality m-learning. Therefore, we need to ask what benefit could come from this transition. The principal characteristic of m-learning is that it allows a situated learning experience (Wenger & Lave, 1991) mediated from a specific technology. The reference is Vygotsky's theory, which maintains that man becomes familiar with the world he lives in through tools and artefacts which remarkably extend the Zone of Proximal Development (ZPD). ZPD being

> *'the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers'* (Vygotsky, 1978, p. 86).

Thanks to these tools, man is not only able to achieve a quantitative boost of his development and work in terms of efficiency and speed, but also to control and organise his behaviour. In fact, the reality which we re-interpret through a continual process of attribution and through the tools which mediate our relationship with reality change proportionally to the quality of the interaction given by the affordance of the tool itself In successive studies, there emerged two further requirements in the situated learning: the need for sorting processes (Latour, 1999) and in particular for managing your own learning in spatial and temporal dimensions (Munnerley, 2012).

The term Augmented Reality is somehow misleading, in fact, it is not the actual reality, but the perception that we have of it that is augmented (Hugues et al., 2011). Perception is almost never purposeless; it is oriented, at a conscious or unconscious level to an action (Auvray & Fuchs, 2007). Through AR one can increase the quantity of information perceived, but, most importantly, it can deliver information more effectively. At the same time, one can have a better mattery of actions related to real events (Hugues et al., 2011). Similarly, to Vygotsky, Auvray & Fuchs (2007) affirm that using a new tool modify our relationship with the environment and thus our perception. New tools can modify our 'preceptory space' in a process aimed at achieving 'target action' more efficiently (Bergson, 2013). Being perception oriented, MRML calls for different teaching where one is invited to learn in view of, and through, actions.

This allows us to understand that the move from m-learning to MRML involve an increase in quality as well (Figure 10).

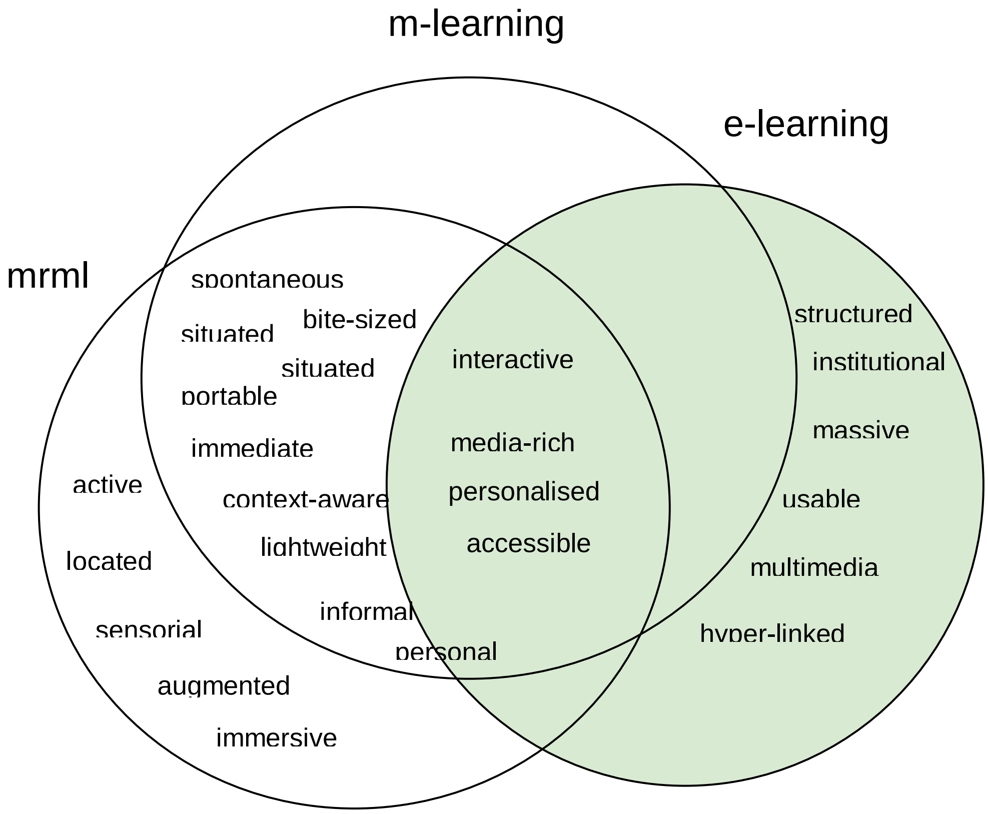

Figure 10: Evolution of the diagram of Traxler (2005) with MRML.

AR/MR applications can support new learning paradigms (Chen & Wang, 2008) filling the gap between the theory and practice using constructive activities. It is for this reason that the choice of setting and teacher's role is so important: the experiences with MRML can certainly be used within a traditional teaching setting in the classroom for example, but in this way, they would lose much of their great potential (Auld & Johnson, 2015). This is the difference between the didactical innovation and a mere technology upgrade. For example, it is critical to discern between tablet learning and m-learning. The former is a sort of e-learning which one can also use on a tablet. This is just a technological upgrade to the e-learning. The latter has both technological and methodological innovation and it is a new kind of e-learning that can be done in mobility.

It is necessary to come up with a new curriculum to allow the student to integrate informal learning through MRML technology and which experiments outside the school context with informal learning processes. Teachers need to encourage these instances of meaningful learning (Jonassen, 2008) providing students with a conceptual means of judging their MRML experiences within the prospect of self-regulated learning and lifelong learning. These examples of informal learning are not distinct elements from the social but an integral part of them because of the social and active way of constructing knowledge (Engeström et al., 1999; Sharples, 2014; Ranieri & Pieri, 2014).

There are in fact many experimentations to create an augmented environment for active learning that could also be derived from school (Zimmermann, 2013; Perez et al., 2014; Miglino et al., 2014).

Pouezevara and Strigel (2012) carried on research about mobile learning used to increase numeracy skills. They classified twenty-three projects using a model that they called 'Variations on Mobile Learning Configurations'. The same model has subsequently been used by Roberts et al. (2015) for research on nearly four thousand tenth grade students in South Africa. This model works in three dimensions with two polarities each: learning context (from formal to informal), kinetic context (from stationary to mobile) and collaborative context (from individual to collaborative). We will use the same system (Figure 11), adding more specifications for each dimension. We have also chosen to rename 'contexts' in dimensions because we see those three dimensions as the learning context. We will also use alongside this model the concept of setting; it could be indoor or outdoor and in many different environments with different peculiarities. As the setting changes environmental variables like space, freedom of movement, freedom of sight, temperature, light, people and sounds also change.

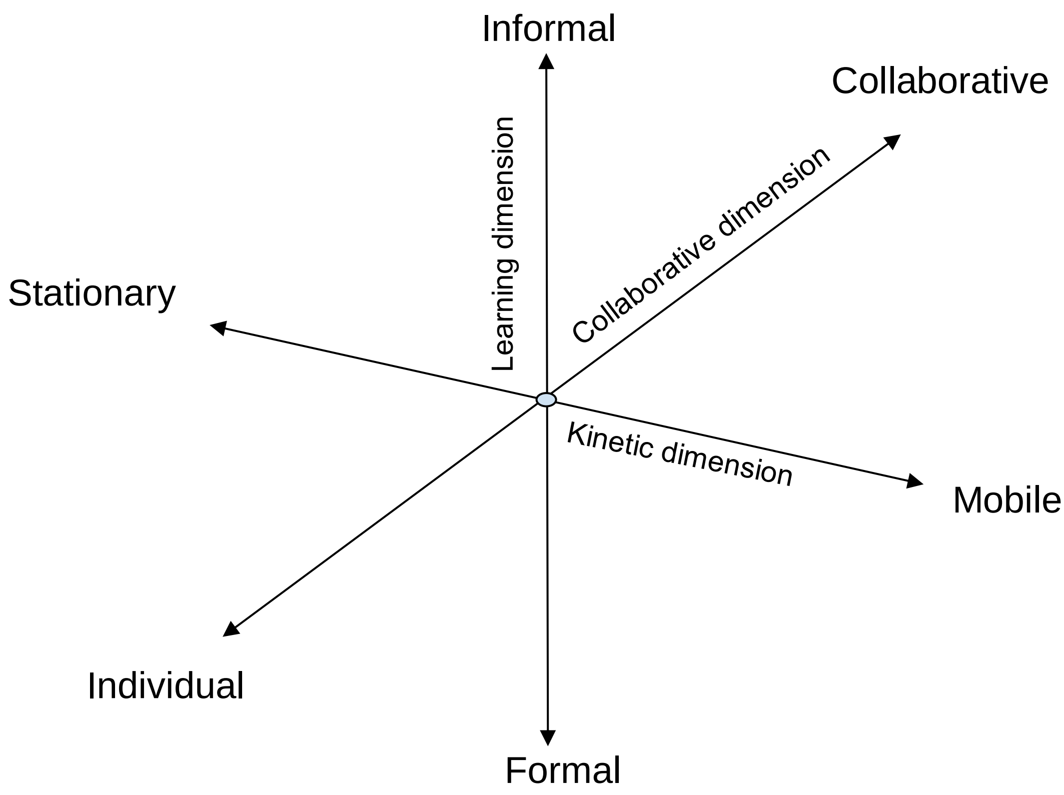

Figure 11: an adaptation of the Pouezevara & Strigel's (2012) mobile learning configurations model.

- Learning dimension:
  Formal --------- Non-Formal --------- Informal

- Kinetic dimension:
  Stationary ----------------------------- Mobile
  + CoEV -------------------------------- - CoEV
  CoEV (Control Over Environmental Variables)

- Collaborative dimension:
  Individual ------------------------------ Collaborative

- Setting:
  Indoor ----------------------------------- Outdoor
  (Lab) -- (Classroom) -- (Museum) -- (Open-air)
  + CoEV -------------------------------- - CoEV

  Every AR/MR experience is developed to take place in a specific setting and context. The combination of setting and context lead to a situation where one can have more or less control over all the environmental variables (CoEV). That means that the teaching/learning methodology, the technology and, generally, the experience proposed changes considerably depending on where we are on the above-mentioned dimensions.

Chapter 3

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CHAPTER 4
Outdoor MR and AR mobile Technology and Heritage Education

With this chapter, the dissertation brings to the fore the added value of interconnecting heritage studies with disciplines such as psychology, cognitive science and didactic philosophy. Technology will play here the role of a binding agent between different disciplines and more importantly between the different contexts in witch learning processes take place.

Looking back at the last fifteen years one can name several examples of software which use Virtual Reality to explore and reproduce artefacts and ancient sites which in modern times present themselves in a totally different form or which are today totally inexistent. Some of earliest, which are discussed later in this chapter, may be listed here: the Virtual Hagia Sophia (Foni et al., 2002), Virtual Campeche (Zara et al., 2004), the Ancient Malacca Project (Sunar et al., 2008), Virtual Pompeii (Jacobson & Vadnal, 2005) and the Virtual Prior Park reconstruction in Bath (Tredinnick & Harney, 2009). This kind of software bears in mind specific aims (Noh et al., 2009):

- to document constructions of an historical object in order to reconstruct them in case of destruction.
- to create resources for the promotion of cultural and historical studies.
- to reconstruct historical monuments or parts which no longer exist.
- to visualize scenes from difficult or practically impossible angles.
- to interact with objects without the risk of damage.
- to promote tourism and virtual exhibitions.

Today virtual reproductions of historical sites are available based on software such as Open Virtual Worlds which allow the creation of environments that permit a virtual interaction with other users and interesting educational outcomes, for example the virtual reconstruction of St. Andrew's Cathedral in Scotland (Kennedy et al., 2013). In the first decade of the new millenium we have not had the same quantity of examples as far as mobile AR and MR for cultural heritage is concerned. However, as mentioned previously, there have been great advances in this field in recent years. This software has similar aims as that which uses virtual reality, but its use is best seen in educational and didactic situations because of the affordance aspect of AR/MR mentioned beforehand. Let us now move on to examine some particularly significant examples. Archeoguide was one of the most ambitious projects in this field (Gleue & Dähne, 2001; Vlahakis et al., 2002). This used to be a client-server application. The server aspect contained a series of information on three-dimensional sites and models linked to a specific geographical place. The client aspect was made up of a laptop along with a specific software installation, a GPS, a head mounted display with a specially mounted camera in front. Thanks to the GPS data the client could download this contextual information including the 3D models. These models featured the structures as they would have appeared soon after completion and could be accurately placed on real life images taken by a camera which, combined to AR, could then be presented to the user by means of the head mounted display. This portable system, which seems cumbersome today (Figure 12), was necessary because, in 2001, devices such as present smartphones endowed with the necessary calculation potential, were non-existent. Its total weight was from 6,8 to 7,3 kilograms depending on the type of display (Table 3).

With a slightly lighter set of hardware, to carry in a backpack as well, Dow et al. (2005) created the mixed reality tour 'The Voices of Oakland'. It was designed to

Figure 12: The Archeoguide equipment (Gleue & Dähne, 2001, p. 167)

Table 3: Weight of the components (Gleue & Dähne, 2001, p. 167)

Main module	
Component	**Weight [g]**
Computer (without batteries)	3500
WLAN Interface	70
(D)GPS Receiver	220
Batteries	840
Backpack (incl. cables, adaptors, etc.)	1500
Total weight	**6,130**
Display unit I	
Component	**Weight [g]**
HMD (incl. controller)	440
Camera (incl. PCMCIA adaptor)	200
Compass (incl. HMD attachment)	100
Batteries	420
Total weight	**1,160**
Display unit II	
Component	**Weight [g]**
HMD (incl. controller and camera)	580
Camera (included in HMD)	-
Battery	90
Total weight	**670**

let visitors discover the histories of the Oakland Cemetery and of the people that have been buried there. There are many stories coming to life since the park is connected with centuries of history and especially with the American Civil War. This mixed reality is not visual but auditive, which means that the perception of being augmented is not the sight but the hearing. As a unique case in all the review, it uses the Wizard of Oz (WOz) technique to deliver the experience, which consists in a human operator acting behind a system that is believed to be autonomous (Hanington & Martin, 2012, p. 204).

The first educational experience we have found, which respects our filters of outdoor mobile AR/MR heritage experience, have been conceived in 2006 by Correa, Ibáñez and Jiménez (2006) with the name 'Lurquest'. In this project high school students had two introductory lessons before the visit. During the visit they used PDA devices equipped with GPS in order to collect data about the site of Santa Maria la Real de Zarautz, in the Basque Country. Results of this experience with 52 students seems to confirm the validity of this teaching methodology and technology used to promote high motivation to learn, learning autonomy as well as students and teachers satisfaction. The second one took place in 2007 thanks to Squire & Klopfer (2007) and it was aimed to K12 students. It used Pocket PC with embedded touchscreen and GPS sensor which is essentially comparable in weight with current smartphones, although the screen is very small and to be precise one need to use a little pen. In this learning experience, children had the opportunity to survey their environment for the presence of toxins in the water with the aid of a map[21], contextualised informations and instructions. The experience was not individual but required a collaboration between children that covered different roles. The third experience was held in the Carnuntum archaeological site (Austria) in 2007 by Lohr & Wallinger (2008) under the name of project 'Collage'. As the project Lurquest, it used PDAs equipped with GPS to augment an out-of-classroom activity for secondary school students and it has the same collaborative and role-play elements. The tasks that pupils had to complete relate with school subjects like Latin, History and Physics. One peculiar characteristic of this project is that teachers were watching while monitoring and communicating with the students through the devices. During the activity 12 PDAs for the students and 1 laptop for the teachers have been used. They had 33 participants one device was used every three pupils. Experts were interviewed, and they remarked engagement and collaboration in the teams, the pedagogical significance of that kind of game-based learning and the power of PDA as a mediation tool (Lohr & Wallinger, 2008).

These are the only three projects selected for this review in the first decade of the 21st Century. There have been others, but these are in the small number of those that have been tested in a proper user experience. Of course, other similar projects were devised, like Augmented Reality in Cultural Heritage (ARICH)

[21] As we will prove in the following chapters, maps have always been very important, and sometimes central, parts of AR mobile apps. Usually, they would show your position as well as points of interest around you. The map is usually alternative (or, sometimes, parallel) to a menu system and provides more contextualised information. For example, to access information of a monument from a map that also shows you posiion, carries more information and meaning than selecting the same monument from a list.

project (Mourkoussis et al., 2002), the project PRISMA (Fritz et al., 2005) which started with the aim of *‘design, develop and implement a new 3D visualisation device based on AR technologies’* (Fritz et al., 2005, p. 2) and ‘Ancient Pompeii’ project (Papagiannakis et al., 2005). Because of the early stage of the technology they all had to face the problem of reduced portability and inadequate mobile operating systems and hardware. For the same reason, most of them were aimed at the technical side of the research more than at heritage education and interpretation. Another issue with such research is that, because of the equipment involved, it was hard to have experiences with many testers, or testers different than the researchers at all.

4.1 AR and MR projects in the last eight years

Once we move a step in the current decade of the 21st Century, the number of outdoor MR/AR experiences for heritage education grows dramatically. We have reviewed nineteen of them applying the usual filter that narrows the field to those documented in a research and that have actually had an experimentation with users. These experiences rely in most cases on the affordances of the new smartphones and tablets: many sensors embedded, new operating systems, powerful CPUs (Central Processing Unit) and GPUs (Graphic Processing Unit), more storage and working memory, bigger screens, easy interaction through the touchscreen and high-resolution cameras. Narrowing the review simply at the level of strictly educational experiences, or, in other words, the experiences that have the heritage education as the first aim, we’ve found ten projects, of which, eight had students as the target audience and two the general public. Just three of them have been created by technical sciences researchers (Angelopoulou et al., 2011; Erenli, 2013; Chang et al., 2015), while the others come from psychopedagogical field. On the other hand, if one does not consider just the education aimed projects, overall, technology researchers have created alone half the experiences (in a selection where every project is about heritage education and have been tested in a heritage education experience). We see that as very significative about the not often well coordinated effort of technology and education experts to deliver respectively new technological and new methodological tools.

On the subjects of tools, in the last decade, all the education-oriented experiences rely on smartphones and/or tablets with few of them using also VR headsets. In fact, the advent of smartphones, with the iPhone as the precursor, and tablets, again, with an Apple product, the iPad, as the pioneer, disrupted the market of educational technologies. With every other producer copying those two models, in few years we had the marked saturated from those devices which now are very affordable even for educational contexts (Sarwar & Soomro, 2013). Analysing the context dimensions, one can notice that three experiences have been formal, four non-formal, one informal and one both formal and non-formal. This data shows on the one hand that those technologies are inherently cross-contextual, while, on the other hand, it is difficult to develop experiences for a true informal learning. This is not necessarily a downside, since formal and non-formal learning often result in a collaborative and shared experience, while informal learning is often an individual one. This is because it is needed a very complex system to bring informal and casual learning in the frame of a collaborative work. Most of the times, the collaborative work requires to have staff to direct and organise people in the context, shifting the experience to a non-formal one.

All these are some of the experiences that have inspired us, as they have fascinating and innovative elements in their design. One of the project more in tune with our principles is the one of Chang et al. (2015) on the Sense of Place (SOP). With SOP the authors intend the combination of feelings of attachment, dependence, concern, identity, and belonging that people develop regarding a place. Their study are based on the synergy between the framework of the Human - Computer – Context - Interaction (HCCI) (Greeno, Collins, & Resnick, 1996) and the strategy of Historical - Geo - Context - Embedded - Visiting (HGCEV) to conduct the visitor to reach the higher level of SOP through the following steps which are all included in the app design and content: to find out the past geographical and historical information about the heritage site; to establish its geographical and historical context; when visitors visit the heritage site, the context allows them to feel interested in and interact with the heritage site, and further to establish the interaction among visitors, the heritage site itself, and the geographical and historical context of the heritage site. A second exciting experience is the one by Smørdal, Liestøl and Erstad (2016) because of the kind of MR that they use, which is indirect (Wither et al., 2011) and based on a situated simulation approach. That is an on-site augmented reality showing how it was the place in the past, how it would be in the future or how it could have been in an alternate reality give certain conditions (like the global warming). They involved a 9th year science class in an experience divided into two hours of classroom preparation on the topic of the climate change, one hour and a half of situated simulation (field trip), two hours work and construction of knowledge after the field trip and finally one hour of presentations in the classroom (five to ten minutes per group). The situated simulation represented the place of the Oslo Opera House and surroundings in the year 2222, in a possible future where the climatic changes raised the level of the water more than 2 metres higher than today. The simulation provided also links to information and material as well as clues of what could have happened. Results of this experience underline how powerful the method of the situated simulation is for a situated learning and experiential knowledge: students were able to make relevant connections between different school disciplines and to use external sources to implement that knowledge. Also, they have been able ponder causes and effects providing likely and original ideas about what have created that situation (Smørdal et al., 2016).

4.2 Other AR/MR Outdoor Heritage Apps

In this section we will present other notable apps which are in the same line of the reviewed projects and are thought for a completely informal context. They are or were available for download on the various app stores and have been used, some more, some less, from the general public. There is not research data for them, nonetheless they are expression of the same wave of interest and enthusiasm for the use of AR and MR technology for the education and interpretation of the heritage. One of the most interesting was developed in the year 2011, presented from the Region of Apulia and available for Android and iOS under the name of 'Puglia Reality+'. This application relies on operative systems, sensors and the power of the new smartphones to provide an AR experience at various levels. Visiting various cities in Apulia you have at your disposal an AR which taking advantage of the smartphone's camera and GPS manages to place virtual labels on real images in an AR visible on screen. The labels are interactive and when selected can provide photographs and information on the monument or the structure selected. If you visit one of the archeological sites where this option is available, the application is able to superimpose 3D models on the real things which allows the visitors to see the structure as it was originally intended thus giving him a tour of the mixed reality presented to him on the screen. A very similar app is iTTP which guides you along the touristic routes in Turin and surroundings, and Tuscany+, that does not support reconstructions of the past. Both of them were developed only for iOS. The Italian Ministry of the Cultural Properties, Activities and Tourism (MIBACT), in 2011, has created one of the most advanced application of this kind to date: 'i-MiBAC Voyager', developed only for iOS, it allows to see how the site of the Imperial Forums in Rome looked like in Roman times. It includes an audio guide and can be used both at home and on site. Thanks to GPS/Compass/Accelerometer sinergy, it was one of the first softwares that let you look at the environment in a heads-up attitude (**Errore. L'origine r**

iferimento non è stata trovata.), through a smartphone or a tablet as it was a window on the past (Bonacini, 2014).

The French company GMT Éditions, developed in 2014 Izzyguide 3D (de Bideran & Fraysse, 2015), which uses the same kind of technology as Puglia Reality+, but is more advanced for it allows a more interactive experience for the user and a richer media and content. From Izzyguide, they evolved the software with Poitiers 3D and Avignon 3D, applications that allow you to follow a guided tour to the respective cities, displaying the evolution of the same place through the centuries by the use of maps (without geolocation) and through mixed reality. These applications, in addition to the information accessible from the menu, allow you to view interviews with experts and listen to audio-guide style information within the virtual tour. Only the 3D Avignon application, the most advanced of the two, also incorporates small interactive games. Of the same series, there are also the apps 'Perpignan 3D' and 'Saint-Crespin-sur-Moine'.

Let's now bring another very particular example. It basically has the same functionalities of the above-mentioned apps, but it uses Epson Moverio AR glasses instead of a Smartphone. Its name is Art-Glass. Thanks to that different

Figure 13: i-MIBAC Voyager heads-up attitude use.

approach one can have the superimposition of the information and of the reconstruction directly in his field of view (FOV). Still he will be able to see through the glasses and see the real environment. It is a very immersive experience, with hands free and one use a pointer at the centre of his FOV to select contents. It works also as an audio guide with the narrator speaking to the user as well as virtual characters that could appear thanks to the AR technology. It was also used in outdoor environment for the roman archaeological site of the capitolium and the roman theatre in Brescia (Italy) and now at the James Monroe's Highlands at Charlottesville (Virginia).

There are apps that are maybe more interesting from a teacher's point of view, mainly because they are frameworks that let one develop its own AR experience, in particular, it is very easy to create scavenger hunts and other experiences involving storytelling and places. To pick two of the best, we can name FreshAiR and Huntzz. Both of them require to install their own app, which allow to use the trial that you've developed and to look at all the trails developed from other users. One cannot have one's own standalone app. FreshAiR is a very easy to use and flexible framework that has been developed after specific design principles for AR learning (Dunleavy, 2014). It allows the use of GPS to trigger events, it embeds a refined events logic[22], a map and an AR viewer in order to see the points of interest (POIs) in the landscape. It allows to use rich media elements, including 360 degrees videos. It can be use a collaborative way thanks to the creations of different roles and interaction through objects. Huntzz has not as many options, but it is a well-established platform with many heritage trails and especially developed for scavenger hunts. Both of them are available for iPhone and Android.

4.3 Summary of AR/MR Outdoor Heritage Experiences

In Table 4, the review of the Outdoor Mobile Augmented and Mixed Reality for Heritage Experiences is summarised. In this section, the word experience takes

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[22] That means one can describe conditions to trigger events with a granular logic control. E.g. one can decide to play a given sound or show information only if the user is within 5 metres from a certain position, has a given object in its inventory, and has already visited another place.

the place of the word app because now we are using the criteria we explained in Chaper 3 to list the experimentations which took place. It does not limit our view at the app, but it considers the research of which it is part, the context and the technology. It worth to be noted that only the researches with an actual experience on the field were counted. Thus, we excluded from the list all the papers of researches which just designed an app and tried it just in a lab, as well as those apps released and never tested in a scientific experimentation. Looking at this tabular summary it is interesting to note how, on twenty-five experiences, six (the highlighted ones) have as target audience primary or lower secondary schools. All the six research were developed by, or in collaboration with, education departments, except one. Five of them (counting in our Verona experience) have therefore a strong educational design and objective. Two of those experiences predates ours while the other two came subsequently. Comparing them, one can notice that two of them were run in formal setting and all of them are thought to be collaborative experiences. Our experience is between the three in non-formal context and the only one which is not primarily relying on classical collaborative mechanics but in an individual-interactive structured mechanic that we called TRI-AR, which will be accurately explained in Chapter 7. On a final note, our experience is the only one among the six using Mixed Reality and headsets.

Table 4: Outdoor Mobile Augmented and Mixed Reality for Heritage Experiences Classification Table. Only studies with user sperimentations were reviewed.

Authors	**Research**				**Context**				**Technology**					
	Main Objective	**Target audience**	**Department of research**	**Subject of publication**	**Learning Dim.**	**Collaborative Dim.**	**Kinetic Dim.**	**Setting**	**Portability Dim.**	**Virtuality Dim.**	**Sensory Range**	**Sensors Range**	**Interaction**	**Device**
Amato et al., 2013	Enhanced visit experience	General public	Information Engeneering	Mobile Computing and Multimedia	Informal	Individual	Mobile	Outdoor, monuments	Ubiquitous	Augmented Reality	Visual	GPS, RFID, Camera	Touchscreen	Smartphone
Angelopoulou et al., 2011	Educational	11 - 16 y.o. childen	Computer Science	Mobile Wireless Computing	Informal, Non-formal	Individual, Competitive, Collaborative	Mobile	Indoor, Outdoor, monuments, museum	Ubiquitous	Augmented Reality	Visual	Camera, GPS	Touchscreen	Smartphone
Boyer & Marcus, 2011	Enhanced visit experience	General public	Digital Humanities	Digital Humanities	Informal	Individual	Mobile	Outdoor, streets	Ubiquitous	Augmented Reality	Visual	GPS, Camera	Touchscreen	Smartphone
Caggianese et al., 2014	Enhanced visit experience	General public	Computer Science	Augmented and Virtual Reality	Informal	Individual	Mobile	Outdoor, buildings, monuments	Wearable	Augmented Reality	Visual	Camera, Depth sensor, GPS, Accellerometer, Magnetometer, Gyroscope	Touchscreen	Custom Headset
Cavallo et al., 2016	Enhanced visit experience	General public	Computer Science	Augmented and Mixed Rality	Informal	Individual	Mobile	Outdoor, streets, buidings	Ubiquitous	Augmented Reality	Visual	A-GPS, Gyroscope, Camera	Touchscreen	Smartphone
Chang et al., 2015	Educational	1st Year University students (~19 y.o.)	Tourism, Technology, Geography, Educational Psychology	Educational Technology	Non-Formal	Individual	Mobile	Indoor, Outdoor, buildings	Ubiquitous	Augmented Reality	Visual, Auditive	Camera	Touchscreen	Tablet
Correa et al., 2006	Educational	High school students	Education	Teaching social sciences	Informal	Collaborative	Mobile	Outdoor, archaeological site	Ubiquitous	Augmented Reality	Visual	GPS	Touchscreen	PDA
D'Auria et al., 2015	Enhanced visit experience	General public	Information Technology, Physics	Digital Information Management	Informal	Individual	Mobile	Outdoor, monuments, buidings	Ubiquitous, Wearable	Augmented Reality	Auditive	gyroscope, accelerometer, magnetometer, GPS, microphone	Touchscreen, Voice	Custom headset

Dow et al., 2005	Enhanced visit experience	General public	Computing, Literature, Communication and Culture, Interactive Media Technology	Computer Entertainement Technology	Non-Formal	Individual	Mobile	Outdoor, monuments	Mobile	Mixed Reality	Auditive	GPS, head-orientation	Controller	Custom Headset + laptop + controller
Erenli, 2013	Educational, Training	Schools, Organisations	Applied Sciences	Corporate Learning	Formal	Collaborative	Mobile	Outdoor, monuments, streets	Ubiquitous	Augmented Reality	Visual	Camera (QR Code reader), GPS	Touchscreen	Smartphone
Georgiou & Kyza, 2017	Educational	Middle and High School Students	Media, Cognition and Learning	Mobile and Contextual Learning	Formal	Collaborative	Mobile	Outdoor, natural environment	Ubiquitous	Augmented Reality	Visual	GPS	Touchscreen	Smartphone
Guimarães et al., 2015	Enhanced visit experience	General public	Art and Communication	Digital Heritage	Informal	Individual	Mobile	Outdoor, gardens	Ubiquitous	Augmented Reality	Visual	Camera	Touchscreen	Smartphone
Haugstvedt & Krogstie, 2012	Enhanced visit experience and exhibit	General public	Computer Science	Mixed and Augmented Reality	Informal	Individual	Mobile	Outdoor, streets	Ubiquitous	Augmented Reality	Visual	Camera, GPS	Touchscreen	Tablet
Kamarainen et al., 2013	Educational	Primary school (6th year)	Education	Computers and Education	Non-Formal	Collaborative	Mobile	Outdoor, monuments	Ubiquitous	Augmented Reality	Visual, Auditive	Camera, GPS	Touchscreen	Smartphone
Kang, 2013	Heritage awareness	General public	Cinematic Content	Wireless personal Communications	Informal	Individual	Mobile	Outdoor, buildings, streets	Ubiquitous	Augmented Reality	Visual	Camera, GPS	Touchscreen	Smartphone
Klopfer & Squire, 2007	Educational	K12 Students	Education	Education Tech	Formal	Collaborative	Mobile	Outdoor, monuments	Ubiquitous	Augmented Reality	Visual	GPS	Touchscreen	Pocket PC
Lee, 2012	Enhanced visit experience	General public	Human Interface Technology	Mixed and Augmented Reality	Informal	Individual	Mobile	Outdoor, streets, buildings, monuments	Ubiquitous	Augmented Reality	Visual	GPS, Compass, Accellerometer	Touchscreen	Tablet, Smartphone
Liestøl, 2014	Educational	General public	Media and Communication	Cultural Heritage	Informal	Individual	Mobile	Outdoor, monuments, streets, buildings	Ubiquitous	Mixed Reality	Visual, Auditive	GPS, Camera, Compass, Gyroscope	Touchscreen	Smartphone
Lohr & Wallinger, 2008	Educational	3rd and 7th grade school students (13 and 17 y.o.)	Educational technology	Wireless, mobile and ubiquitous technlogy in Education	Formal	Collaborative	Mobile	Outdoor, archaeological site	Ubiquitous	Augmented Reality	Visual	GPS	Keyboard	PDA

Pacheco et al., 2015	Enhanced visit experience	General public	Synthetic, Perceptive, Emotive and Cognitive Systems	Digital Heritage	Informal	Individual	Mobile	Outdoor, memorial site, buildings	Ubiquitous	Mixed Reality	Visual	GPS, Compass, Gyroscope	Touchscreen	Tablet
Petrucco & Agostini, 2016	Educational	Primary schools students (5th year)	Education	e-Learning and Knowledge society	Non-formal	Individual, Interactive (TRI-AR)	Mobile	Outdoor, monuments, streets	Ubiquitous	Mixed Reality	Visual	A-GPS, Gyroscope	Touchscreen / Virtual pointer	Smartphone, Tablet, VR Headset
Pintus et al., 2004	Educational	Schools	Education	Mobile Learning	Formal	Individual	Mobile	Outdoor, archaeological site	Ubiquitous	Augmented Reality	Visual	GPS	Touchscreen	PDA
Pombo & Marques, 2017	Educational	Primary and Secondary students (9-11 y.o. and 13-14 y.o.)	Education and Psycology	Computers in Education	Non-formal	Collaborative	Mobile	Outdoor, parks	Ubiquitous	Augmented Reality	Visual	Camera	Touchscreen	Smartphone
Smørdal et al., 2016	Educational	9th grade students	Media, Communication and Education	Technlogy, Culture and Education	Formal	Collaborative	Mobile	Outdoor, environment, buildings	Ubiquitous	Mixed Reality	Visual	GPS, Camera, Compass, Gyroscope	Touchscreen	Smartphone
Vlahakis et al., 2002	Enhanced visit experience	General Public	Computer Graphic	Computer Graphic in Art History and Archaeology	Informal	Individual	Mobile	Outdoor, monuments, archaeological sites	Mobile	Augmented Reality	Visual, Auditive	DGPS, Camera, Compass	Touchscreen	Laptop + HMD + Sensors devices / Pen Tablet

Chapter 4

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CHAPTER 5
Research Design

In this chapter, all the aspects from the selection of a research field and the review of the literature to the actual research experience and experimentation are addressed. It is mainly the formalisation of theoretical and practical processes which entail important epistemological and methodological choices. These choices should consider the context and the resources available. In subchapter 5.1 the three main questions which guided and fixed the aims of the research are presented while in subchapter 5.2 I introduce the best methodology I was able to adopt in order to answer them. Following, in subchapter 5.3, the experimental design for both Verona and Hestercombe experiences is displayed. The latter required further adjustments due to its particular situation and the type of classes actually made available. After specifying the data collection methods that were used in section 5.4, the steps that were implemented are explained. Finally, in subchapter 5.6, the limitations of the research are pointed out.

5.1 Research questions

Taking interest in a specific science or knowledge inevitably raises questions. In educational sciences, questions are often born from the everyday practice of teaching and from the problems that one encounters in the attempt. Technological tools are flexible, powerful and ubiquitous, and that is why they often kindle the interest of skilled teacher and education practitioners. In its raw form, a question starts with a “what if” aimed at solving immediate teaching problems applying a specific tool and strategy to a specific situation. In the following paragraphs we refined those questions and explained how and why they took shape. Nevertheless, in the research process, especially when an experimentation took place for the first time, it is it is important to acknowledge that unexpected elements can arise. That is why, sometimes, it is better to remain open and ready to gather and consider data which fall outside the refined specific question, but are included in a generic “what if” question. This is what we tried to do designing this research.

5.1.1 Question 1

Can the use of mobile mixed reality technology for outdoor cultural heritage education, along with an adapted teaching methodology, support the learning and interpretation processes better than traditional tools? How effective is it from the point of view of interaction, understanding and memory/retention?

Mixed reality technologies, starting with virtual reality and then with augmented reality, have always been perceived as potentially very powerful in the field of education and training thanks to their ability to simulate and augment reality while giving help and information to the learner, enabling an experiential learning (Psotka, 1995; Andolsek, 1995; Hughes et al., 2005; Lee, 2012). At the same time, it has always been difficult to test in breadth the impact of this technology in education because it was costly and not easy to obtain. As extensively explained in Chapter 3, this technology is at last affordable and easily reachable. In Chapter 1 we discovered that European and national institutions are looking to the use of new technologies as a means of fostering awareness and knowledge of cultural heritage. This is important because it will create a heritage economy and a sense of belonging in the local community and the broader European community. In Chapter 4, all the efforts made by researchers in technology and education have been reviewed to understand if and how mobile MR can be applied to education and interpretation of cultural heritage, in particular, to outdoor heritage. This is a new challenge as the conditions inside museums and other indoor contexts in closed environments (with no variations of light notably) can easily be controlled, which is rarely the case outside. The trail, furniture, plaques, position of artefacts, lighting, temperature are just some of those variables that can be managed and adjusted indoors.

I would like to understand how the technology, along with a correct methodology, can be used for outdoor heritage education. Heritage lends itself to interdisciplinarity hence the intervention will concern various school's subjects at once. It will be necessary and challenging to toe the line of school curricula. I would like to understand not just whether the experience is enjoyed and why, but, also, if it is effective on the level of awareness, knowledge and recall of information.

5.1.2 Question 2

What are the changes between the "classic" visit, with a booklet as mediating tool, and the augmented visit, with a smartphone as mediating tool? How does the relationship between student - technology - guide – heritage get modified?

The use of a tool rather than another affects the cognitive processes that are activated and the relationship with the environment (Vygotsky, 1978; Kaplan, 2017; Tomkins & Messick, 1963; Maslow, 1966)[23].

> *"I suppose it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail." (Maslow, 1966, p. 12)*

This concept from Abraham H. Maslow is often referred to as 'Maslow's Hammer', but the American psychologist was not the first to express it. In fact, the American philosopher Abraham Kaplan expressed this concept in 1964 giving it the name 'the law of the instrument':

> *"I call it the law of the instrument, and it may be formulated as follows: Give a small boy a hammer, and he will find that everything he encounters needs pounding." (Kaplan, 1964, p. 28)*

In Chapter 2, 3 and 4, based essentially on the work of Vygotsky, and then Leont'ev's, Engstrom's and Jonassen's, the relations between the subject (learner), the mediating tool (technology) and the object (learning outcome, heritage) were analysed. It was assumed that using mobile devices and MR apps, which have different affordances than traditional tools like booklets, will change the learning and cognitive processes as well as the relationship between subject and tool, subject and object, and object with the tool. We will analyse these relations while gathering quantitative and qualitative data from both the case studies and following the Activity Theory framework.

5.1.3 Question 3

Is such technology and methodology transferable to other cultural contexts and heritage?

The issue of the use of ICT for Heritage Education is a European and possibly global priority. That is why I would like to test out the technology and methodology not just within

[23] Each one of them supports the thesis that the tool is not neutral. It substantially influences the way of thinking and acting. The following 'hammer' example is iconic and used in different situation from each one of them (except Vygotsky) to exemplify this concept.

an Italian context, but also with a different kind of cultural heritage. It would be important for the research to have consistent results in both the study cases, because that would indicate the possibility of a format for outdoor heritage education with mobile MR technology. It would also be interesting to understand if the type of heritage can affect the effectiveness of the MR technology as a mediator.

5.2 Research Plan: strategy and methodology

In order to answer these three questions, we need to adopt different research strategies and methods. To answer Question 1, we need a quantitative approach since we wish to grade the reception and the effectiveness of the experience. Typical quantitative data is represented by numbers, measurements and statistics. For example, in the case of the first question, we will gather grades and will make statistics on them.

To answer Question 2, adding a qualitative approach is desirable since relationships and processes must be analysed. We need to tell and describe how they are. Moreover, we do not actually know what to expect since a similar experimentation on primary classes has never been done. We must be open to discovery, in a more grounded approach (Larkin, 2010). Typical qualitative data are descriptions, interviews, answers to open questions.

Question 3 would require a comparison of the experiences and both qualitative and quantitative data gathered in Italy and England. This approach is called a mixed method, and for the above-mentioned reasons is broadly used in educational, psychological and social research (Johnson & Onwuegbuzie, 2004; Mertens, 2014). It combines in the same research qualitative and quantitative techniques, methods, approaches, concepts and language (Burke & Onwuegbuzie, 2004).

In particular, we will adopt a triangulation mixed-method design (Figure 14), which is a concurrent type of design where qualitative and quantitative data are gathered at the same time and are used together for the interpretation of the research (Creswell, 2009).

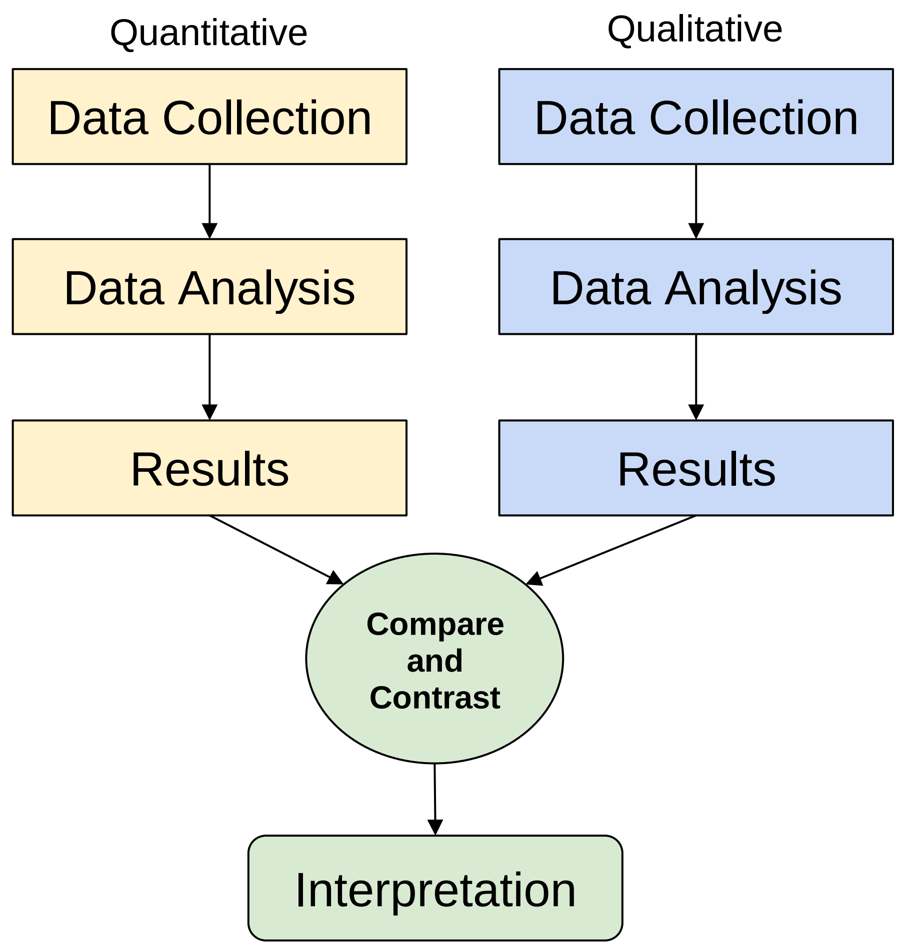

Figure 14: Congruent mixed methods adopted from Creswell (2009)

5.2.1 Research Settings

Even though settings of the visits are thoroughly described in the following chapters, a general idea of our research settings can be given here in order to contextualise better population, sampling and design.

The first case study took place in Verona (Veneto, Italy) in three different primary schools and, for the experimental part, in Verona's city centre, where ancient Roman remains are still visible and in use.

The second one took place at Hestercombe, a property near Taunton (Somerset, UK) which includes three gardens of three different epochs: a Georgian landscape garden, a Victorian terrace and an Edwardian formal garden. The visit focussed on the first of these.

In both the case studies, the class visits were led by a guide who both was an expert on the place and trained to use the AR app. The visit was kept as much as possible to the format that the guide usually adopted, with appropriate linguistic and conceptual adaptations for children when required. There were also some adjustments in timings and about the interaction with visitors to facilitate the use of the AR App, which are detailed in the following chapters. This way of proceeding was a guarantee to increase the chances of meaningful research results (Hammersley & Atkinson, 1983). Every couple of children in the experimental classes had a device (smartphone or tablet) to use the app, while the control classes used a booklet. The researcher was always present for the visits to assist with any problems with the devices and to make notes about the development of the experience.

5.2.2 Population and sampling

The subjects of this study have been classes of 5th-year primary school children, aged ten to eleven years old. The classes were selected, in Italy, in the city of Verona, from three different primary schools. The schools were chosen because they were ready to accept this research. The classes were chosen amongst the 5th primary with teachers willing to participate to the project.

5.2.2.1 Population and sampling in Verona, Italy

In quasi-experimental design, one needs experimental and control groups. The former will be exposed to the experimental factor, while the latter will not. At the end, the two results are compared. The two groups must be as homogeneous as possible in order to avoid variables that would bias the results. To comply, in our case, each experimental class had, as a control class, the so-called ‘parallel class’. Parallel classes are classes of the same year, in the same school and they share programmes and sometimes teachers. Teachers of parallel classes plan the teaching together. We hoped that selecting parallel classes as experimental and control would minimise the incidence of external variables.

There follows Table 5 with the population involved in Italy:

Table 5: classes involved in Italy.

Class	Section	School	Research	Number of pupils
5	A	Camozzini	Control	27
5	B	Camozzini	Experimental	17
5	A	Dall'Oca Bianca	Control	16
5	B	Dall'Oca Bianca	Experimental	19
5	B	Rosani	Control	16
5	A + C	Rosani	Experimental	22 + 15
			TOT	**132**

5.2.2.2 Population and sampling in Taunton, England

In Taunton (Somerset, England) it was not possible to find as many classes and schools as we found in Italy. Only two classes, in two different primary schools, accepted our invitation to take part in this research. That means that we had to think another way to make the English study case comparable to the Italian one. One also has to take into account that when the first primary class visited, the second class had not yet accepted the invitation to participate. For that reason, we decided not to have a control class, but experimental and control stopovers throughout the visit. The two English classes were nonetheless more numerous than the Italian ones (Table 6).

Table 6: classes involved in England.

Class	School	Research	Number of Pupils
5	Bishops Hull	Experimental and Control	28
5	Blackbrook Community	Experimental and Control	34
		TOT	**62**

5.3 Research Designs

The quantitative plan of research was meant to have a quasi-experimental design (White & Sabarwal, 2014)[24]. This was possible in Italy, while in England we had to adopt the strategy that we mentioned above and will explain more fully in the Hestercombe Research Design sub-chapter.

5.3.1 Verona Romana Augmented Visit Research Design

In Verona, it was possible to develop the research design originally intended: a quasi-experimental design with experimental and control classes, in order to gather quantitative data to answer our questions. It was thought as follows: both experimental and control classes, being parallel classes, had the same preparation on the subject of the Roman civilisation. To better prepare the class to the visit, and to better prevent possible bias due to an uneven preparation, we organised for both experimental and control classes a lesson of two hours about the history of Romans in Verona. It was also asked the pupils to fill in a questionnaire about their proficiency in the use of mobile technology and their interest in cultural heritage. Subsequently, the experimental part was run. The experimental and the control classes were brought for a visit to the Roman remains in Verona. During the visit, they went to the same places, and the guide explained the same concepts and told the same stories. The experimental element was the mobile device and app that every child had, whereas the control class had a classically illustrated notebook. At the end of the visit, we asked for feedback on the visit and the technology as well as a short interview with teachers. A few days later we ran a follow-up test.

In parallel with the quasi-experimental plan, there was the qualitative plan, intended to help in the gathering of qualitative data, to understand what happens in such an experience at the level of relationship and processes. The first qualitative input was in the initial survey in the form of an open question. Then, during the visit, footages were filmed with a wide-lens camera and a close-up one in order to be able to explain better what happened during the visit (both experimental and control). In the feedback survey, at the end, other open questions about the visit and, for the experimental classes, about the use of the technology were proposed. Finally, a couple of days after the visit, drawings with descriptions about the thing they liked most about the visit were gathered (Figure 15).

[24] Howard White and Shagun Sabarwal, in 2014, conducted research on quasi-experimental design and methods for UNICEF and wrote a paper on the UNICEF journal 'Methodological Briefs: Impact Evaluation 8' about how to implement it.

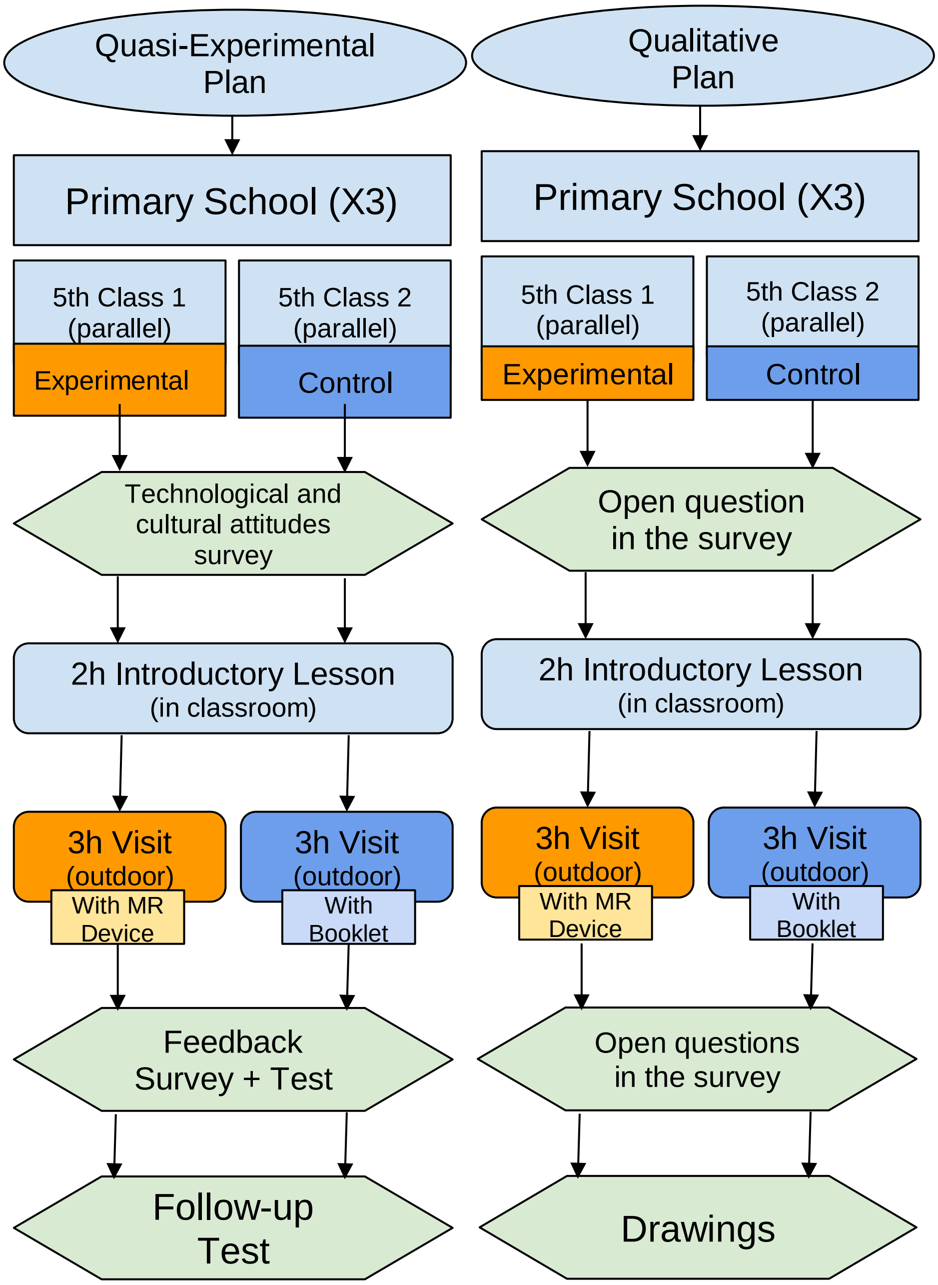

Figure 15: Roman Verona Case Study research design.

5.3.2 Hestercombe Gardens Augmented Visit Research Design

At Hestercombe, we were not able to follow the same research design we adopted in Verona for two reasons. The first is that we were only able to involve just two classes in two different schools. The second is that when we had confirmation and conducted the experiment with the first class, we were not sure of the participation of the second. Also, we had no opportunity to give a lesson at either school before the visit. The solution we found was not to have experimental and control classes, but experimental and control stopovers during the visit. With the help of Hestercombe Garden Trust expert guides, we were able to select stopovers with similar features, and we designed the visit to have four of them experimental, with the use of AR app, and four of them of control, with the usual visit explanation and printed pictures. Both the initial survey on technology and heritage and the feedback survey at the end of the visit are an adaptation of the ones we used in Verona. Of course, they were translated into English and modified for the Hestercombe context. Finally, the follow-up test was a different one because of the different content of the visit.

On the qualitative data plan, we gathered three open answers in the immediate post-visit feedback and in the follow-up test we added open questions and a drawing (Figure 16).

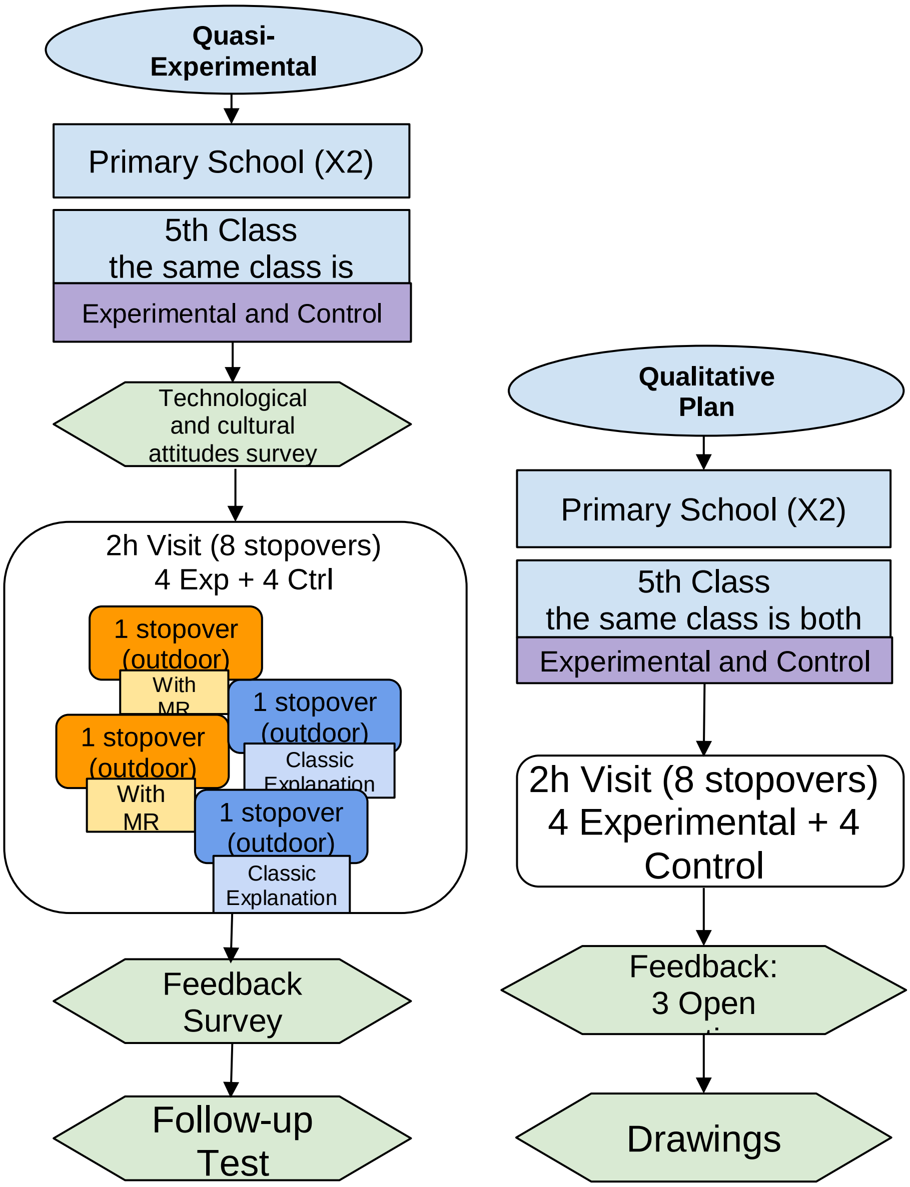

Figure 16: Hestercombe Gardens Case Study research design.

5.4 Data collection methods

Data collections methods in this research are divided into quantitative data collection methods and qualitative data collection methods. But the same survey form often contained both types of data collection.

The survey was the primary data collection method in this research. As is visible in Figure 15 and Figure 16, in both case studies there has been an initial survey and a survey after the visit. The first one was aimed at understanding the general knowledge, interest and skills in the field of technology and heritage. The latter had the objective to ask for feedback on the visit in general and the use of the AR app and devices in particular. In Verona, the first survey had an open question inside while the second had none. At Hestercombe, the second had two open questions while the first had none. In both cases, the follow-up test was done by means of a set of multiple choice and true/false questions. At Hestercombe the follow-up test also asked to make a drawing considered as qualitative data. In Verona, the drawing was requested before the follow-up test, along with a free narrative or caption. For each one of those methods, the parents of the students have given their consent for all the data to be used for research, dissemination and academic purposes. All the questionnaires and tests that have been used are contained in Appendix 1 along with an explanation of their categories and dimensions.

5.4.1 Drawings as a tool for assessment of cultural heritage understanding

With quantitative data, we were able to assess the child's satisfaction with the experience and the recalling of information and concepts about the Roman history of Verona. We were also able to compare experimental and control classes. It was not possible to tell however if there were unexpected differences in the acquisition of information and the process of internalisation between the experimental and the control group. That is why it was decided to include drawings in the tools of assessment and evaluation of the different experiences. Although it is difficult to come to a shared definition of what a drawing is, it can be defined as *an external model that involves the formation of an internal model* (Quillin & Thomas, 2015, p. es2, 2). This model is created by selecting, organising and integrating information (Mayer, 2009). In particular, children's drawings have been used in the psychological field to enable them to express things that they cannot verbalise. Only in the last few years, they have also been seen as ways in which children express their understanding of the world (Stanczak, 2007). When the drawing of children involves conceptual knowledge, it represents the student's thinking, understanding, and change, including conceptual understanding (Anderson et al., 2014). In Chapter 3 we have discussed meaningful learning and how this was the most desirable result of a didactic intervention. Johnassen et al. (2005) highlight the conceptual change that is the '*process of constructing and reorganising personal conceptual models*'. Drawing externalises conceptual models, thus we analysed it using as a basis the 'conceptual models' analysis tools proposed by Jonassen (2005) in his 'rubrics for assessing systems dynamics models' (Figure 17) where it was applicable. In fact, usually, one can create a checklist of features that, seen in a drawing, shows the internalisation of concepts; in our case, we have instead discovered in the drawings differences between experimental and control groups.

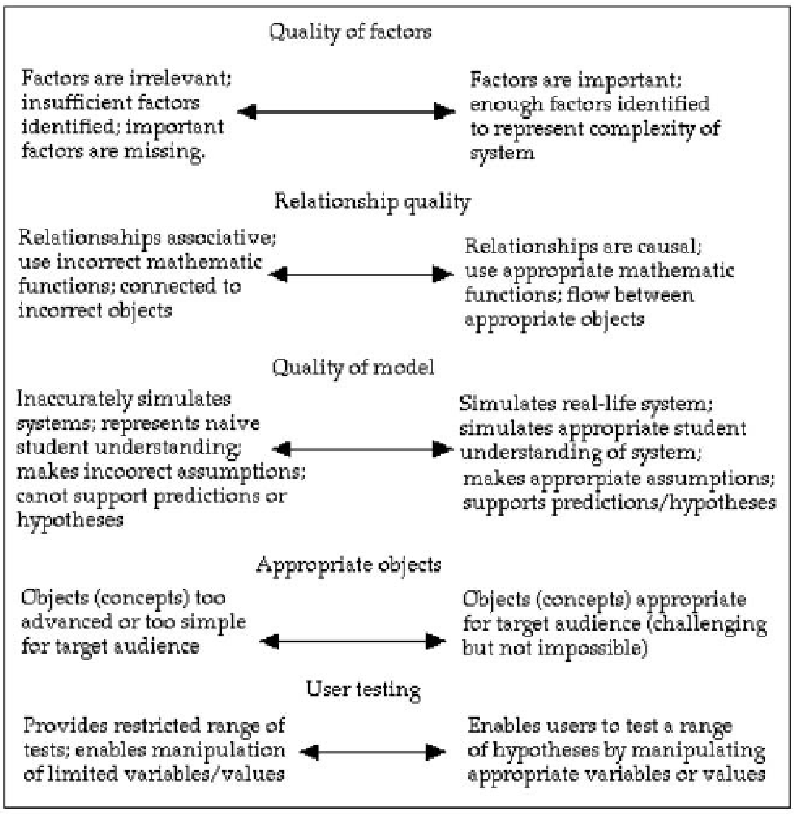

Figure 17: the rubrics for assess system dynamics models proposed by Jonassen et al. (2005). We used the basic dimensions in this model to assess and compare students' drawings.

5.5 Activity Theory Checklist

As mentioned in Chapter 1, the Kaptelinin and Nardi Activity Checklist (Kaptelinin et al., 1999; Kaptelinin & Nardi, 2009) was used throughout to analyse and interpret the context of the augmented visits in Verona and Hestercombe.

They proposed the Checklist in order to easily apply and verify the five basic principles of AT - which were already addressed in Chapter 1: Object-Orientedness, Hierarchical Structure of Activity, Internalisation and Externalisation, Mediation and Development - as perspectives to design or evaluate a 'target technology'. Also, the principle of tool mediation is at the centre of the Checklist, as it was inherently designed to analyse how people use computer technology. There are two slightly different checklist variants: the design version and the evaluation version. Since with our research, we are entering already structured systems, and our goal is to evaluate them, we are going to use the second version. The checklist works as a wide examination tool for the various areas of interest, but it also allow, once they have been individuated, to be a very in-depth analysis tool. It is supposed to be used not as the only instrument of evaluation, but together with other techniques. Furthermore, the fact that the checklist is presented linearly doesn't mean that one needs to consider each point as an individual one, ignoring the rest. All the rest of the checklist should be taken into account while working on one point (Kaptelinin et al., 1999).

5.5.1 AT Checklist sections

'Means and ends' is the first section of the checklist. It contains questions to evaluate the impact of the technology on the users regarding facilitation and constraint to reach the goal. It also considers whether the technology resolves and/or provoke conflicts between those goals. The second section is called 'Environment' and analyses how the technology integrates with all the aspects of the environment like social rules, requirements and other tools. 'Learning, Cognition and Articulation' is the third one and enquires how do internal and external components support each other and how do they get transformed to form the use of the technology are the main issues of this section. Lastly, the 'Development' section considers concepts, goals, attitudes, activities, and the environment along the development of the activity and their transformations.

5.6 Research Plan and Design Limitations

It is known that quantitative-qualitative mixed methods have pros and cons. One of the main limitations is that they usually take more time and resources, which, typically, are already limited, to be applied (Bell et al., 2018). Another one is that they should be used only from expert researchers as there are more opportunities to make mistakes (Greene & Caracelli, 1997).

Concerning the research plans of the two case studies, the one in Verona is by far the more solid because, even if we had not the opportunity to randomise the sample of the population, we have been able to have two parallel classes to do the experimental and control one for three different schools. An issue could be seen in the difference of numerosity between classes that in some cases could bias the statistic. The Hestercombe one, because of the problems encountered, uses just two classes, although quite numerous (28 and 34), and do not have control classes. The idea of having experimental and control stopovers have been good but, needing a consistent visit script the guide could follow, we have not been able to adopt the best practice of changing experimental and control stopovers in the second visit.

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PART II-

Ancient Verona and Georgian Hestercombe Augmented:

Research Methodology and Development

The following chapters present the methodological and practical development of the research. In Chapter 6 and 7, the case studies of Verona and Hestercombe are presented respectively. They are at the core of the thesis as they contain the practical experimentations of the principles and theories studied in Part 1 and constant use was made of them to answer research questions. Also, thanks to the statistical and AT analyses, I have been open to evidence of effects or outcomes that were not expected. Each study is comprehensive of a brief description of the cultural heritage involved and its visual representations during the centuries, the description of content, of the app creation and the visit. Finally, I described in detail the process of elaboration of data and feedbacks following the steps of the research design, which is based on a mixed method that uses both quantitative and qualitative approaches. In Chapter 8, some elements of the two case studies are compared. Then, all elements are gathered in order to understand the outcome of the research as well as implications, limitations and future developments.

CHAPTER 6
The Roman Verona
Augmented Visit

This study was the first of the two and the one made with the advantage of being in situ in Verona, where already existing contacts facilitated the task of finding experimental contexts. At the same time, it was the harder one in terms of the preparation of tools and technologies since it was the first time we tried to do anything comparable, everything had to be designed from scratch. That is why only in this chapter there is a detailed description of the creation of the mobile app (sub-Chapter 6.3). Preliminary thoughts on context (6.1) importantly help us understand the cultural context and the kind of sources that we have used to design the experience. Section 6.4 describes in detail the visit with the methodologies and the instruments employed. Data analysis is at the core of this dissertation, to test the effectiveness of the methodology and technology we employed. It is presented in section 6.5, while in section 6.6 the experience through the activity theory checklist is assessed. Generally, the main focus of this study is to understand how to sustain interest in students in the cultural heritage of the Roman monuments of Verona and the landscape to which they belong. During the project, experimental classes have been able to discover the transformations the territory has undergone over time using ancient and present maps, 3D models and virtual reconstructions of the ancient Verona.

6.1 Preliminary thoughts on context

Verona is a settlement existing since Neolithic times, but the foundation of the city in the current shape and position was made by the Romans in the first century BC. Since then the city has evolved to the present day without interruption. The whole city of Verona is part of the UNESCO-protected World Heritage on the basis of the following reasons:

- Criterion (II): For its urban structure and its architecture, Verona is an outstanding example of a city that has developed progressively and uninterruptedly over two thousand years, incorporating artistic elements of the highest quality of different periods that have followed;

• Criterion (IV): Verona represents in an exceptional way the concept of the fortified town in the most characteristic stages of European history.

(UNESCO World Heritage Committee, 2017)

One of the main reasons that makes Verona a unique place in northern Italy is the quantity and the quality of the remains from the Roman civilisation. In fact, in the fourteenth century, it was common in the cultured environment to refer to Verona as the ‘sister city’ of Rome or as the ‘second Rome’ (Bolla, 2015). It includes a big amphitheatre called ‘the Arena’, that probably predates the Coliseum, and nevertheless is in the better state. Then there are two Roman gates called Porta Borsari and Porta Leoni. Of the former, we have just the imperial facade in a very good state; with the latter we have half the imperial and republican facade, as well as an open-air dig that shows its ancient structure. A Roman bridge, the oldest in Verona, is still used by people to cross the river Adige, where the Roman theatre has been partially restored. Other remains include the monumental Gavi’s arch, towers, columns, statues, *Domus*, walls, streets, fountains, thermae. Everything is visible proof of an ancient past that often is just as far as few layers of bricks away and mostly disguised. The streets inside the Roman walls are mostly the same as two thousand years ago, and the chessboard of *decumani* and *cardi* is apparently visible. Strolling around the city, one can see many buildings which incorporate Roman big stones and pieces of monuments and temples as the basis or angle stones for subsequent structures (Bolla, 2015).

6.1.1 Roman Verona in the visual arts

The first document we have that visually represents Verona is also the only one of Roman times and one of two before the Renaissance. It is the siege of Verona sculpted in low relief on the Arch of Constantine in Rome (AD 315). The second one is the Raterian iconography which is a painted scroll made in the tenth century by Raterio, a bishop of Verona and discovered in the Benedictine abbey of Lobbes, in Belgium. The scroll was destroyed in the wake of the French Revolution, in 1793. Nowadays we have reproductions of the scroll that have been commissioned by Scipione Maffei (Figure 18) and Gianbatista Biancolini in the eighteenth century. This is an exceptional document because it shows the city of Verona from a high point of view with all the significant buildings, the most of which still Romans, and features (Bolla, 2001).

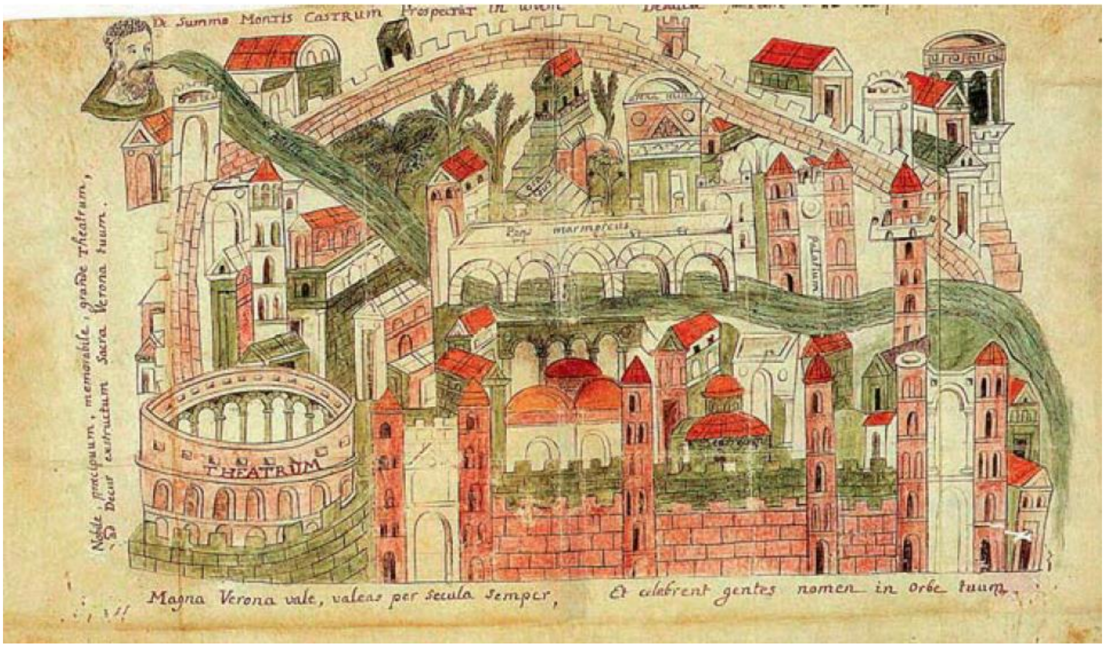


Figure 18: Raterian Iconography, drawing on parchment, IX-X century, Copy commissioned by Scipione Maffei in 1739, Verona, Biblioteca Capitolare, ms. CXIV - 106

With the Renaissance, the remains of the Roman buildings of Verona have been the inspiration for historians and famous artists and even for collaboration between them. They inspired Fra Giocondo when, in 1511, he published his illustrated book on Vitruvius, Falconetto and Lipsius with their studies on the Arena, Sanmicheli and Fogolino. The work of Falconetto, who painted frescoes depicting the Roman remains of Verona in the background (Figure 19) is of great interest.

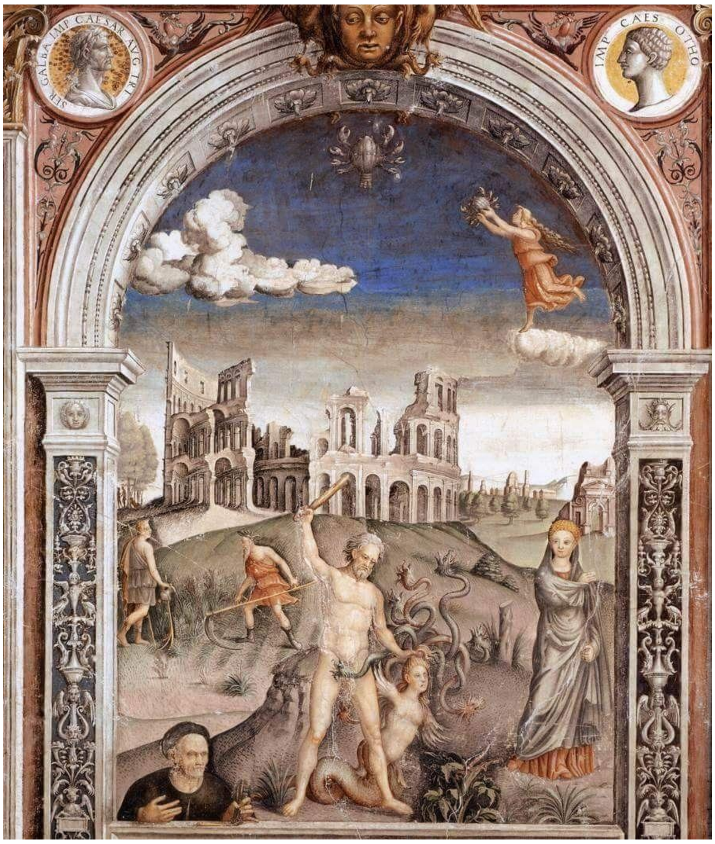


Figure 19: Giovanni Maria Falconetti, Segni Zodiacali. Cancro, affresco, 1520 circa, Mantova, Palazzo d'Arco.

Torello Sarayna wrote the book '*De origine et amplitudine civitatis Veronae*' with illustrations and contributions from Giovanni Caroto, which subsequently re-published the drawings. Those drawings are of huge interest because they represent monuments sometimes how they were in the sixteenth century and sometimes how they should have been at Roman times on the basis of literary and archaeological data. His drawing of the Roman Theatre of Verona is representative of the city for Sebastian Münster's famous book '*Cosmographia universalis*' in the year 1550 (Figure 20). Saraina's book is particularly significant in this context because he recognises these antiquities to be constantly endangered and he fostered their conservation and restoration. Meanwhile, Andrea Palladio was repeatedly drawing the Roman monuments of Verona, notably the gates (Figure 21), the Arena, the theatre and the Arch of Gavi, as part of as he worked to refine his style. Peruzzi, Antonio da Sangallo and Serlio are other architects who drew Verona's Roman monuments (Fontana & Tosato, 2008).

Figure 20: Caroto's drawing of the Roman Theatre of Verona. Cosmographia Universalis.

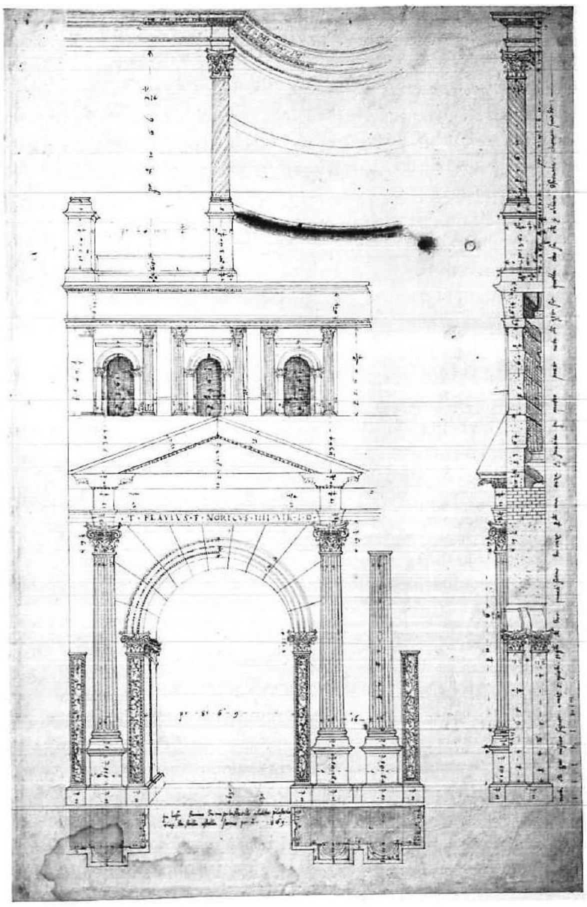


Figure 21: Andrea Palladio, Porta dei Leoni, elevation, plan and section of the later facade, London, RIBA, Palladio XII, 20r

At the end of the eighteenth and in the nineteenth century there was a new impulse to include in paintings the Roman monuments of Verona, due to the neoclassical movement that was spreading in Italy. The work of Giovanni Caroto was used as basis for two oils on canvas from an anonymous author. They represent the Roman Theatre. One of them shows the proscenium with actors on it, the second a naumachy (a mock sea battle) on the river Adige in front of the theatre. Other notable nineteenth-century paintings representing the Roman remains of Verona are Francesco Zuccarelli's series of capricci, Carlo Cannella's depictions of joyful events in Verona and Francesco Ronzani's detailed tables. In the same century, many foreign visitors found those monuments equally impressive, for example Thomas Little (1802-1869) who was able to capture the light and the atmosphere of Porta Borsari (1826) (Bolla, 2001). In the twentieth century, another artist from Verona was fascinated by the ancient remains and began to draw the city as it was in Roman times, always following updated archaeological surveys. His name was Gianni Ainardi (1925-2012), born in Egna (near Bolzano) who lived in Verona from the age of thirteen; he was painter, sculptor and historian. He drew the Roman Verona, not just from a technical and architectural point of view, but showing it in a descriptive and didactical way (Figure 22).

Figure 22: Gianni Ainardi, Porta Leoni,

6.2 Phases of the project

After some months of research and experimentation into a project deliberately choosing to employ mobile AR technologies for the (re)discovery of the walled cities of Veneto (Petrucco & Agostini, 2015), in the latter half of 2015, I came up with an experience which targeted the primary schools of Verona. It was not my intention to create a new experience from scratch, but rather to provide a new tool and ‘augment’ something already existing. Historians and educators of the Association of Social Promotion “Quartiere Attivo” were active from a couple of years with educational projects in primary schools aimed at fostering the knowledge of the Roman remains and history of Verona. Together with Quartiere Attivo, I worked to integrate the MR technology in their workshop and visit format. Also, the historian who usually leads the visits was asked what kind of functions he would like to have in the app to make his explanation more palatable for children. Teachers of six primary school fifth year classes, including more than one hundred children, agreed to be part of the research. With them, I made sure that the content of the visit was in line with the school curriculum and that the school programme would have reached the right moment when the experiment started to abide by the research design protocol. The experimentation started in March under the name of “Verona Romana Augmented Visit” with the intention of enabling all the classes involved to learn more about Verona and its classical monuments at the time of the Romans - monuments which are still an integral part of the city’s landscape. The experience was closely linked to the school curriculum because the fifth-class programme, includes the study of Roman civilisation in its kingdom, republic and empire phases:

The complete schedule involved the following steps:

1. Analysing the traditional format and adapting it for the use of MR technology.
2. Discussing with the experts of Quartiere Attivo what kind of features in the App would help them during the visit.
3. Creating the AR App.
4. Agreeing and sharing with teachers the plan of the introductory lesson and the tour.
5. Planning the classroom lesson: in this phase, which takes two hours and is held by the historian of Quartiere Attivo, students are provided with the interpretative tools that are used during the tour. Different classes are brought at the same level of knowledge on fundamental aspects of Roman civilisation, especially as regards the construction of cities and infrastructure and to the Verona’s context in its principal phases.
6. Administering the first survey about the pupils’ background on mobile technologies and cultural heritage.
7. Performing Verona tour: this is the heart of the experience. Led by the historian and by the class teachers it aims to discover the Roman remains in Verona in order to understand their former and actual functions and meanings. The observation of the landscape is especially crucial for this interpretive process. To support the explanations of the historian, half of the classes use the mixed reality tool (one for every couple of students) and the other a paper aid with as near as possible content (one per student). In both cases, the historian, during the tour, in the explanations will refer to the material provided to children. This phase is videotaped to enable subsequent video-search and collection of quantitative and qualitative data.

8. Administering a second survey of feedback on the visit and the use of the MR technology.
9. Producing drawings accounting for the experience in order to better understand the effectiveness of the tool concerning the process of understanding and appropriation.
10. Making a follow-up test on the main content and concepts of the visit.

The classes participating in this research were paired according to a quasi-experimental approach. The pair of classes are part of the same school complex and shares the same design of curricular programme (parallel classes). This to reduce the incidence of external variables.

6.3 The creation of the Roman Verona MR App

6.3.1 The first design of App

The first design of an App in the context of this research was developed during my collaboration with the Italia Nostra association in order to create visits with primary and secondary schools in the numerous walled cities of the Veneto region. The aim was to recreate through a mobile AR application all the important characteristics of Veneto's walled cities and to have an app for each city, beginning with Cittadella, in the province of Padua, which is one extraordinary example of a walled city. The App was intended to show characteristics of the cities and the hard-to-see architecture of the walls, as well as concepts which are difficult to understand looking at the modern landscape. To encourage an innovative approach to learning about the past, the design of the app was the result of dialogue the cultural heritage experts of the Italia Nostra association. The principles which guided us in designing the prototype were:

1. The respect of the pedagogical principles and educational aims of MRML.
2. To stay within the pedagogical framework of the cultural heritage education.
3. Keep it simple to use and find a way to encourage interactivity with the user.
4. The content should coincide precisely with a tour of the actual site.
5. Possibility for the students to provide feedback of what they have learned.
6. Encourage practical activities which help the interaction between children and the guide.

These aims go beyond the applications described above but also share some of their characteristics. That was partly expressed in technical characteristics which should have been incorporated and which summarise the better features of the applications that we have reviewed to date:

• Client-server model: as in Archeoguide allows the application to download material and information from the server and to update it according to the GPS location.

• To enable one to visualise the present-day structures and places as they were at the time of their construction thanks to superimposed 3D models through AR technology, as in Poitiers 3D and Avignon 3D.

• Historical and actual Maps with POIs as in Avignon 3D.

• Specifically geolocated and interactive AR tags as in the "Puglia Reality+".

• Some 3D interactive models of, for example, siege machines.

• Interactive quizzes, treasure hunts and mazes.

• The connection between the various devices thanks to social functions which allow the participants to share ideas and promote teamwork.

• Effective mixed reality through the Google Cardboard compatibility: better understanding thanks to immersive experience.

In practice, the project of Walled Cities of Veneto with the AR-CIMUVE App (Petrucco & Agostini, 2015) has not been pursued; still, it was an excellent first step in the design of a mobile MR App for heritage education.

6.3.2 The prototype of the Verona Romana MR App

Building an app for the Verona Romana Augmented Visit was not my first option. I would have liked to find an existing tool with the necessary features to cover what was needed to best answer our research questions, illustrate our pedagogical approach and the features recommended from teachers and Quartiere Attivo historians and educators. Such a tool did not exist, and this is the reason why, owing to its fundamental necessity to conduct this research, it was decided to create one on the basis of different tools that could cover all the features required in a sort of *bricolage*.

6.3.2.1 A Guide or teacher-led procedure: a link between past and present

The first and foremost characteristic of my 'app' is that, unlike any other AR and MR App reviewed, it was designed to be used purposefully during a guided tour or an educational tour led by a teacher. It was not designed to be used by a student or a visitor alone. The information that is provided on the screen are complementary and not a substitute for explanations by the guide. These are presented with the peculiar mode of augmented reality, then superimposed on the real vision of the artefact. Therefore it can be better understood because it is accurately integrated with what the viewer is actually looking at.

The second distinctive characteristic is owing to a shift from an AR-'app' to an MR one, as required both from the Italia Nostra and from the Quartiere Attivo experts who insisted on the difficulty of letting children imagine, visualise in their mind, what they are being explained by the guide. It is challenging for a 5th class child to imagine a Roman gate, even if the guide makes every effort to explain it clearly, and if they cannot see the wall, it is difficult to explain to them why the gate was so important, and that it was a part of a broader system of defence. Children under eleven years old are not in a cognitive phase when they are capable of abstract thinking, even if that developmental process may have just begun (Piaget, 1970; Fischer, 1980). Even using pictures was not of great help because often that meant showing an A4 paper to many children or passing along pictures during the explanation. Also, often, these architectural or artistic pictures were not easy to decipher for a 5th class pupil. Taking all these observations in consideration, I also took special care to integrate into the app a feature allowing pupils to actually see monuments, architectures and landscapes as they were in Roman times and visualise the layering of the city throughout the centuries.

6.3.2.2 Prototype *Bricolage* App Tools

Bricoler is a French verb that indicates that activity of manual labour made at home. It can be done as distraction, a hobby, or to save the money of a professional worker. While in professional context the results are often seen as sloppy works, it is not necessarily so. Mounier in his *Traité du caractère* praised the *bricolage* attitude in 1946 as revealing an '*aptitude for games, the resourcefulness, the ability to get out of complex difficulties or to take advantage of means of fortune, the ability to make plans, sometimes the taste to manufacture, rearrange*' (Mounier, 1946, p. 640). Subesquently, Claude Levi-Strauss (1966) elaborated the concept of the *bricoleur* as the '*savage mind*' who uses pre-existing things, '*the means at hands*', in new ways, in contrast with the engineer, the '*scientific mind*' who designs and create from scratch new tools and systems. In 1970, Jaques Derrida (1993) criticised this idea, which would make of the *bricoleur*'s divergent thinking something inferior to the engeneers's scientific thinking. He maintained that in the first place it is not possible to be the '*absolute origin of his own discourse*', more, '*the engineer is a myth produced by the bricoleur*' (Derrida, 1993, p. 6). In this perspective, the *bricoleur* just wants to be effective and have a job done. He has no particular interest in the tidiness or stability of a tool or a system (Mambrol, 2016). It is the same approach we can see nowadays looking at Internet. By means of tools like 'how-to' and 'DIY (Do It Yourself)' webpages and videos[25], *bricolage* is knowing an unprecedented success. The same kind of approach has been used in the creation of App tools that were not existent but were needed to answer our questions. In fact, to test the technologies, we needed a way to prototype the app rapidly. Also, we had time constraints because of the schools' programmes and deadlines. That left just a few months to create the app and the content. Hence, external instruments and services were used in order to create the interface and manage the content. Once integrated, they have enabled the creation of a web-app prototype. While not reflecting in every detail the original idea, the prototype allowed us to test methodology, technology and the main features that we explained in the preceding paragraphs.

Main development tools were: Holobuilder, Sketchup, Unity 3D and Google Forms:

- Holobuilder is a software developed by a start-up based in Aachen. Currently, it is very different from the first version that we used as testers. In fact, now it is a software for construction companies which want a tool to help architects, builders and professional on the construction site to visualise the state of the works and to explain and show works that need to be done through augmented virtual tours. In 2015 it was still a general-purpose web app with mixed reality capabilities. It allowed the integration of equirectangular 360°x180° images (photospheres) with three-dimensional models and sensitive points: the interface features are possible thanks to the engine of this software. The Holobuilder team has been active in supporting and implementing some of the required functions.
- Sketchup is a program, free in the basic version, which allows to create three-dimensional models easily.

[25] Youtube (youtube.com) is the most famous example of this tendency. It features countless how-to channels that cover every possible subject (engines, computers, electronics, plumbing, woodwork, medicine, etc.). Another very well-known website is IFixIt (ifixit.com) which explains how to fix more than ten thousand devices from more than one hundred thousand issues.

- Unity 3D is a popular game engine, free in the non-commercial version, which allowed the creation of a 3D environment of Verona in Roman times and to extrapolate photospheres.
- Google Forms allows integration in interface windows and has been used to receive feedback, show questions, insights and other images.

Looking forward to the diffusion of technologies similar to Google Project Tango, Google AR Core and Apple AR Kit, which allow a precise matching of the virtual level to the real background, it was decided to use an indirect augmented reality approach (Wither et al., 2011). The image on which the virtual layer is superimposed is therefore already acquired and is taken from the memory of the device rather than real-time from the camera feedback. The interface overturns the usual methods of accessing content that includes starting from a structured text menu that refers to isolated interactive and multimedia content. In the Roman Verona, MR App prototype one begin from an immersive interface. Links to additional content and insights are distributed in the application's mixed reality space, thus making them very contextualised: their position in the virtual space is already an interpretive key of the content. For example, finding a link to information on a specific part of a Roman monument, say a column, in the mixed reality, is already an interpretative key of the information that will be given since one already know precisely to which part of the artefact is referring and how and where that part is (Figure 23).

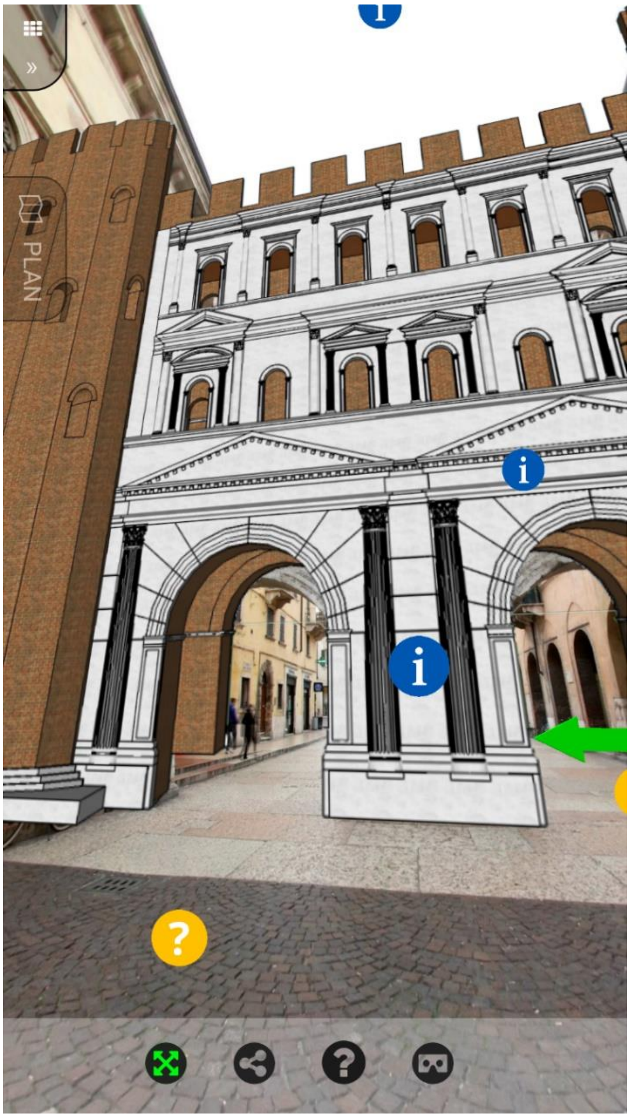


Figure 23: Verona Romana MR App. The disposition of informaton in the 3D space gives to the user hints on the content.

Capabilities include:

• Augmented Reality with superposition of three-dimensional models and other bi-dimensional interactive objects (Figure 23).

• Virtual Reality, compatible with Google Cardboard (a very cheap headset for virtual reality) (Figure 24).

• Zoomable map.

• Embed of external content via html5 popup.

• Programmable feedback through Google Forms.

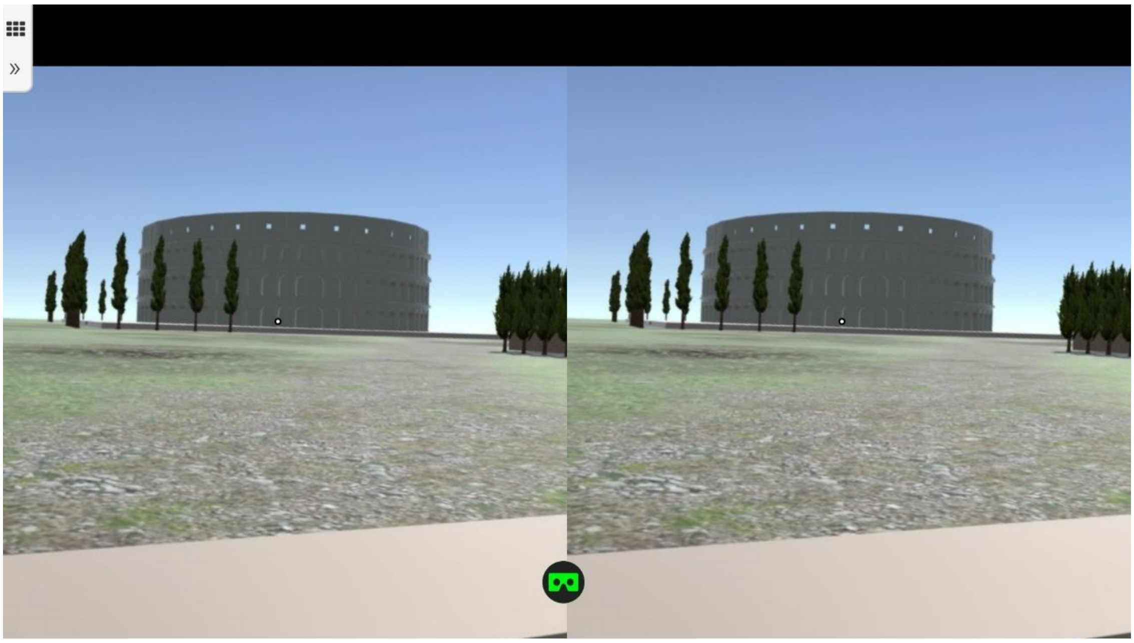


Figure 24: the Cardboard VR mode of the App

6.3.2.3 Creation of a virtual Roman Verona

In order to create the complete app experience and allow the students actually to see the past, monuments that would be shown in the visit had to be re-created as 3D models. The idea, thanks to AR technology, was to let the students see the monuments as they were in Roman time superimposed on the monuments as we see them now (Figure 23). We thought to add another layer, enhancing the AR to become MR. By allowing the students to time travel and see not only the monument but the whole surrounding landscape as it was two thousand years ago (Figure 25) to enable them to better

Figure 25: Porta Borsari Time-Travel and Map

understand the meaning and the utility of the monuments in the Roman city system. To achieve that a virtual environment had to be created whereby I could rebuild – part of – Verona in Roman times. Without any ambition to create an archaeologically accurate or high definition reconstruction, we tried to produce something suitable for educational purposes. Archaeological documentation of the city and monuments was used, also observing what is visible today and using historical documentation the Palladio's and Caroto's drawings as inspiration to recreate the monuments in their former splendour.

The creation of an indirect AR has necessitated taking in advance photos from the exact place where the user would stop for an explanation during a visit. This has been possible because in every visit the guide stopped at the same places. Vast stopovers like the site of the Arena required more than one point of view because during the stopover the guide needs to move to specific places of the site. The photos needed for indirect AR are not ordinary pictures, but high-resolution equirectangular pictures, covering 360 degrees horizontally and 180 degrees vertically. That way, the software would be able to map it on a sphere and present it like an immersive panorama, on which it would be possible to superimpose an informative layer or 3D models. To use this technique, it is mandatory to have a smartphone with a gyroscope, and ideally to have a compass sensor to calibrate the orientation of the indirect AR.

At first the idea was to create a Web App to exploit Bring Your Own Device (BYOD) opportunities. It is a well-tested methodology that has been able to gather consensus in its educational application (Song, 2014; Afreen, 2014). It would have helped to keep Android and iOS compatibility (thanks to the fact that it was sufficient to have a modern browser on the smartphone) and for ease of updating since it was in first developmental phase (no need to update every device with new versions of the app, with a Web App it is enough to update it once on the Web and everyone would have the new version). The first reason was my main reason for adopting this course because I wanted to avoid all the expense involved in buying a set of devices to use in the school for the experimentation. Unfortunately, this reason was the one of the three which defeated me. From an early survey, I discovered that only a fraction of the children would have been able to bring with them their own smartphone or tablet. On reflection I had some concern about the possibility of distraction that a mobile device already personalised by the pupil could have had. The deciding factor though was the lack of gyroscope in most of the devices they had at home: smartphone manufacturers put this sensor only in medium/high and high-end devices, which are also the most expensive. As discussed in Chapters 3 and 4, the gyroscope is a fundamental sensor for MR applications. Without it, the tracking of the movement would have been too imprecise and slow. Therefore, in order to continue the research, I had to buy a stock of used smartphones equipped with a gyroscope[26].

6.4 The Roman Verona augmented visit

As previously mentioned, after an initial lesson in the classroom, every experimental and control class involved an outdoor visit in the city centre of Verona, where the most noteworthy Roman monuments in the area stand. The usual visit duration was three hours, recreation excluded. The trail in Verona was about four and a half kilometres long (Figure 26). With that time limit, it was not possible to see and present all the Roman remains in Verona, so, as visible on the map, focus was placed on commentary about significant places and monuments, with a total of nine stopovers. The students took different buses to reach different destinations in the centre depending on the location of their schools. Therefore, it was not possible to make the stopovers in the same order during each visit. In the following table, the stopovers appear inTable 7 in the order in which the classes visited them.

Table 7: the sequence of stopovers along the visit.

[26] Further information about the gyroscope can be found in section 7.4.1

Scuole Camozzini e Dall'Oca Bianca	Scuole Rosani
1. Arena 2. Mura di Gallieno (Gallieno's Wall) 3. Porta Leoni (Leoni's Gate) 4. Piazza Erbe (Roman Forum) 5. Piazza dei Signori (Roman Street and Sewer) 6. Ponti e Teatro (Bridges and Theatre) 7. Arco Giove Ammone (Amon Jupiter Arch) 8. Porta Borsari (Borsari's Gate) 9. Mura Gallieno vicolo Guasto (another part of Gallieno's Wall) 10. Arco dei Gavi (Gavi's Arch)	1. Ponti e Teatro (Bridges and Theatre) 2. Piazza dei Signori (Roman Street and Sewer) 3. Piazza Erbe (Roman Forum) 4. Porta Leoni (Leoni's Gate) 5. Mura di Gallieno (Gallieno's Wall) 6. Arena 7. Mura Gallieno vicolo Guasto (another part of Gallieno's Wall) 8. Porta Borsari (Borsari's Gate) 9. Arco dei Gavi (Gavi's Arch)

The order of stopovers was taken into account in the analysis of the results because fatigue might have influenced the children's attention and understanding. In both cases, with the experimental classes, there was an introductory stopover where the use of the device and the navigation in the app were explained. Also, the guide explained the phases of a stopover following the Tri-AR model, which is explained in the next sub-chapter. In addition to the guide and teacher, the author of this paper was present at the visit for observational purposes and to help students who experienced problems with the app or the device.

Whether the class was experimental or control, the students did not use the same mediational tool at every point of interest, and this was also be taken into account during the analysis phase. The experimental classes used the AR and MR technology, along with the VR immersive experience in the 'Arena', 'Borsari's Gate', and 'Gavi's Arch' stopovers. They only used the AR technology during the 'Leoni's Gate' stopover, whereas at the 'Roman Forum' and 'Bridges and Theatre' stopovers simple pictures and texts on the device were used. At the 'Amon Jupiter Arch,' pupils were challenged to find the remains of the arch using a playful approach. At the 'Roman Street and Sewer' stopover, as well as at both the 'Gallieno's Wall' venues, the guide performed a plain oral explanation. For control classes, booklets with pictures and texts were used at almost every stopover. More is said about the booklet in following sections about tools. At the 'Amon Jupiter Arch,' stopover, the guide used the 'find-the-remains' approach as well, while at 'Roman Street and Sewer' and 'Gallieno's Wall' stopovers, he just used plain explanation.

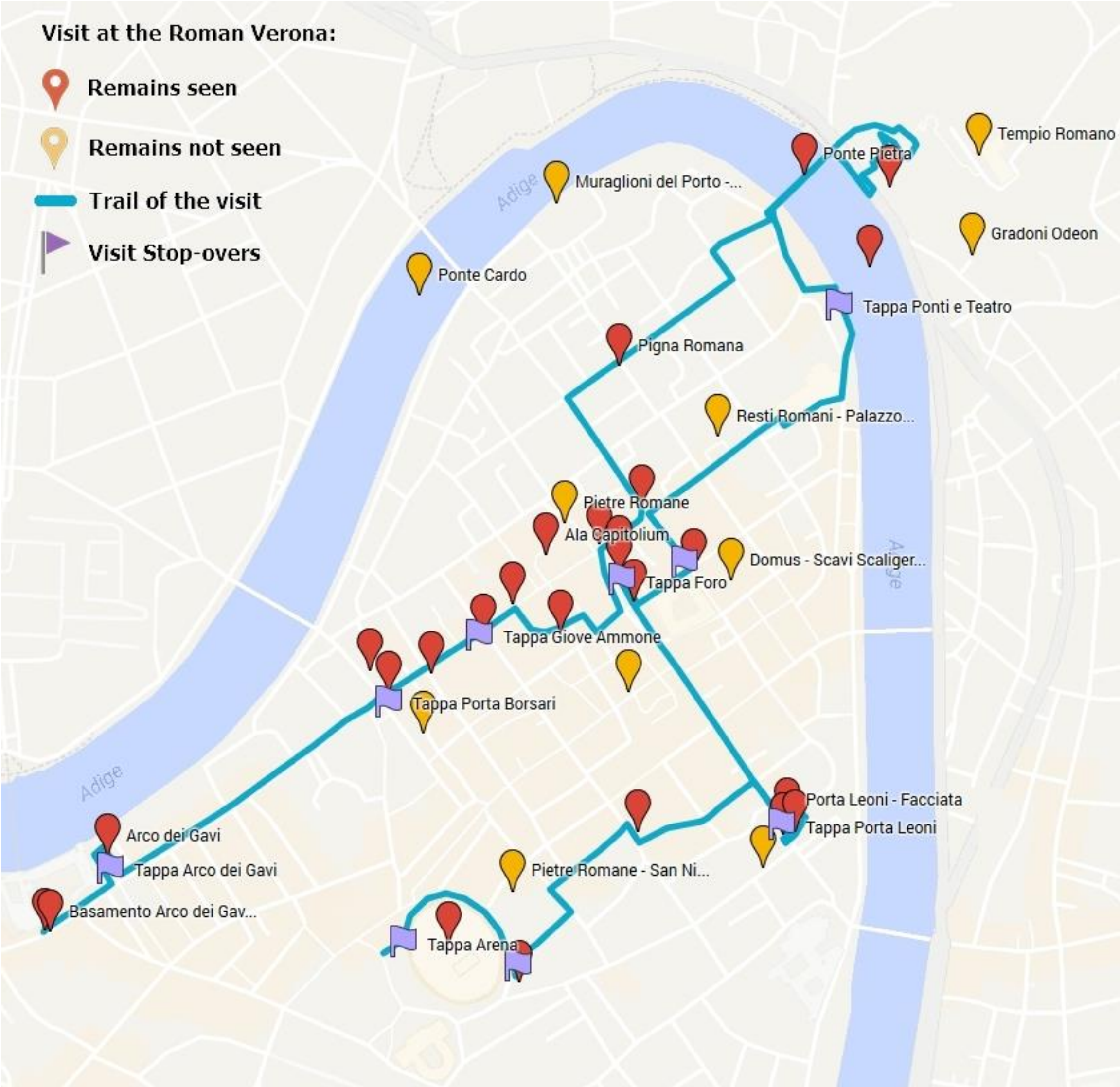


Figure 26: The trail of the visit to the Roman Verona

6.4.1 The inclusive Tri-AR model

One of the challenges was to design and to experiment with an AR/MR app while trying to construct a didactic model that could take into account the context of the visit, as well as the content and interactions between those involved (i.e. the guide and participants). In addition, the model needed to include an assessment of primary school classes to understand if this approach helped the students to understand the related historical, cultural, and artistic content and concepts. A triadic model called Tri-AR, designed specifically for this research, served this purpose. Figure 27 illustrates the interactions in this model, which is based on the most general model of the cultural-historical activity theory. The elements include the student (*subject*), the app or a generic mediator tool (*tool mediator*), the guide or the teacher (*human mediator*, absent in the AT, is part of the *community*), and the heritage or the environment (*subject*). In this particular research, the heritage is represented by its physical crystallisation (i.e. visible and tangible artefacts). This model calls for the involvement of the guide in the design of the app and the visit regarding the stopovers chosen, the content and the narrative (explanation) related, the 'rules' of the visit, where and how to use the device, and the AR and VR options. This approach is less complete but more specific compared with the AT triangle (see Chapter 2). Here the students, heritage, guide, and app are connected to one another by a network of interactions that are translated into a visit format by means of rules. Those rules define a specific sequence of interactions and are communicated to students at the beginning of the visit. The paradigm of reference come from Vygotsky: Human beings interact and learn thanks to the mediation of tools and artefacts that

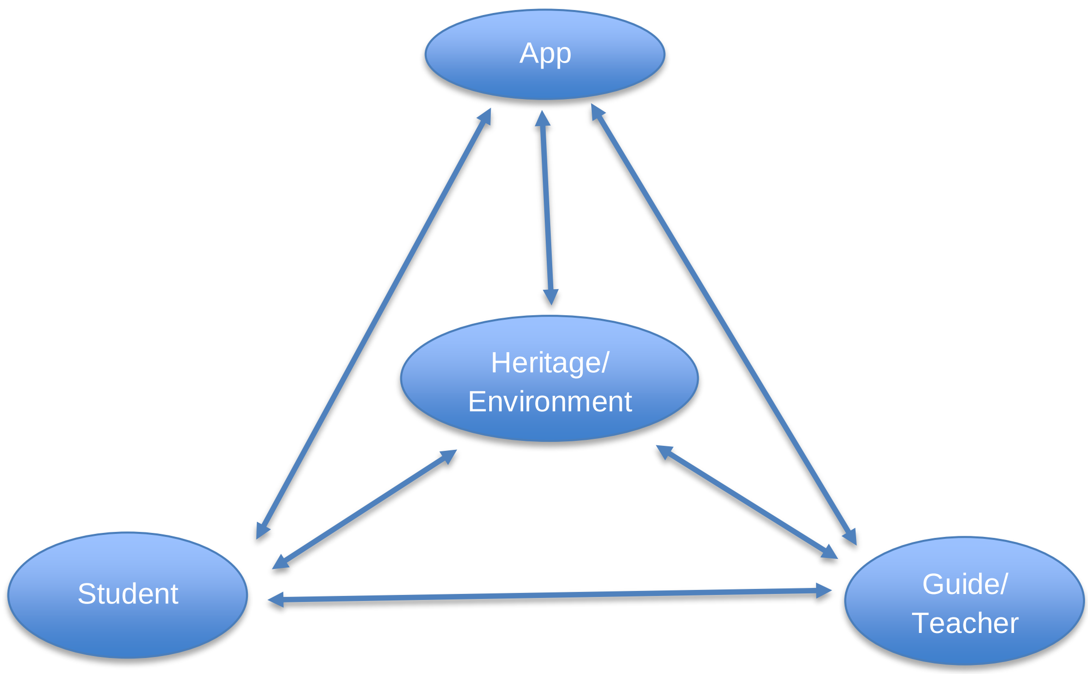


Figure 27: The Tri-AR model

expand the 'zone of proximal development', but they also need interactions with people. Therefore, the teacher and the guide are important as mediators of experiences of augmented and mixed-reality mobile learning. The sequence that we decided on with the guide for the Roman Verona augmented visit is as follows:

1. Guide → Students → Heritage: The guides provide an introductive description of the place or the monument, its history, and its use in Roman times. Also, they highlight the differences between the place how it is now and how it was in the first century.
2. Guide → Students → App → Heritage: The guides encourage the students to use the app to discover in the environment explained in the initial explanation. The

guides ask the students to discover details and AR or MR content while asking for feedback by posing specific questions.

3. Guide ← Students ← App ← Heritage: The students provide feedback and, freely exploring the environment through the App, ask their own questions.
4. Guide ←→ Students ←→ App ←→ Heritage: The guides answer students' questions, using the app if required. The students interact with the guide, referring directly to the artefacts or the environment or using the App as well when they think it is useful.

The fact of having presented this script to students at the beginning of the visit helped the guides and students to manage the timing, questions, and the use of the device.

6.4.2 Experimental and control technological mediating tools

This section expands on the discussion of the software side of the creation of the app and explains the kind of devices and technologies used to run the Roman Verona augmented visit. The following list contains a description of all the hardware used:

- Fifteen smartphones and five small tablets: As outlined in section 6.3.2.3, it was impossible to use the devices that children had at home, so we bought used smartphones and small tablets to avoid giving children bulky devices to carry for a long time. All the devices were pocket sized. The most critical specifications were to have one gigabyte of RAM or more, a GPS system, and a gyroscope, as well as a compass (preferably). As explained in Chapters 3 and 5, those sensors are essential for this kind of MR experience. To avoid misuses of the technology and distractions, every device was configured so as to give access only to our Roman Verona web app.
- Twenty Google Cardboard VR headsets: Only requiring a gyroscope, these inexpensive headsets are made of cardboard and a pair of plastic lenses, allowing students to use any smartphone as a VR headset (Figure 28).

- Two mobile routers: We had to face the fact that our application was a web-app prototype, and using a SIM from a mobile provider for every phone would have been expensive and potentially problematic because of the ease of access the children would have had to calls and messages. Therefore, we used two mobile 4G routers with one data SIM each. Each one of them had the capacity to connect 10 devices to the Internet.


Figure 28: a pupil while using Cardboard VR

The control classes used booklets instead of the devices. Booklets were more complete than they would be used to having in a standard visit. In order to have a fair comparison between the experimental and the control mediating tool, we created a booklet that showed everything as it was represented in the app, including the same drawings and 3D models. Of course, the affordances and the characteristics inherent in the tool changed. We provided one booklet per pupil.

6.5 Quantitative data analysis

In this analysis, mixed-effects linear models, also known as multilevel linear models (MLMs), were employed. These models are an extension of linear models (e.g. the linear regression or the ANOVA), that enable researchers to deal better with quasi-experimental designs in which some variables cannot be controlled (Pinheiro & Bates, 2000; Gelman & Hill, 2006). To compute those models based on the data gathered, the statistical software ‘R’ was used, extended with the following packages: *afex* for statistical analysis (Singmann et al., 2017), *MuMIn* to calculate the weight of the model (Bartoń, 2017), and *psych* to manage the descriptive analysis (Revelle, 2017).

6.5.1 Principal component analysis

To begin the statistical analysis, the pre and post-visit questionnaires need to be tested. In fact, they are inclusive of many questions that need to be reduced to a smaller number of dimensions. In fact, the questionnaires were divided into dimensions before, but they are still too elaborate to be used in evaluating the performance of every single student. To solve this issue, the technique of the principal content analysis (PCA) was employed. It examined the different questions and merged those with a similar trend in unique components.

Pre-visit questionnaire on technologies PCA

A parallel analysis was run to understand in how many components it was possible to group the questions. Then the question from '*Hai la connessione Internet a casa?*' to '*Console portatile, la potresti portare da casa per imparare all'aperto?*' were used because they have ordinal values. Also, all the questions which more than ten students did not answer were removed. The questions which remained are reported in Appendix 2. The result of the parallel analysis (Appendix 2, Figure 1) indicates that nine different components are needed. Hence, the PCA was performed, setting it up in order to have nine different components orthogonal between them, that means that they are not correlated. To achieve that the PCA with VARIMAX rotation was applyed. This gives results as 'loadings', that is weights indicating the importance of individual questions for the component in a range from one to minus one. It is necessary to decide a threshold under which the question is not significant for the component. It was decided to set this limit to nought point five. The questions of the questionnaire were numbered from one to seventy-five. From the loading table (Appendix 2, Table 1) we created the following nine components.

Table 8: component at column 1 of Table 1, Appendix 2. Named: Use of mobile devices for learning.

Component 1: Use of mobile devices for learning		
	Question	Loading
Q60	Per cosa usi il Tablet: Per imparare	0.7288459
Q59	Per cosa usi il Tablet: Per condividere informazioni e contenuti	0.7106770
Q55	Per cosa usi il Computer: Per fare i compiti	0.6776587
Q6	Quanto usi i seguenti dispositivi a casa: Smartphone	0.6527560
Q57	Per cosa usi il Tablet: Per cercare informazioni	0.6223387
Q19	Quanto usi seguenti dispositivi all'aperto o negli spostamenti: Smartphone	0.5703252
Q56	Per cosa usi il tablet: per giocare	0.5698042
Q25	Quando hai vistiato città che dispositivo hai usato: smartphone	0.5674744
Q65	Per cosa usi il Tablet: Per fare i compiti	0.5572215

Table 9: component at column 2 of Table 1, Appendix 2. Named: use of computer to communicate and multimedia.

Component 2: Use of computer to communicate and multimedia		
	Question	Loading
Q40	Per cosa usi il Computer: Per comunicare con gli altri	0.7795075

Q37	Quanto sei capace a usare: Smartglasses e VR Headset	0.6848783
Q63	Per cosa usi il Tablet: Per creare contenuti	0.6691984
Q44	Per cosa usi il computer: Per ascoltare musica	0.5665572

Table 10: component at column 3 of Table 1, Appendix 2. Named: Use of devices for games.

Component 3: Use of devices for games		
	Question	Loading
Q21	Quanto usi seguenti dispositivi all'aperto o negli spostamenti: Console portatile	0.7156084
Q9	Quanto usi i seguenti dispositivi a casa: console portatile	0.6414852
Q20	Quanto usi seguenti dispositivi all'aperto o negli spostamenti: Tablet	0.5672160
Q8	Quanto usi i seguenti dispositivi a casa: console fissa	0.5337343
Q68	Per cosa usi lo smartphone: per giocare	0.5062355

Table 11: component at column 4 of Table 1, Appendix 2. Named: Use of the computer for information sharing.

Component 4: Use of the Computer for information sharing and learning		
	Question	Loading
Q41	Per cosa usi il computer: per condividere informazioni e contenuti	0.7674793
Q42	Per cosa usi il computer: per imparare	0.6319741
Q36	Quanto sai usare: console fissa e portatile	0.6106663

Table 12: component at column 5 of Table 1, Appendix 2. Named: use of the smartphone for communication and research vs visits to cultural heritage.

Component 5: Use of the smartphone for communication and research vs visits to cultural heritage		
	Question	Loading
Q70	Per cosa usi lo smartphone: per comunicare	0.6179128
Q69	Per cosa usi lo smartphone: per cercare informazioni	0.6063503
Q24	Quanto spesso visiti le citta' per storia, monumenti ed arte	-0.5568123
Q23	Quanto spesso vai al museo o alle mostre	-0.6961987

Table 13: component at column 6 of Table 1, Appendix 2. Named: Use of the Interactive White Board.

Component 6: Use of the Interactive White Board		
	Question	Loading
Q17	Quanto usi i seguenti dispositivi a scuola: LIM usata da te	0.6929200
Q16	Quanto usi i seguenti dispositivi a scuola: LIM usata da insegnante	0.5461258

Table 14: component at column 7 of Table 1, Appendix 2. Named: Use of AR and VR headsets.

Component 7: use of AR and VR headsets		
	Question	Loading
Q22	Quanto usi seguenti dispositivi all'aperto o negli spostamenti: Smart glasses o VR headset	0.8143223

Q18	Quanto usi seguenti dispositivi all'aperto o negli spostamenti: Computer portatile	0.7264894
Q28	Quanto usi seguenti dispositivi nelle visite a citta': Smart glasses o VR headset	0.7241010
Q10	Quanto usi i seguenti dispositivi a casa: Smart glasses o VR headset	0.5812305

Table 15: component at column 8 of Table 1, Appendix 2. Named: General use of tablet.

Component 8: General use of Tablet		
	Question	Loading
Q32	Quanto sei capace ad usare: Tablet	0.6018710
Q73	Per cosa usi lo smartphone: Condividere informazioni e contenuti	0.5794630
Q7	Quanto usi i seguenti dispositivi a casa: Tablet	0.5133077

Table 16: component at column 9 of Table 1, Appendix 2. Named: Use of mobile devices at school.

Component 9: Use of mobile devices at school		
	Question	Loading
Q14	Quanto usi i seguenti dispositivi a scuola: Tablet	0.6914454
Q13	Quanto usi i seguenti dispositivi a scuola: Smartphone	0.5563827

The next step was to recognise the components and give them a name. I decided to name them as it follows:

1. Pre C1: Use of mobile devices for learning.
2. Pre C2: Use of computer to communicate and multimedia.
3. Pre C3: Use of device for games
4. Pre C4: Use of the computer for information sharing and learning.
5. Pre C5: Use of the smartphone for communication and research vs visits to cultural heritage.
6. Pre C6: Use of Interactive White Board
7. Pre C7: Use of AR and VR headsets.
8. Pre C8: General use of tablets.
9. Pre C9: Use of mobile devices at school.

Discussion on Component 5

Component 5 (Table 12) is made of four questions, two with a positive and two with a negative loading, which have comparable weight. It is difficult to name such a split component because it represents an unexpected dimension which links the cultural heritage with the smartphone technology. The positive loading of the use of the smartphone technology for communication of research or information seems to be antithetical to the habit of visiting cities, museums and exhibitions. To have the correct answer we should be able to answer to the following question. Which is that thing that is influenced positively from the use of the smartphone to communicate and search information and negatively from the visiting of cities, museums and exhibitions?

Post-visit questionnaire on satisfaction Principal Component Analysis

The same procedure that we followed for the pre-visit questionnaire was repeated for the post-visit one. It followed a parallel analysis to understand in how many components it is possible to group the questions. Then the questiosn from '*Hanno spiegato tutto quello che avevano promesso all inizio*' to '*Conoscenza Android*' and from *'I dispositivi sono stati utili durante l'uscita...solo per chi li ha usati.*' to '*Quanto sai usare gli smartphone Android cioè i dispositivi che hai usato in uscita...solo per chi li ha usati.*' were used because they have ordinal values. Also, all the question to which more than ten students have not answered were removed. The questions which remained are reported in Appendix 2. The result of the parallel analysis (Appendix 2, Figure 2) indicated that just one component (Post 1) was needed. Hence, the PCA has been set up in order to have just one component. The threshold was kept to nought point five. Questions of the questionnaire were numbered from one to thirty-five. From the loading table (Appendix 2, Table 2) I created the following component and I called it 'Visit satisfaction'.

Table 17: component at column 1 of Table 2, Appendix 2. Named: Satisfaction on the visit.

Component 1: Visit Satisfaction		
	question	**loading**
Q8	Gli insegnanti sono stati molto coinvolti dall esperienza.	0.7888142
Q11	Hanno risposto alle domande e agli interventi.	0.7307657
Q15	Hanno.utilizzato.del.buon.materiale.didattico…presentazioni.power.point..schede..libretti..dispositivi..applicazioni..ecc….	0.7197192
Q9	L.educatore.lo.storico.hanno.condotto.bene.l.esperienza.	0.7118615
Q18	I.dispositivi.sono.stati.utili.durante.l.uscita…solo.per.chi.li.ha.usati.	0.6918051
Q2	Hanno.spiegato.tutto.quello.che.avrei.voluto.sapere.	0.6415927
Q14	Hanno.utilizzato.abbastanza.materiale.didattico…presentazioni.power.point..schede..libretti..dispositivi..applicazioni..ecc….	0.6374131
Q12	Sono.stati.chiari.e.comprensibili.nelle.spiegazioni	0.6043380
Q13	Hanno.dato.delle.informazioni.corrette.	0.6041311
Q1	Hanno.spiegato.tutto.quello.che.avevano.promesso.all.inizio.	0.5997878

Q4	Sono.stato.molto.coinvolto.dall.esperienza…Ho.partecipato.attivamente..con.interesse..con.emozione..	0.5906750
Q10	Hanno.gestito.bene.il.tempo.della.spiegazione.	0.5902512
Q6	Gli.insegnanti.sono.stati.molto.coinvolti.dall.esperienza.	0.5861090
Q17	Il.materiale.fornito.è.stato.facile.da.usare.	0.5816880
Q19	I.libretti.sono.stati.utili.durante.l.uscita…solo.per.chi.li.ha.usati.	0.5474459
Q3	Ho.imparato.cose.che.mi.saranno.utili.in.futuro.	0.5353020
Q20	I.dispositivi.sono.stati.facili.da.usare.durante.l.uscita…solo.per.chi.li.ha.usati.	0.5151314

6.5.2 Analysis of the components

The next step was to analyse the components obtained from the PCA. As a first step, it was checked if some component correlates with others and to do this the ρ index (Pearson correlation) that varies in arrange from minus one and one was used. One represents the perfect correlation, that is at every increment of the first value there is an increment of the second. Minus one is the perfect inverted correlation: at every increment of the first value, we have a decrement of the second and *vice versa*. Usually, the values do not reach plus or minus one, thus, in general, it is said that in a range between plus nought point three and minus nought point three there is no correlation while higher or lower values represent

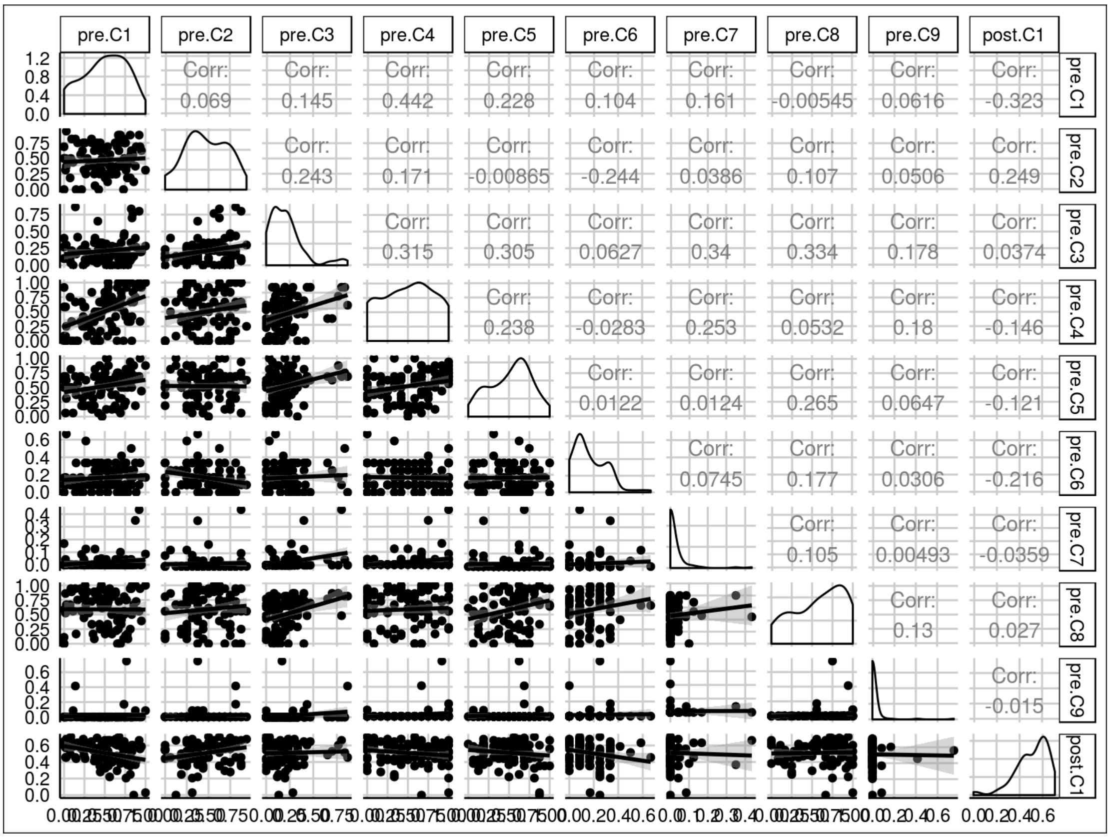


Figure 29: component correlations graphic.

a correlation. Analysing the results (Table 3 and 4, Appendix 2) one sees how Component Pre C1 correlates with Components Pre C4 and Post C1. Then, Component Pre C3 correlates with Components Pre C4, C5, C7 and C8 (Figure 29).

It was interesting to understand that the 'use of mobile devices for learning' correlates positively with the 'use of a computer for information sharing and learning' and negatively with the 'visit satisfaction'. In other words, this suggests that the more a pupil uses mobile devices to learn on his own, the more he also uses the computer for sharing information with others and learning. Is seems like consistent attitude towards the technology. Also, it makes sense that a higher proficiency in the use of mobile devices to find information and learn could result in more criticism of the use of the same technology for similar tasks. Having the prototype several stability issues, those pupils could had remarked them with more with more competency. They could have also been more exigent than a student who does not use mobile devices for the same task.

Furthermore, we saw that the 'use of the device for gaming' correlates positively with 'use of the computer for information sharing and learning', 'Use of the smartphone for communication and research', 'use of AR and VR headsets' and 'general use of tablets'. We find those correlations sensible. The use of the device for games, includes the preferred use of game-oriented devices, like consoles, to play. It seems they are more selective users for what concerns the affordances of the devices. They use the best device for the task they have to complete.

The subsequent step was to run MLM analysis on components. The aim was to check if there were differences in the pre-visit characteristics between the experimental and the control group. It would be good to have homogeneous characteristics to avoid the employment of countermeasures in the successive analysis. This is important at the group level while individual students can have different characteristics. Basically, this is to verify that the two samples can be compared. Those MLM analyses have as main (fixed) factors considered the type (experimental/control) and the gender (male/female). As random factor we have school (since it is not possible to test the quality of teachers and many other environmental variables in every school) and, as variables, the different components. Results of the analysis (Appendix 2) indicate how there are no significant differences between the two groups except for components 'Use of the IWB' and, partially, for the

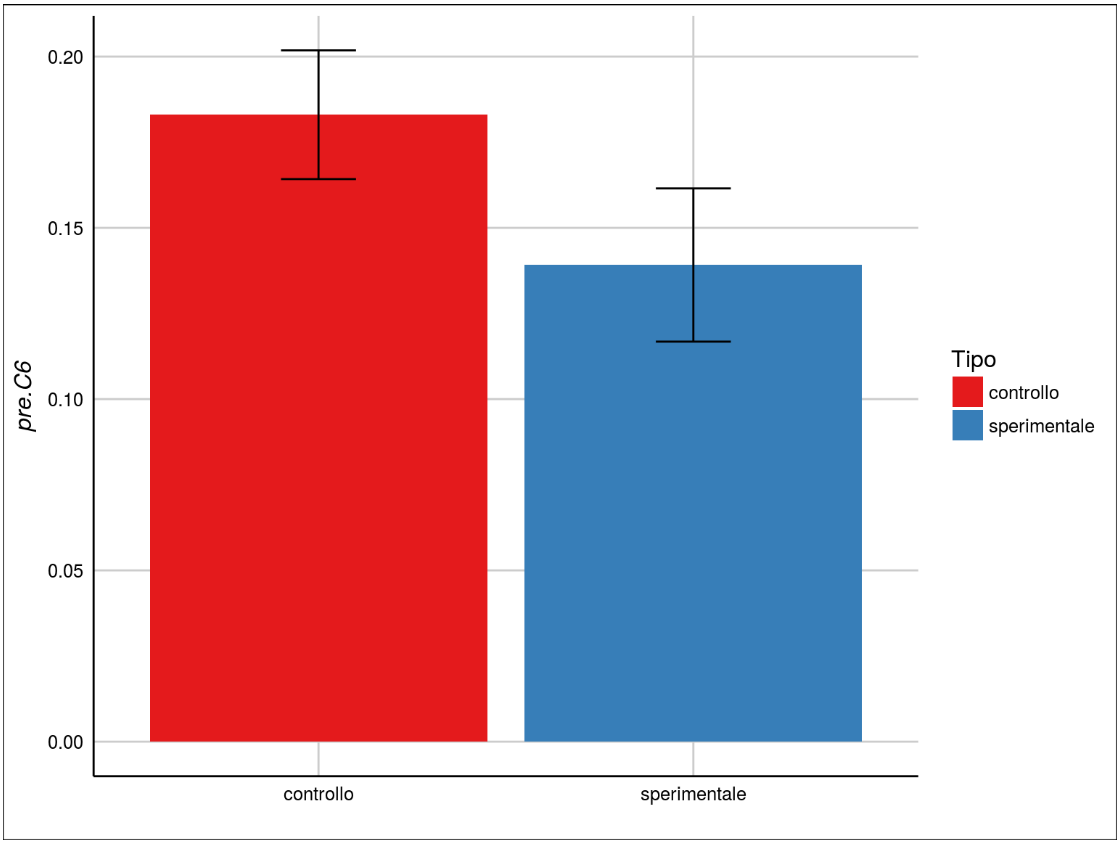


Figure 30: means and standard errors in the Component Pre 6 (Use of IWB) between experimental and control group.

component 'general use of the tablet'. As is visible in Figure 30 the control group used the IWB technology more than the experimental group. We would take it into account in the subsequent analysis. We found also a significant difference in the component 'use of devices for gaming' between males and females (Figure 31). This is not an issue for the following analysis because it does not relate with the fixed factor 'type' (experimental / control) but with 'gender' (male / female). Finally, we have found that girls in the control group had a little more familiarity with the use of tablet (Figure 32). This needs to be taken into account in the following analysis.

For what concerns the unique Post Component 'visit satisfaction' (Figure 33) we found that either girls appreciated the experience slightly more than boys or they have a more

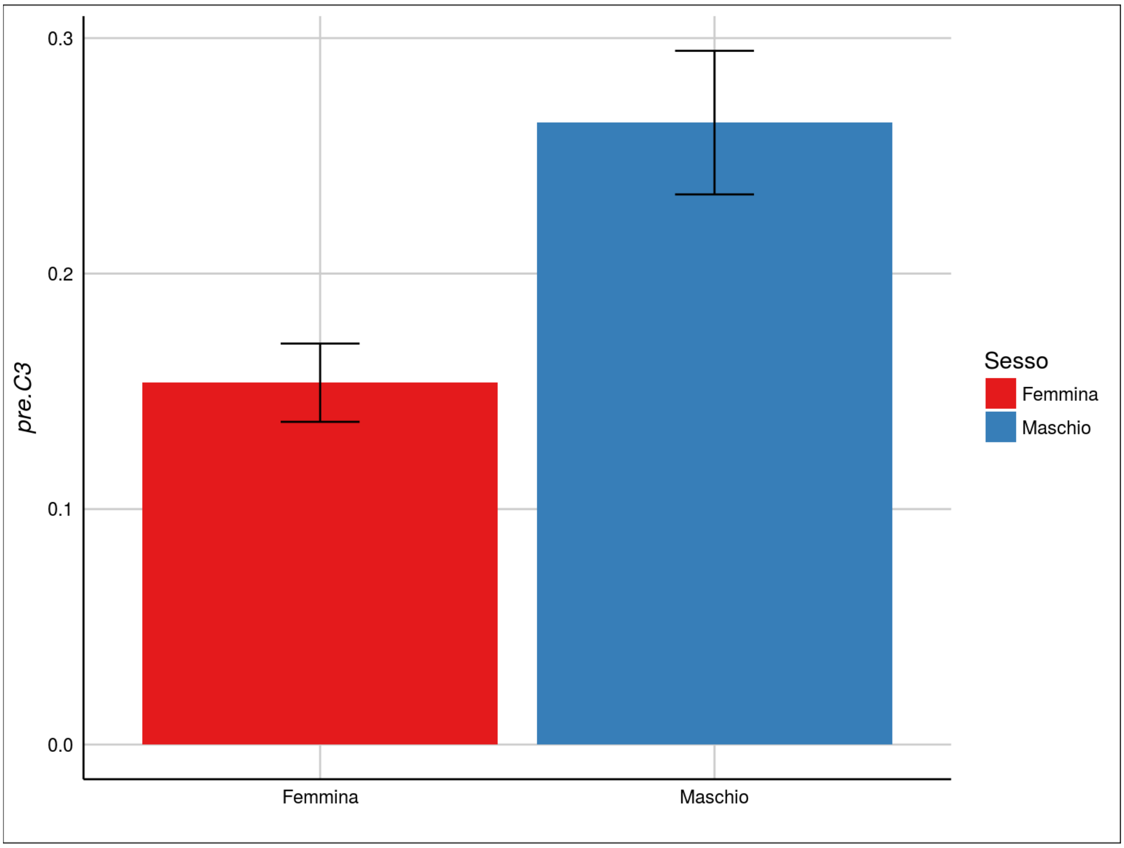


Figure 31: means and standard errors in Component Pre C3 (use of devices for gaming) in relation with gender.

positive attributional style. Here, again, is not something to be taken into account in further

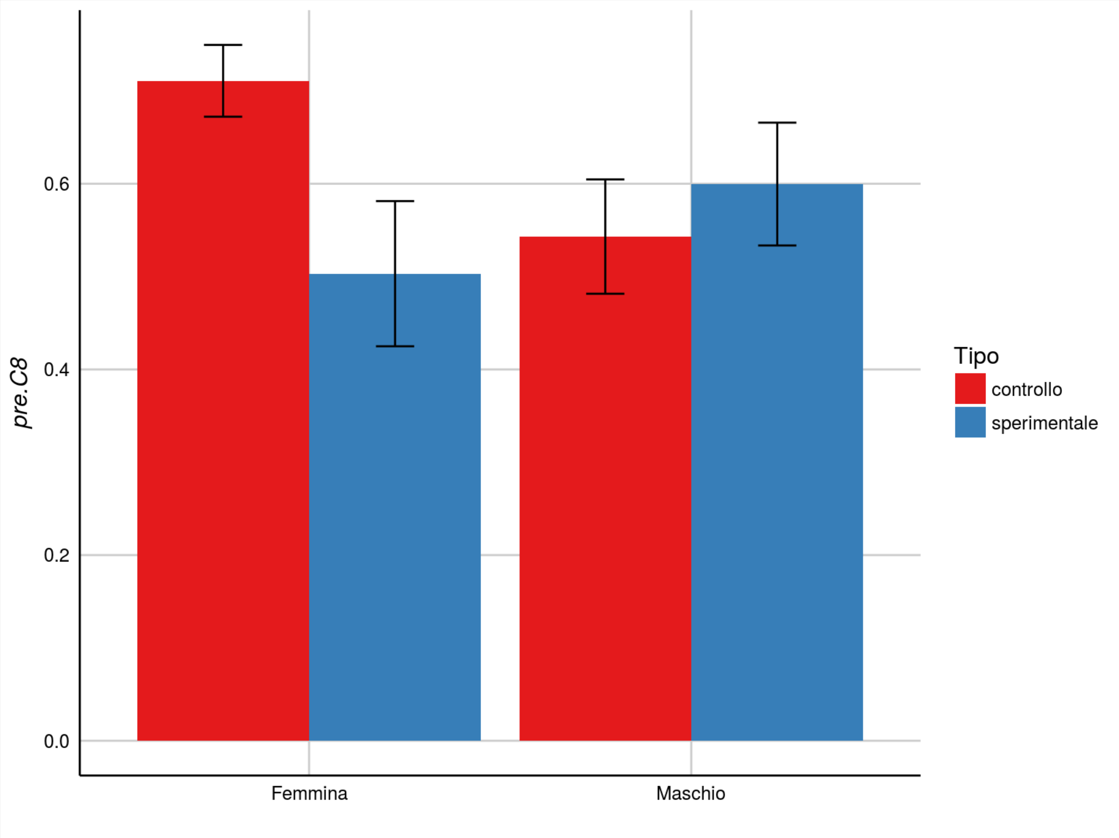


Figure 32: means and standard errors in Component Pre C8 (general use of tablet) in relation with gender and type.

analysis because it is not related to the 'type' factor.

6.5.3 Analysis on the scores of the follow-up test

The follow-up test (in Appendix 1) has been handed to pupils two weeks after the visit. The test had thirty-eight multiple choice and true/false questions. Questions were relating to explanation given in a particular stopover. As an example, questions 7, 12, 13, 16, 20, 22, 23, 34 are related with the Arena stopover. Hence, for the analysis, the questions have been grouped in stopovers. This was important especially because in different stopovers

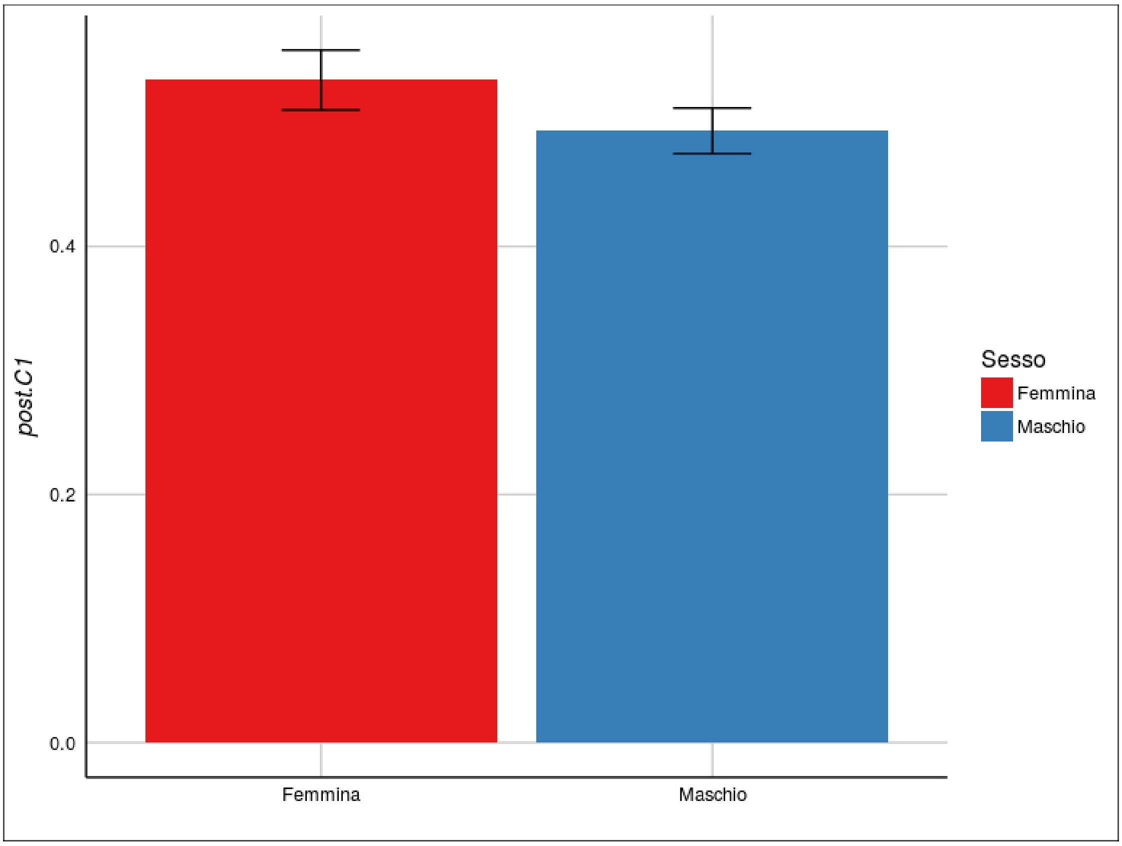


Figure 33: means and standard errors in Component Post C1 (visit satisfaction) in relation with sex.

we used different tools, even in the same experimental visit. Table 18 shows the mediating tool used in every stopover of the experimental and control visit.

Table 18: mediating tools used in each stopover from control and experimental classes.

Stopovers	**Mediating tool**	
	Experimental visit	*Control visit*
Arena	App AR & VR Cardboard modes.	Direct contact with the remains artefact
Gallieno Wall	Direct contact with the remains artefact	
Porta Leoni	App AR only mode	Pictures on booklet
Piazza Erbe	Pictures on smartphone	Pictures on booklet
Piazza dei Signori	View of the remains artefact	
Bridges and theatre	Pictures on smartphone	Pictures on booklet
Porta Borsari	App AR & VR Cardboard modes.	Pictures on booklet
Gavi's Arch	App AR & VR Cardboard modes.	Pictures on booklet
Amon Jupiter's Arch	Observe and find game	
Roman city organisation	Slides presentation through IWB and oral explanations during the visit	

Simple comparative analysis

The first analysis done on the data was just a comparison between the scoring at the follow-up test of experimental and the control classes. It has been done comparing the mean score on questions related with a particular stopover from the control classes and the experimental classes. Standard deviation has not been calculated because the score is a mean of total scores and the total scores are a mean of answer where one can have just success or not success (1 or 0). In Figure 34 it is visible how the experimental classes generally retained more information (had higher scoring) than the control classes for what concerns the teachings given in experimental stopovers where AR and MR have been used. Notably, the highest difference is in Porta Leoni stopover where we used only the AR technology. The second graphic (Figure 35) shows interesting mixed results for what concerns the stopovers where both the experimental and the control classes used the same mediator (City Organisation, Gallieno Wall) and those where they used similar technologies (plain pictures on booklet and plain pictures on smartphone – in a classic m-learning fashion – in Piazza Erbe and Bridges and Theatre). It is notable how where the mediator has been the same during a stopover, this mediator being interacting with the physical artefacts, like in the case of Gallieno Wall, we have a practically identical result, and a very high one. On the other side, we see how if there is no actual mediator but the explanation of the guide, and the concept is spread in the whole visit and possibly during movements between one stopover and another, things changes. This is the case of the Roman City Organisation, where the control group scored substantially better than the experimental one. Causes must be further analysed, but a first explanation based on qualitative data from observation, suggest that during the displacement from one stopover and another one the experimental group is distracted by the devices whereas the control group is readier to get by-the-way suggestions from the guide. But there is also a quantitative explanation. We have seen in Figure 30 how in the control group has a significantly higher familiarity with the use of the IWB. In the introductory lesson we made use of the IWB to explain the Roman organisation of the city.

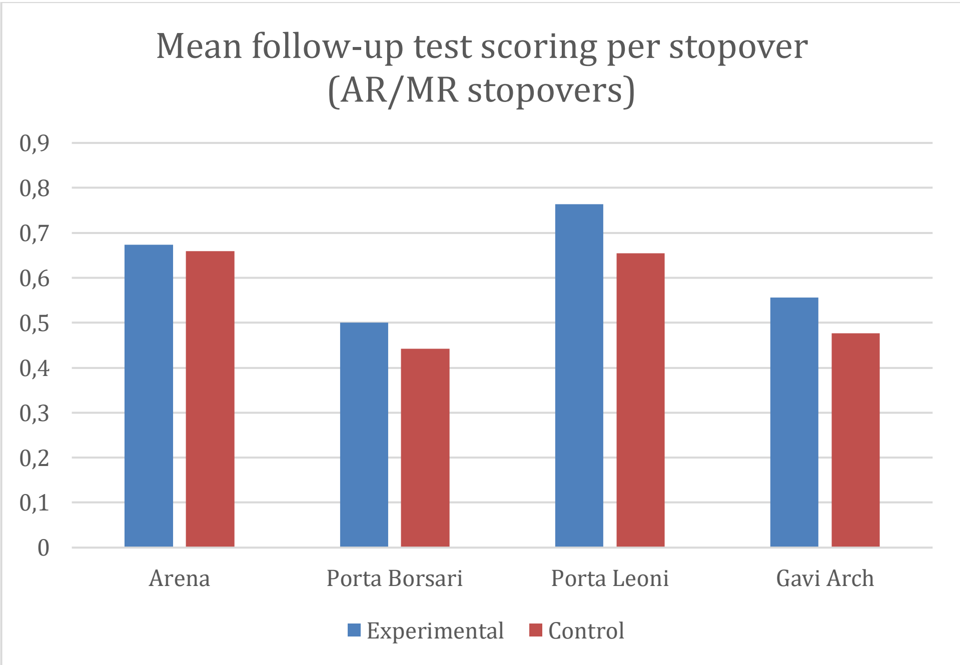


Figure 34: mean follow-up test scoring per stopover, where in the experimental group it has been used the AR/MR mediator and in the control group the booklet.

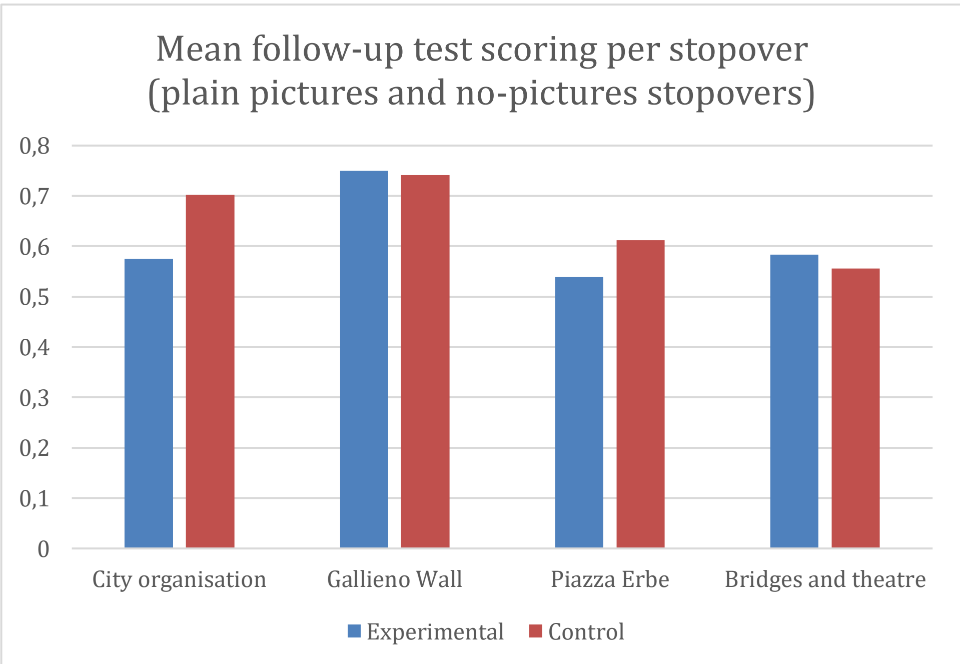


Figure 35: mean follow-up test scoring per stopover, where in both the experimental and the control group it has been used a similar mediator.

MLM analysis in the follow-up test scoring

In order to better explain the results obtained, it was decided to proceed with a MLM analysis with Type (Experimental/Control) and Gender (Male/Female) as fixed factors and as random factors the school and the order of the stopovers during the visit (to take into account the tiredness of the students). Partially overlooking the overall scoring at the final test, which is not of great significance given the analysis we have already done, I will analyse in the following sub-chapters the scoring about the single stopover. All of them are consultable in the Appendices, while here I will discuss just the relevant ones.

A significant non-MLM parenthesis

Using, just out of curiosity, the correlation analysis instead of MLM, which is not the best practice, I noticed a significant interaction in most of the experimental group stopovers, as wells as in the overall score, which is completely absent from the control group. This is the Pre C5 Component factor, the "use of the smartphone for communication and search of information vs familiarity with cultural heritage" (Figure 36). In the experimental group, the more the pupils normally use the smartphone for communication and search of information,

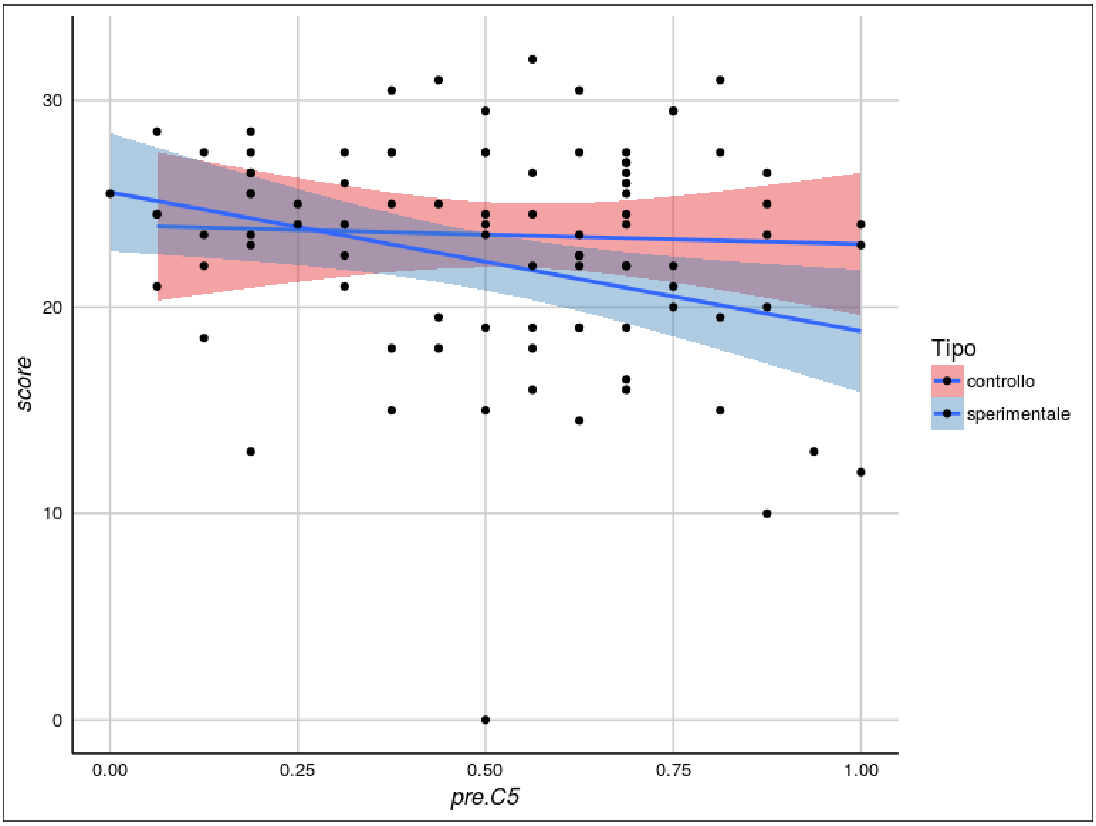


Figure 36: correlation between total scoring and Pre C5 (use of the smartphone for communication and search of information vs familiarity with cultural heritage).

the worse the score they get in many of the experimental stopovers and thus overall. We have an explanation for this in section 6.5.1.1, where we discussed the components.

Arena

The analysis highlights the significance of Component Pre C3 with a slope of 3.652. That means that students which use device for gaming more also have a better score in questions regarding the Arena stopover at the follow-up test (Figure 37). To better understand this significant interaction, it was subsequently analysed under the lens of the gender factor. As it is visible in Figure 38, while for boys the C3 influence on the score is negligible, for girls it is significative. In other words, if normally a girl that do not use devices for gaming had a slightly inferior scoring on the Arena stopover, the more the girls have used devices for games the more they matched and eventually outclassed the boy's performance. When one considers also the control and the experimental group, with the factor type, the result is confirmed for the girls but oddly the experimental group performance of boys seems to worsen the more they use device for gaming. That could

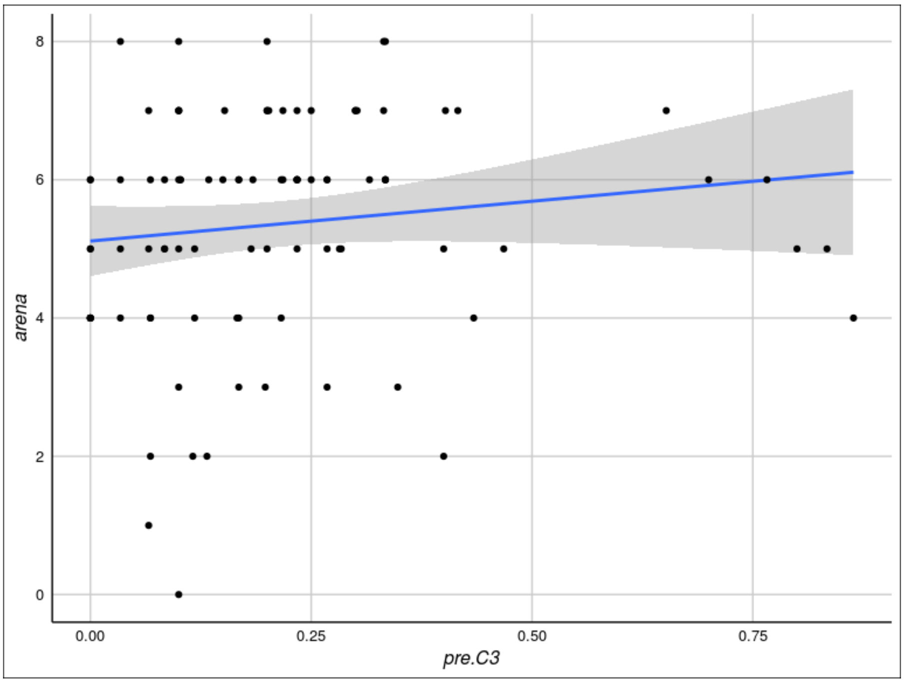


Figure 37: MLM between Arena scoring and Pre C3 (use of device for games).

mean that they get distracted from the technology or from some other elements. It is something to consider during the qualitative analysis.

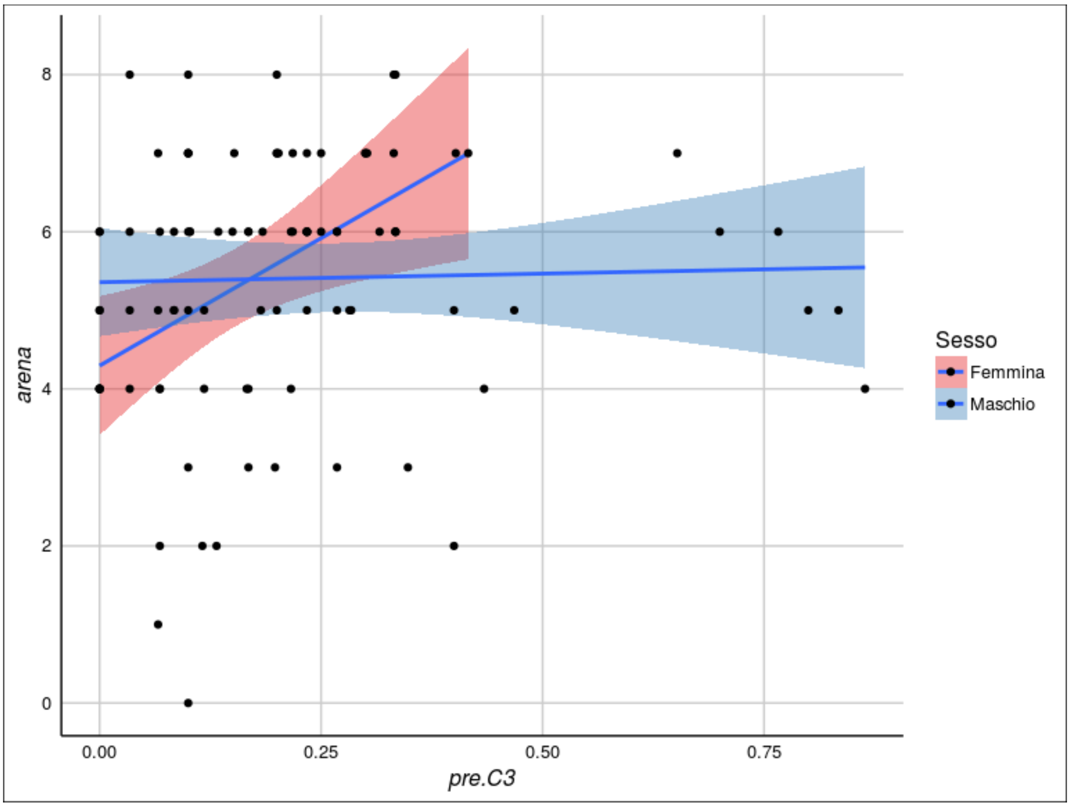


Figure 38: MLM between Arena scoring and Pre C3 (use of device for games), divided by sex factor.

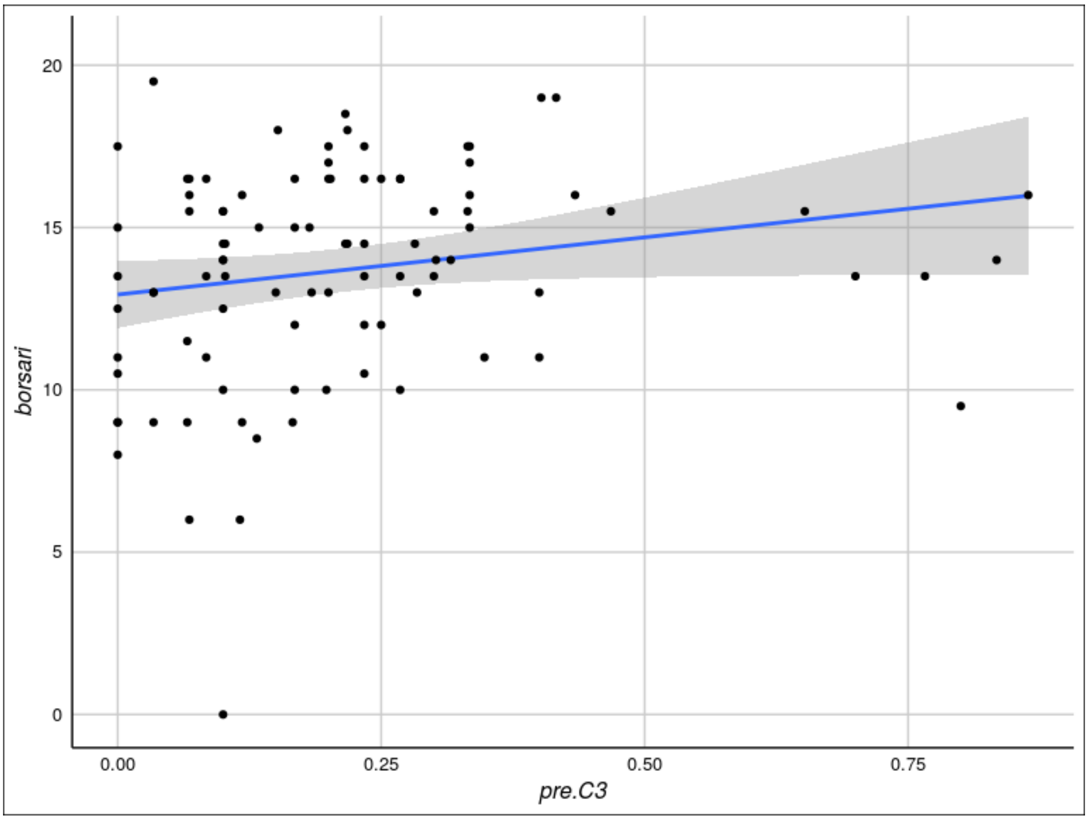


Figure 39: MLM between Porta Borsari scoring and Pre C3 (use of device for games).

Porta Borsari

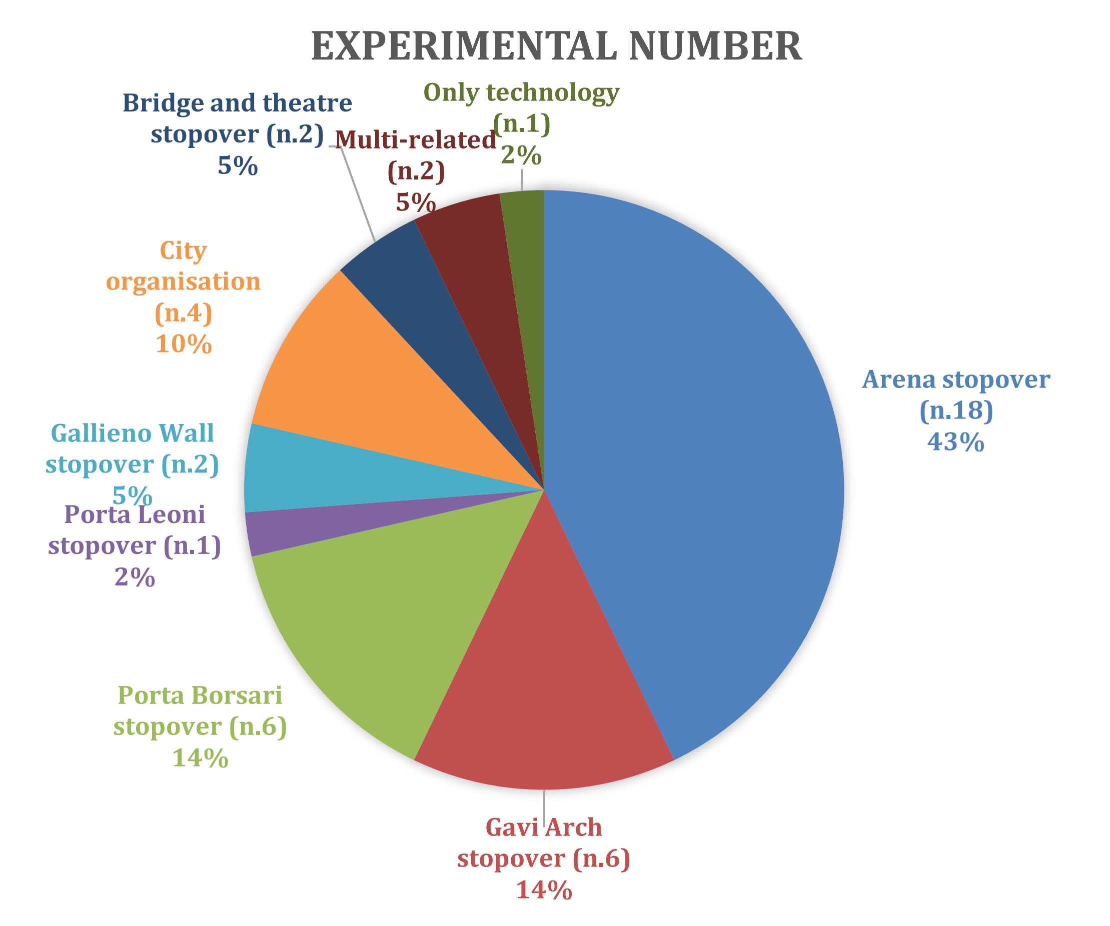
From the other stopover with the richest kind of AR/MR mediation with the Arena comes another significant effect. It is a significant interaction with the component Pre C3 (Figure 39), which is the same we found significant in the Arena stopover, the use of device for games. The slope in this case is steeper 8.838, thus indicating a stronger interaction. The more the pupils were familiar with the use of device for playing games the better the follow-up score was on questions regarding Porta Borsari stopover.

The gender factor

During the analysis, I saw many differences in the scores and interactions of boys and girls. Even if those differences are not all of direct interest for the current study, I considered it useful to speak about this aspect here in a separate section because it seems something of which it is better to be aware during the design of this kind of experience. In both the experimental and control groups, the girls tended to have very different, or even inverse, results compared those of the boys in their interactions with the components. One example of this occurred in the Arena, where training with videogames seemed to be important for the girls and optional for the boys. Moreover, in the Arena, the interaction with Pre C2 (the use of computers for communication and multimedia) in the experimental group again seemed to result in a slight advantage for the girls and a slight disadvantage for the boys. However, those discrepancies were not confined to the experimental groups. It is not just the technological mediator. In Porta Leoni, in the control group, the girls tended to have lower scores the more they used mobile devices for learning (Pre C1), whereas the boys tended to have higher scores. Finally, in the Gavi Arch stopover, in the experimental group, the girls had a negative tendency with Pre C4 (the use of computers for information sharing and learning), whereas the boys had a positive trend in this regard. Of course, one should also consider that, according to the component analysis, the girls used the devices much less for gaming purposes (Figure 31). Hypotheses could be made about those different outcomes, which could easily be the subject of further research. Future researchers might want to consider differences when using pictures reproduced in print and by means of other technologies, especially three dimensional, immersive, and spatial ones, but also when simply showing a building or an artefact from a visual point of view. According to previous studies, male and female brains may process these types of images in different ways, which could explain the discrepancies that observed during this research (Bradley et al., 2001; Sabatinelli et al., 2004; Llinares & Page, 2009; Mercer Moss et al., 2012).

6.6 Drawings as Feedback: A Great Entry into Virtual Reappropriation of Historic Structures/Visits

The teacher asked all the pupils in both the experimental and control classes to draw the 'thing' that they liked most in the visit to Roman Verona and to add a title or a very brief description. This allowed for the use of qualitative insights to better explain the quantitative results or to complete the picture with new information or effects. In fact, drawings represent a unique way for students to reenact and externalise experiences in a way that provides more insights into certain processes of internalisation and acquisition. Notably, this seemed sensible because the teacher was asking both the experimental and the control group members for an externalisation of information and concepts that were based on visual technologies. Ninety drawings representing different subjects were gathered. All the subjects related to a single stopover in the visit were collected, using the procedure followed for the quantitative analysis. Figure 40 illustrates how the drawings were distributed in the stopovers. Overall, the Arena was by far the most commonly drawn monument, followed by the Gavi Arch, the Bridge, and Porta



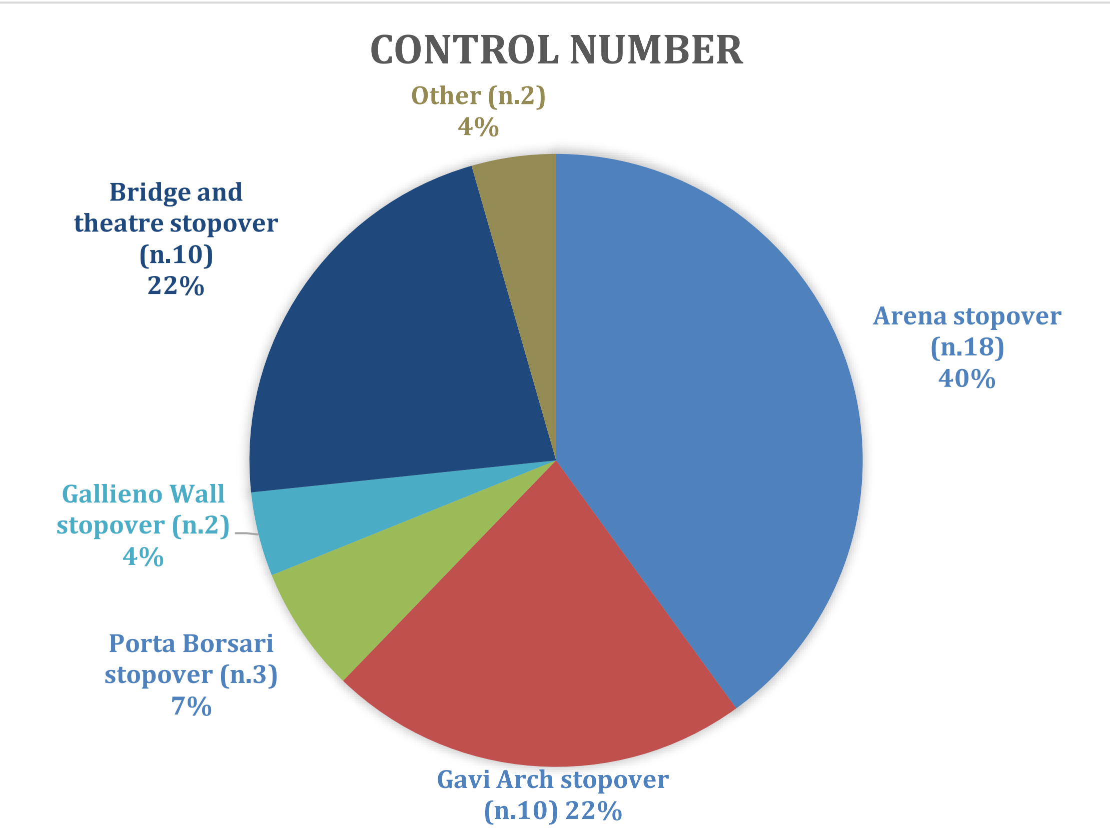


Figure 40: Experimental and control numbers of drawings related to stopovers.

Borsari, but differences emerged between the experimental and control groups. While the Arena and Gavi Arch had a great appeal to both experimental and control groups, the bridge and theatre stopover, a major one in the control group, had remarkably little relevance in the experimental group. The opposite was true for Porta Borsari. Those differences clearly demonstrate the influence of the use of the MR technology in changing the pupils' focus from some stopovers and aspects to others. In particular, the gates are not well known and monumental like the Arena and the Roman bridge and theatre stopovers, but in the experimental group, they attracted much more attention. Porta Borsari is represented in drawings of the experimental group twice as much as in the control group (14% against 7%). Porta Leoni is represented twice in the experimental group—once alone and another time in conjunction with other monuments. In the control group, it does not appear at all. City organisation is not present in the drawings of the control classes, while the experimental classes produced drawings dedicated to city organisation alone and to the presence of city organisation inside drawings of other subjects.

The quantitative data revealed the extent of the real differences between boys and girls when it comes to interpreting and internalising visual information. Because of that observation, I looked for a pattern in the differences between male and female drawings in the experimental group. The analysis on the drawings—only of those where the gender of the author was known—do not indicate the existence of any significant differences to be reckoned with between the boys' and girls' productions. The only noticeable detail is that, on average, the girls had better colouring techniques and also tended to use more colours than the boys did.

6.6.1 Three-Dimensional Understanding and Model Precision?

Looking at drawings made by experimental and control groups, coherent, group-specific characteristics became apparent. One of them was the different representation of monuments. In the experimental group, the monuments were drawn with a higher resemblance to the original and with a more correct projection of the three-dimensional object on the two-dimensional paper medium. This is true only for the stopovers where the students used MR technology. In the control group, most of the representations, seemed based on two-dimensional projections of two-dimensional models. Of course, it is possible that both the experimental and control groups used photos of the monuments as a model for their drawings, but this does not seem to nullify the general pattern. In Figures 41 and

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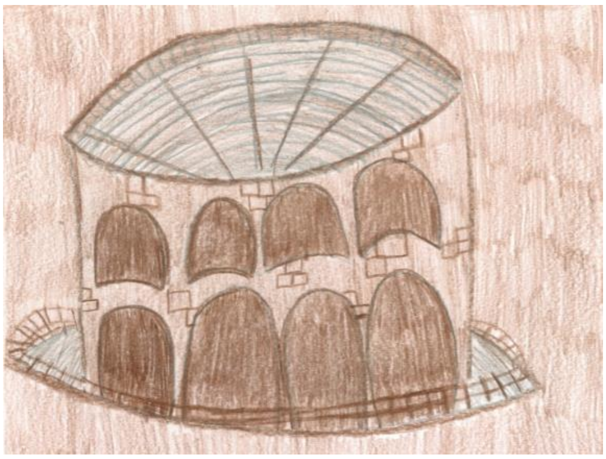
2.

3.



4.

Figure 41: particulars of drawings of experimental group.

42, some details of the drawings of the Arena are isolated to help visualise the pattern. While the mental model regarding the Arena seems to be a three-dimensional one in the experimental group (Figure 41), in the control group (Figure 42), it seems to be a two-dimensional one or at least a less refined three-dimensional one.

6.6.2 The past and taking history into account

In many pictures drawn by both control and experimental groups, the details reveal an understanding of complex concepts, often differing between the two groups. For convenience, the same Figures 41 and 42 can serve as examples here. For instance, Figures 41-1 and 41-3 indicate that the pupils had a very clear understanding of the concept of the old perimeter of the Arena and of it being two metres lower than the actual ground level. In Figure 42-3, one can see the details of the upper *arcovoli* (arches in the Arena's structure) bricked over, highlighting that students understood the history of the monument and the different uses made of those arches throughout the centuries.

Only a few of the experimental group members drew the monuments as they were in the past. There are two drawings of the Lustral Jupiter Temple that used to be in front of Porta Borsari, just one of the Arena (while others are not clearly identifiable as the original Arena), one of Porta Leoni, and one of Gavi's Arch.

Giulia's drawing

The latter (Figure 43) is a very impressive drawing for many reasons. Giulia created the following caption for it '*This drawing represents what is visible from the smartphone of the guides. It represents Roman Verona, reconstructed. One can see: Gavis's Arch (in the middle), the Arena (on the left) and a gate of the walls (on the right)*' (Appendix 3 CD-ROM). Firstly, Giulia had to remember the VR environment where she had had the experience, and she had no opportunity to see it again after the visit. She demonstrated an understanding of the spatial disposition of Roman monuments in Roman times, and she depicted this in a two-dimensional drawing. Of course, she was not able to show what she was able to see with a 360 degrees headset, so she created a capriccio-like drawing to illustrate it.

In Roman times, Gavi's Arch was in the middle of the Postumia Road and from the same spot in the middle of the road one was able to see the Gavi's Arch, the Arena and Porta Iovia (Portoni Borsari nowadays), but not

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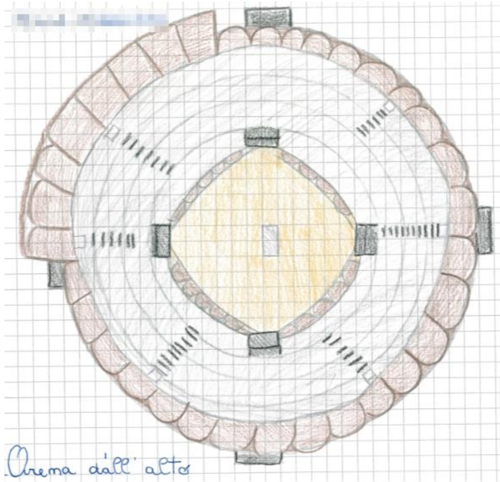

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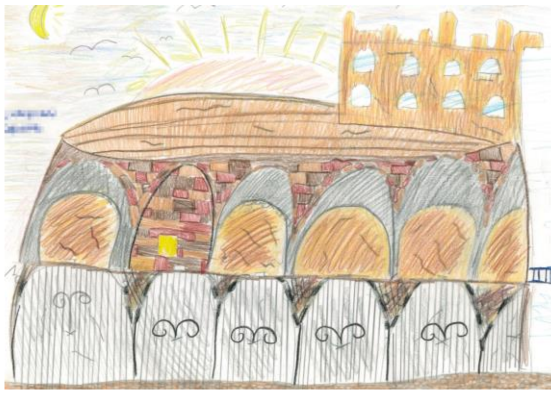

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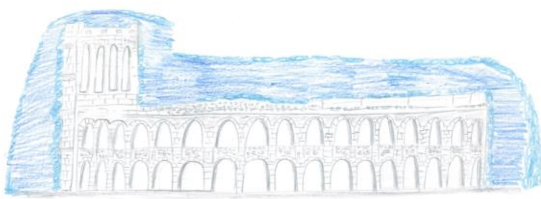

Figure 42: particulars of the control group's drawings.

Figure 43: Gavi's Arch capriccio drawing.

quite simulateneously at the same time. A Roman visitor looking towards Gavi's Arch, being just outside Porta Iovia, would have had to turn slightly left to see the Arena and almost back to see Porta Iovia. While looking with a headset at the virtual reconstruction, Giulia was—virtually—in that same position. The three-dimensional environment was all around her and in order to look at the different monuments she had to turn accordingly. She was virtually at the centre of a spherical 360x180 degrees space. To achieve such an effect on a bi-dimensional medium such as paper would require employing the technique of panorama painting and have a spherical, or, at least, 360 degrees medium. Since the only medium at her disposal was an A4 sheet of paper, Giulia synthesised in that drawing what she learnt. She arranged the elements in a *capriccio*-like fashion, respecting the relative distances of the monuments from the observer, but rearranging them to be partially visible in the same view. Foreground, middle plane and the background are perfectly discernible in the drawing. Gavi's Arch stays as a focal point in the middle of the street on the background, with the two statues that used to be there[27], the Arena partially appears on

[27] to be noted that the two statues were not reconstructed in the virtual environment, their presence was a textual information in the AR mode of the app that was also externalised by Giulia in this drawing.

the left at middle distance and Porta Iovia partially appears in the foreground[28]. This disposition leads one to think of eighteenth century's *vedutisti* such as Guardi, Canaletto or Pannini who were used to add or 'drag' elements in the background, middle ground and foreground of their vistas.

I think the work of Giulia is a particular example of ekphrasis because she represented the information of a certain type of medium, the virtual 360x180 degrees environment and the AR environment—which includes also textual information— into another one, the bi-dimensional paper sheet.[29]

Thinking about further research employing the drawing analysis, would be interesting to interview the children about their paintings after the analysis. It would also be interesting to explain to children some of the roman architecture through veduta paintings, of Pannini for example, and to see how this pictorial 'translates' in their paintings and helps them in describing graphically the cultural landscape.

6.6.3 Awareness and Interference Caused by Augmented/Mixed Reality Tools

It is apparent from Figures 41 and 42 (even if they are particulars) that, in general, the experimental group's pictures have more context than the control group's pictures—but one can see it better looking at the full pictures to be found in Appendix 3 CD-ROM. That is, the experimental group representations include more depictions of the monument on which the students were focussing as well as elements of the sourrounding landscape. Furthermore, more of the experimental group's drawings depict a foreground (which was usually the ground), the monument, and a background. The elements that the experimental group added were often spatial references, such as streets, plants, other monuments, and people, which contributed to an understanding of the relationship between the monument and the landscape.

Control group drawings do not show any mediation between the cultural artefact except for, rarely, the guide and the teacher. No drawing directly represents the booklet, although some drawings seem to have been inspired by the booklet pictures. The booklet appears to function as a 'transparent' mediating tool, even if—as argued in section 5.1.2—no tools are ever perfectly 'transparent' as they always carry along their own mediating means and

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[28] details here are remarkable: she distinguishes the Republican brick part in brown form the Imperial stone facade in grey, which is the only part that still stands. Crenellations nowadays are no more existent either.
[29] See section 8.6.4 for further thoughts about ekphrasis in this research.

effects. The drawings from the experimental group indicate the AR device (i.e. the smartphone or the tablet) was not transparent for everyone. In some case, on the contrary, it might have distracted the students. The list below describes the four different layers of technology interference detected during the research period:

1. They focussed purely on technology: This was the kind of interference that we were hoping to avoid. This worked, for the most part, but one drawing still shows signs of it. This type of drawing only represents the technology (i.e. the device) without any information about the heritage or the context (Figure 45-3). We only found one of this type, representing 2% of the experimental drawings.
2. They focussed on heritage through technology: This is similar to drawing a picture of a real object. Pupils represented the heritage in the frame of the device and the app (i.e. the pupil drawn the device on paper in the first place as a frame for the heritage, then were there should be the screen of the device they represented the heritage) (Figure 45-2). The students produced two drawings of this kind—almost 5% of the experimental group drawings.
3. They focussed on heritage and technology interaction: These drawings represent how the heritage is in reality but also refer to the use of the technology and sometimes heritage as it is perceived through technology (Figure 45-1). Basically, there is a first—and third—person view of the interaction with the technology. This category covers the 14% of the experimental drawings.
4. They focussed on augmented heritage: This kind of interference is a positive one and something to pursue for later research. It is a synthesis of real and virtual information. These drawings represent the past or the present augmented by visual imagery or written information where the technology is transparent and invisible, as illustrated in Figure 43. One variant of this kind of interference involves using the drawing sheet as an organised space that mimics the function and categories of the app (e.g. keeping the space for a map on the top-right corner). We classified 26% of experimental group drawings in this category.

Figure 45: Examples of drawings of the first three categories of interference.


Figure 44: Details of drawing with the guide explaining and pupils looking around with and without carboard VR.

In summary, although being aware of mediating tools can help students at the level of meta-cognition in their learning process, in this kind of experience, ensuring the transparency of those tools would help to prevent them from acting as an overly powerful distractor: They should deliver information while remaining as unnoticed as possible. As already discussed when explaining the design of the tool in sub-Chapter 6.3, I tried to avoid all the possible menus and complicated interactions with the app to let it be used just as a ‘frame’ to look at the reality in the most transparent way possible.

It was interesting, from my point of view, to gather intelligence on the use of the technology captured in drawings. Therefore, here I am talking only about drawings made by the experimental group. Clues as to the attribution of meanings, importance, and emotions were founded. One of the first aspects that emerged from some drawings relates to emotions raised by the technology. While I found nothing about the use of AR technology, there were clues about the use of VR technology. In Figure 45-1, the girl using the headset is looking around at a virtual landscape, and she is smiling. Elsewhere (Figure 44), children have been represented in a ‘jaw-dropping’ expression of amazement while using the Google Cardboard headsets and seeing what the guide is telling them. In addition, some pupils paid attention to the brand of the device, its shape, and the position of software buttons. Some of them also remembered the interface of the MR app in minute detail. This seems to indicate a special interest in the tool itself and its working principles, as well as an acquired competence in the use of the MR app.

6.7 Evaluation of the experimental visit through activity theory

The case study of Roman Verona consisted of complex interactions between at least four different activities systems (ASs) sharing the same boundary object as ‘the’ object, as well as another boundary object serving as a mediating artefact (Figure 46). The shared object was the Roman Verona experience, while the mediating artefact was the object of another AS that led to the creation of the MR app. This sub-chapter contains an analysis of the augmented visit AS, which is the shared object of the other four, with the interactions between the four systems in mind. As mentioned in Chapter 5, elements of the activity checklist were integrated into an analysis typical of third-generation AT.

6.7.1 The augmented visit activity system

The augmented visit class Activity System (AS) (Figure 47) has, as its subject, the student of the class that participated in the visit and, as its object, the Roman cultural heritage of Verona. As the mediating artefact, which is a tool in this case, there is the MR technology; as the community, there are the other classmates, the teachers, the

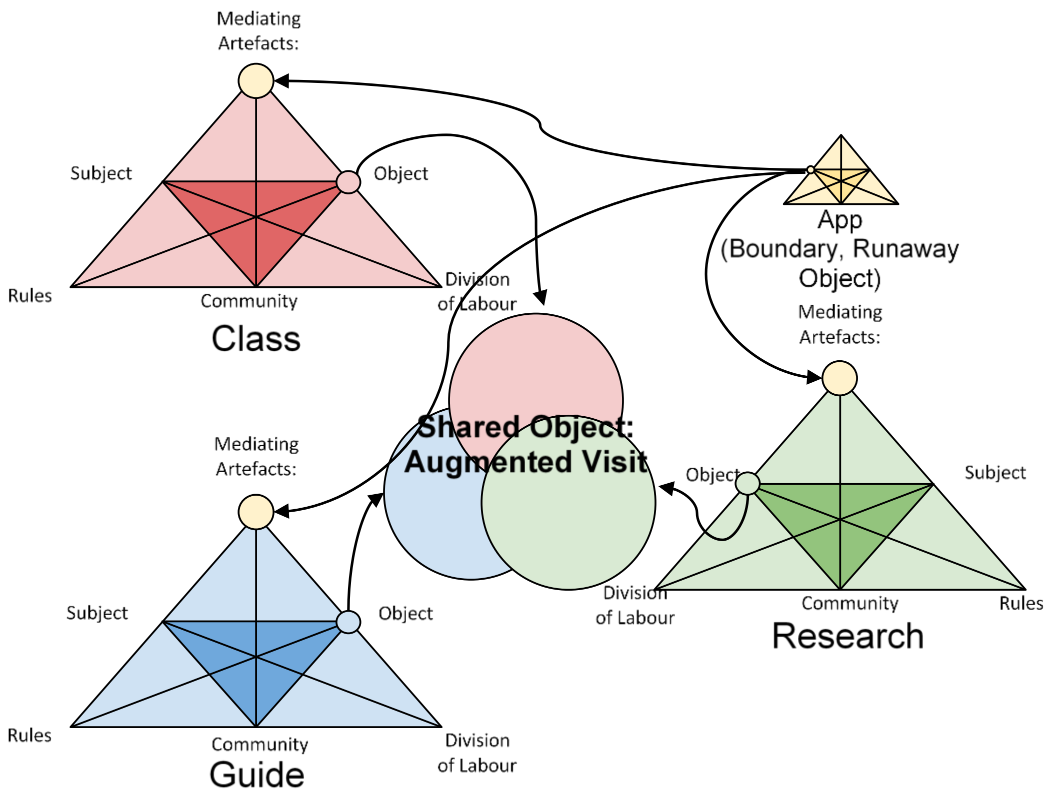

Figure 46: The Roman Verona study activity system.

researcher, and the guide. The rules are those common during every school visit, plus some particular to this visit, such as the use of the mobile device. The division of labour has to do with the roles that each person in the visit had, as well as with the alternation between the two children in the pair sometimes required in the use of the mediating tool. Finally, later in this chapter, the outcomes are presented. The desired outcomes are closely connected with the goals of the activity.

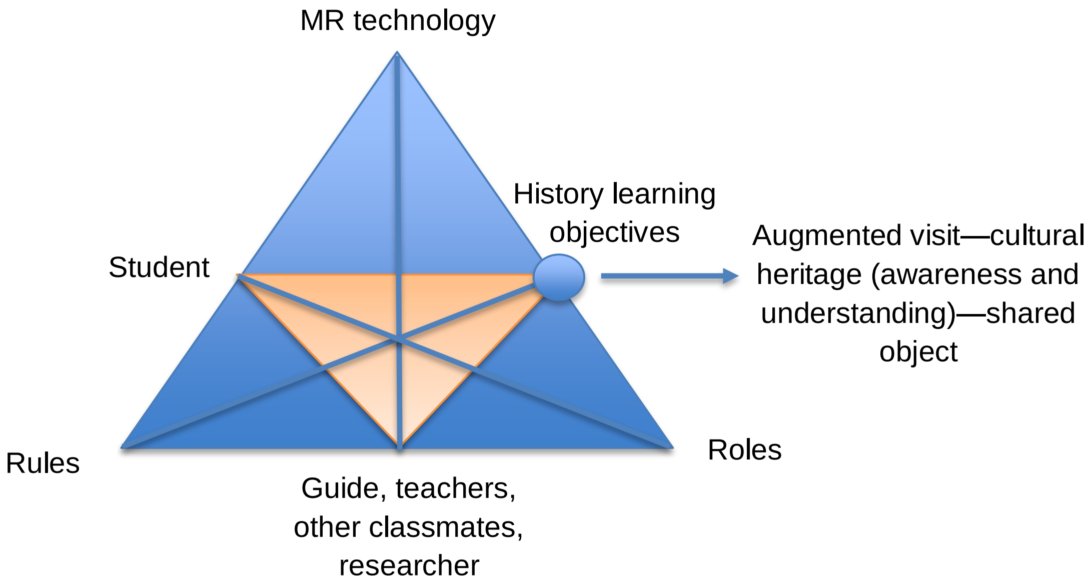

Figure 47: Roman Verona augmented visit—class activity system.

Goals and sub-goals of the activity

As stated before, the main objective of the activity was to make accessible the Roman history of Verona and the importance of the visible remains in the city to students. Added to this was also the aim to show the transferability of the same concepts to other Roman cities. One final goal was to impress upon them that what they have visited is a collective heritage shared between every one of us, one that should be understood, protected and passed on. Sub-goals were, for example, an understanding of the road system, of fortifications, civil, entertainment and celebratory structures in the Roman city of Verona. In addition, they had to discern the transformations of the city and the layering of artefacts from different times.

All these goals were sometimes in conflict, because not of inconsistency, but possible temporal overlap. We had to ensure that while the guide was giving data on a monument, pupils did not get distracted from the context by means of the MR technology. We employed rules and the Tri-AR methodology to avoid this.

Criteria for success or failure of achieving target goals

Success would mean having most pupils remembering main ideas and key concepts in the follow-up test, thus demonstrating that they understood the function in the Roman Verona system. Furthermore, they needed to express themselves in the open questions and drawings spontaneously, demonstrating their views and reflections on the visit and the heritage. If those indicators showed hints of an understanding of the importance of the heritage, the activity was considered a complete success.

The strange case of heritage as the object

As briefly explained in Chapter 1, heritage is a particular object to deal with. It could be both the object and the mediating artefact. Moreover, it could be also the *objekt* and *predmet*: both the physical object that exists independently outside of the human mind (e.g. a tree) and the kind of object that exists only in relation to human use (e.g. the labour involved) (Kaptelinin, 2005).

MR technology mediation

The mediating technology was the MR app used by the students (in pairs), by the teachers (as auditors), and by the guide. The researcher was present for observation and technical support. To better understand the nature of this interaction between the students and the app, we propose analysing it with Engestrom's mediating artefacts hierarchy. The MR app seems to occupy more than one place in the hierarchy in this case. The first class is represented by the 'what' artefacts, and the MR app is part of this category because it is a means of achieving the object. It is also part of the 'why' class since it provides motivation and engagement for the achievement of the object. Finally, it is of the 'where-to' class as well since it fosters the evolution of all the elements of the AS.

Students–MR technology relationship

The main focus will now bear on the interaction between pupils and the tool, and the active behaviour they had while using it. Pupils actively looked for information and correspondence through and thanks to the 'app', so every action of the activity mediated by the technology required an active attitude to reach the goal (Kuutti & Arvonen, 1992). For example, with the sub-goal of understanding the inside of the Arena in Roman times and the epochal changes, the students needed to use the mobile phone, look around, and explore the virtual scene, in order to find all the differences and connect what they were looking at with the guide's explanation. I explored this relationship to understand which kind of actions the subjects preferred (Figure 48). Almost everyone answered this question. The findings indicate that 52% of the students enjoyed using the Google Cardboard VR immersive interaction most, 24% seeing and better understanding the past, and 11% using the device and app in general. That means that at least the 76% of the pupils enjoyed the action of seeing the past through the MR app.

Nevertheless, the observation and feedback revealed that there was a conflict in this

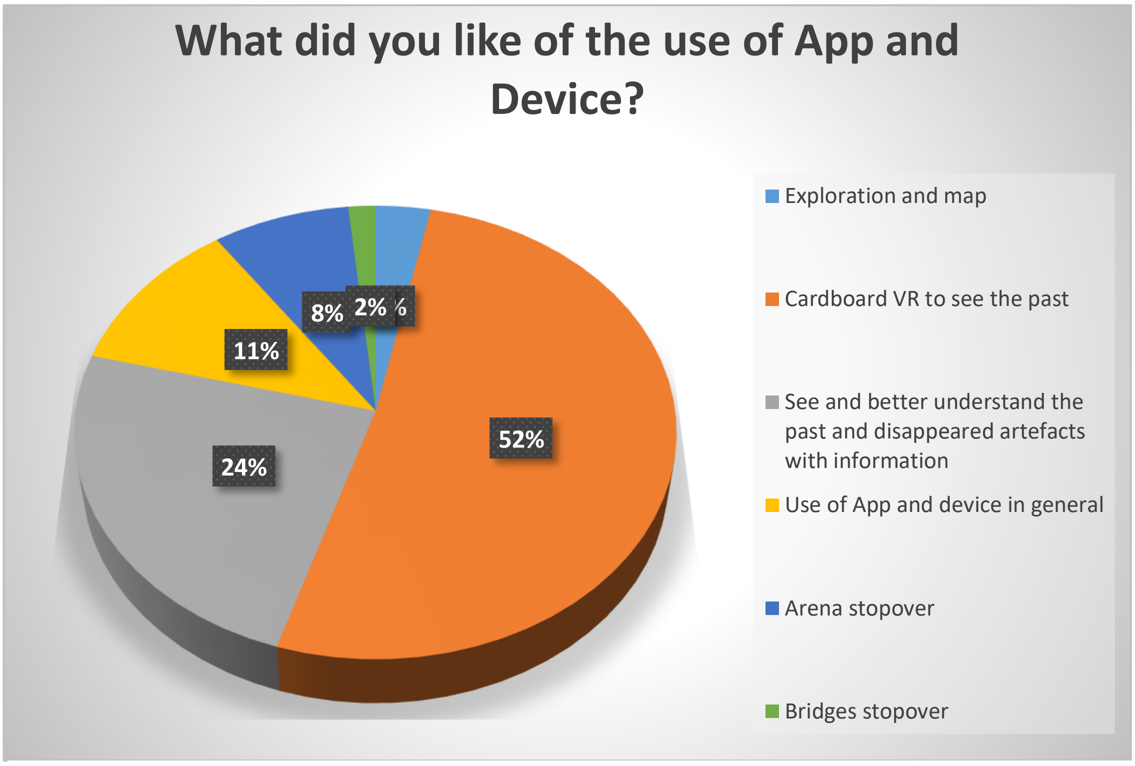

Figure 48: Graphic on the question of the post-visit questionnaire for Roman Verona: 'What did you like about the use of the device and app?'.

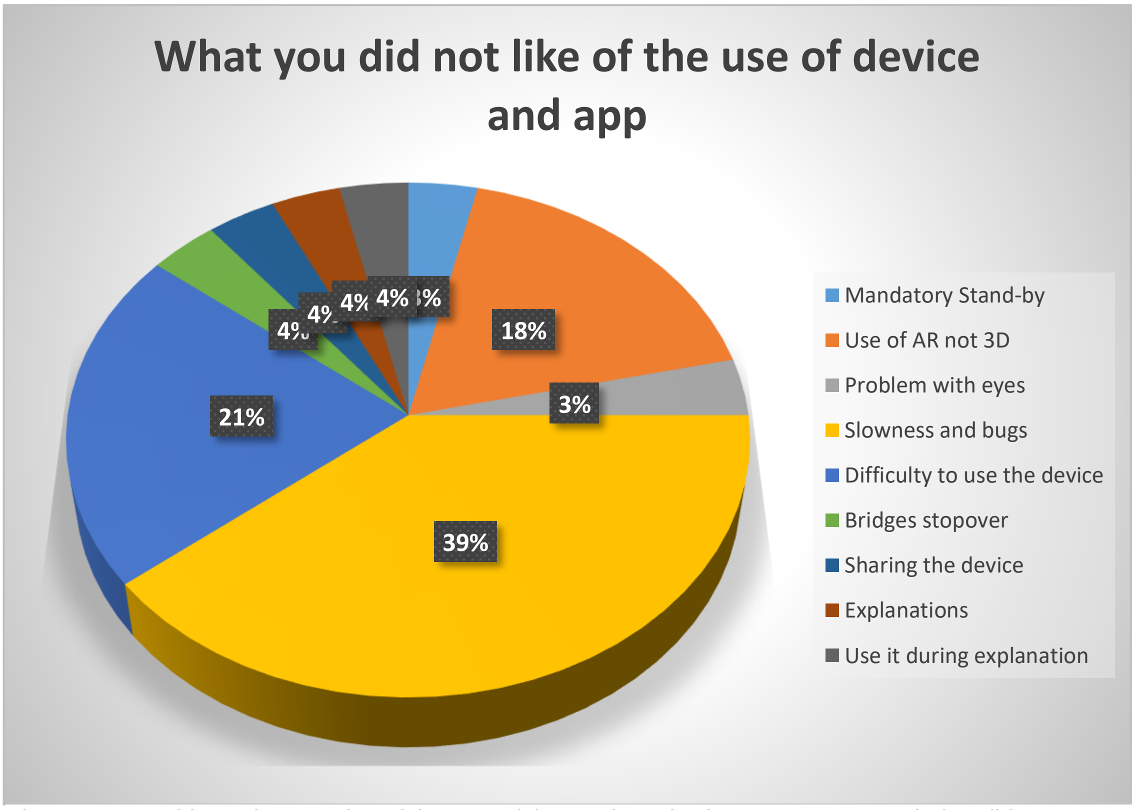

Figure 49: Graphic on the question of the post-visit questionnaire for Roman Verona: 'What did you not like about the use of the device and app?'.

interaction because of several problems the app experienced in terms of bugs, lags, and crashes (Figure 49). Pupils using the less up-to-date devices experienced this issue severely. Only 28 of the 70 (40%) children taking part in the experimental group answered the following question: ‘What did you not like about the use of the device and app?’ Several of the others only answered the positive question or wrote that they found nothing bad in the device and the app. However, 39% of children that did not like something mentioned slowness and bugs. This, together with pupils who had general difficulties in the use of the device, brings the percentage to 60%. It is also worth noting that 18% found it frustrating not to only using the device in VR mode. This can be considered more as a conflict with the rules or a conflict between modalities of the same mediating tool, but we cannot really solve these tensions. After the first experimental visit, I tried to fix these errors when possible, but many of them were related with the following issues.

1. Old devices: lack of funding on my part to buy newer, more powerful devices.
2. Misuse of the device: although the pupils were generally able to use the smartphones, they did not have an understanding of how they worked and the proper way to use the mobile operating system. For example, they continued to restart the app instead of re-opening the same instance of the app. Therefore, the working memory (RAM) of the mobile phone often became full, resulting in a frozen device.

Troubleshooting strategies and techniques

Having anticipated those kinds of problems with the devices and the app, I decided, as a technology expert, to participate in the visit for technical support and observation purposes. Due to the many devices that froze during the visit, it was necessary to stop for a few minutes and explain to the students how to use the Android task manager properly. After that, students did not need the researcher’s help as much because they were able to solve or prevent most of the problems with the app, which were often related to a lack of memory.

Support and mutual transformations between actions and operations

At the beginning of the visit, during the explanation of the Tri-AR method and the use of the app and the device, the students received instructions about how to use both and respect the phases of Tri-AR. Almost everything concerning the interface of the app had to be learnt in those first minutes. For example, students had to learn how to navigate and explore their surroundings, how to activate hotspots, and how to time travel. After this short training and throughout the visit, those actions became operations since they were automatically activated to execute an action (e.g. exploring the Arena). In the situation described in the previous section, where the smartphones kept freezing, we reversed those operations to an action level in order to perfect the procedure and therefore avoid most of the device blocks.

6.7.2 Environment and heritage relationships between the MR app and students

Role of MR technology in reaching the goals of actions and relating with the object of the activity.

Rarely has the concept of a 'functional organ' been more appropriate than in this activity. A functional organ is, in fact, the result of the temporary fusion of internal and external resources, human capabilities, and tool properties to attain goals that could not be attained otherwise (Ukhtomsky, 1978; Leontiev, 1981; Zinchenko, 1996; Kaptelinin, 1996). Looking at the MR technology used (extensively explained in Chapter 3), which allows the use of the smartphone or device to merge a virtual visual layer with reality, we can understand how it fits in the 'functional organ' definition. Without such a technology, it would have been very difficult for the students to understand and imagine Verona in the first century AD, how the single monuments visited were integrated into the fabric of the city, and the purpose they served. In addition, the technology contributed to the engagement of the students, creating internal conditions conducive to learning (Figure 50). It is interesting to notice how

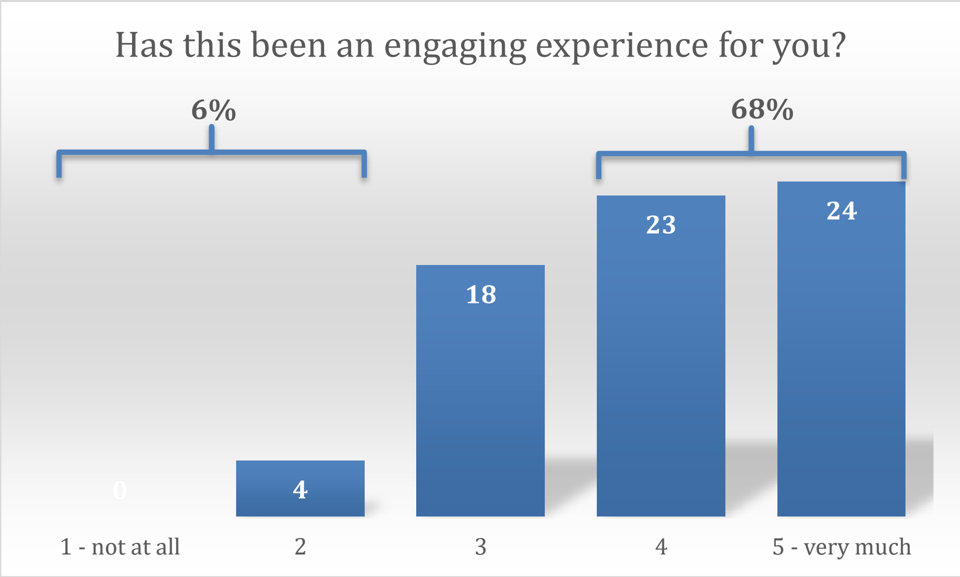

Figure 50: Frequency distribution of the answers to the following statement: 'Has this been an engaging experience for you?'

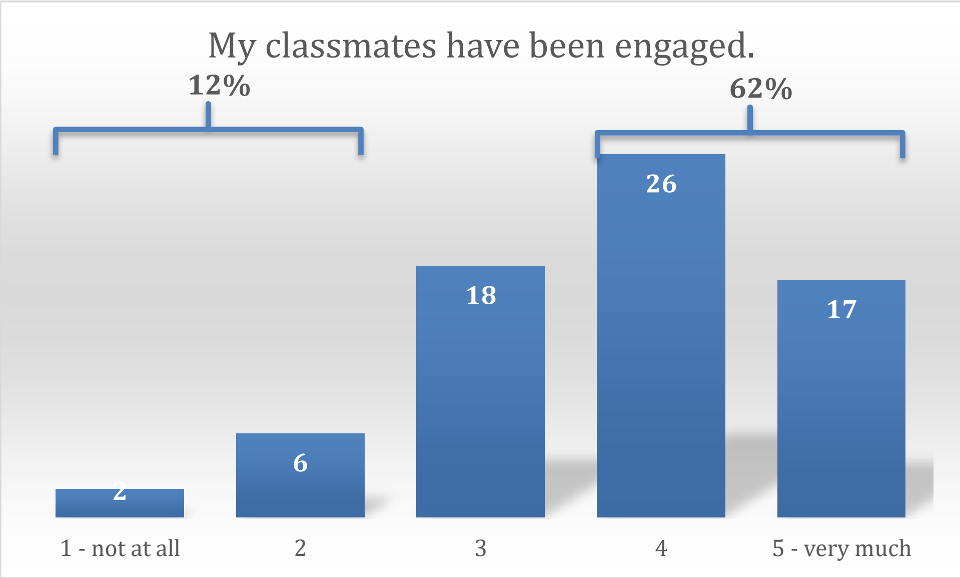

Figure 51: Frequency distribution of the answers to the following statement: 'My classmates have been engaged.'

the students could evaluate the engagement of their classmates as well (Figure 51) in a more critical way. As already illustrated in Chapter 3, MR technologies have the capability of presenting very contextualised information that can contribute to the construction of knowledge providing 'just-in-time' information. Finally, MR forced the students to work to normalise the cognitive dissonance between reality and mixed and augmented reality through a process of reinterpretation of reality by means of their newly acquired knowledge.

Heritage as a mediator

Section 6.9.1.3 contains an explanation of the concept of heritage as a mediator and object at the same time. Therefore, this section elaborates on how this variable acted as an additional tool available for the students. Following the instructions of the guide and their own visual exploration and manipulation of the artefacts, the pupils were able to understand cultural meanings and symbols. This happened through the artefacts (the remains) as mediators of heritage, the result of the crystallisation of social meanings. For example, during the explanation of the guide at the *Mura di Gallieno* (Gallieno Wall), the guide invited pupils to look at and touch the stones of temples and other monuments used by Emperor Gallieno in order to build the wall. It resulted one of the most successful stopovers (see sub-Chapter 6.6.1) even without the use of any MR technology.

Tools and materials shared between several users

Both the devices and the heritage itself were shared tools. But, while heritage is inherently shared, the shared use of devices sometimes became an issue. The devices were shared between two children. In part, the initial instructions were designed to explain that the device had to be given to the other child at each stopover. During a stopover, both children had to do the same exercise with the device and the app even though only one would be carrying the device. Sometimes, this arrangement was not adhered to, requiring an intervention from the teacher.

Division of labour, the roles during the visit

During this detailed analysis, the description of roles and division of labour has been partially illustrated. It consists of four main roles. The guide leads the visit, explains the activity to children, and interacts with them, sometimes through the app, following the patterns of the Tri-AR model (section 6.4.1). The class teachers had a role in maintaining the pupils' good behaviour and answering all their needs falling outside the conduct of the visit. The researcher was an auditor as well for most of the excursion, except when a technical problem with a device arose, in which case the researcher's job was to fix or replace the device to enable the visit to proceed as smoothly as possible. Of course, the students had their role: to listen, understand, explore, and ask questions. Moreover, they had collateral roles for organisational purposes, such as forming pairs and to carrying mobile devices and Google Cardboard headsets.

Rules, norms, and procedures regulating social interactions and coordination related to the use of target technology

It is normal that a visit involving a school class has a defined set of rules regarding the safety of the pupils, as well as the responsibilities of the adults and, notably, the teachers. Rules exist to specify how many teachers are needed for a certain number of students, requiring the students to wear high-visibility vests and carry documents with all the information needed in case they get lost. For this particular visit, as already mentioned, we took a few minutes at the beginning in order to explain the rules regarding the interactions between the guide, the students, and the technology. The rules are included in the Tri-AR model and described in section 6.4.1. In brief, the development of every single experimental stopover (stopover with the use of MR technology) is split into four phases. When the phase changes, the rules changes. The rules relate to whether or not the students may interact with the app, with the guide, or between themselves. The rules start with a first phase when pupils need to just listen (if they are not questioned by the guide) and proceed to a final phase when they have the initiative and the freedom to interact with both the guide and the app.

6.7.3 Learning/cognition/articulation

Internalisation and externalisation processes in the visit

Internalisation and externalisation processes existed on two different levels during the activity. The first one occurs at the mental processes/external behaviour level, and the second one happens at the inter-psychological/intra-psychological level (Vygotsky, 2012)—in other words, external mental processes shared with the community (inter-psychological) and the mental processes inside one's own mind (intra-psychological). During the visit, these processes were continuously occurring and especially appreciable at every stopover during the Tri-AR routine. For the sake of simplicity, this research only deals with the internalisation and externalisation processes from the perspective of the pupils.

In this first step (Figure 52), the guide provides an introductive description of the place or the monument, its history, and its use in Roman times. The guide also highlights the differences between the place as it is now and how it was in the first century. In this phase, the student, who is always the subject of the action, internalises information directly from the guide and, at the same time, the information and meanings mediated by the heritage being explained.

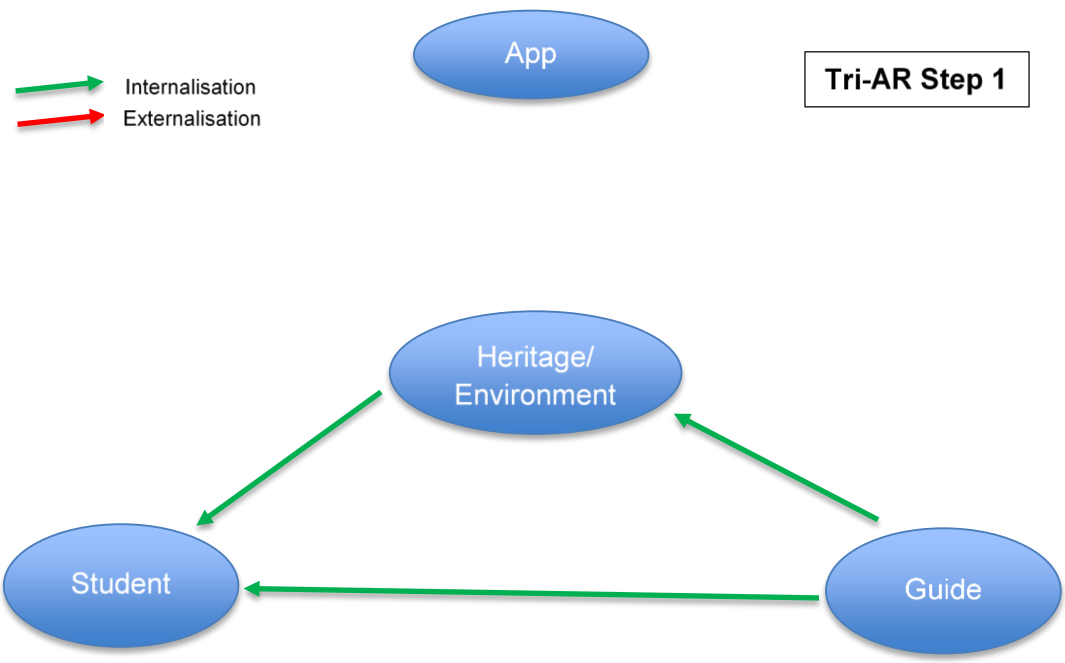

Figure 52: Internalisation and externalisation processes of the students in the first step of the Tri-AR methodology.

In the second step (Figure 53), the guide encourages the students to use the app to discover the elements discussed in the initial explanation in th actual environment. Then, the guide asks the pupils to discover details and AR or MR content, eliciting feedback by asking specific questions. In this phase, the student is called to actively engage with the app as a mediator with the heritage. This process makes the pupils externalise—at the action level—what they have just acquired from the guide. While looking for the correspondence between what they have just learnt and the information on the app, they internalise information and meanings.

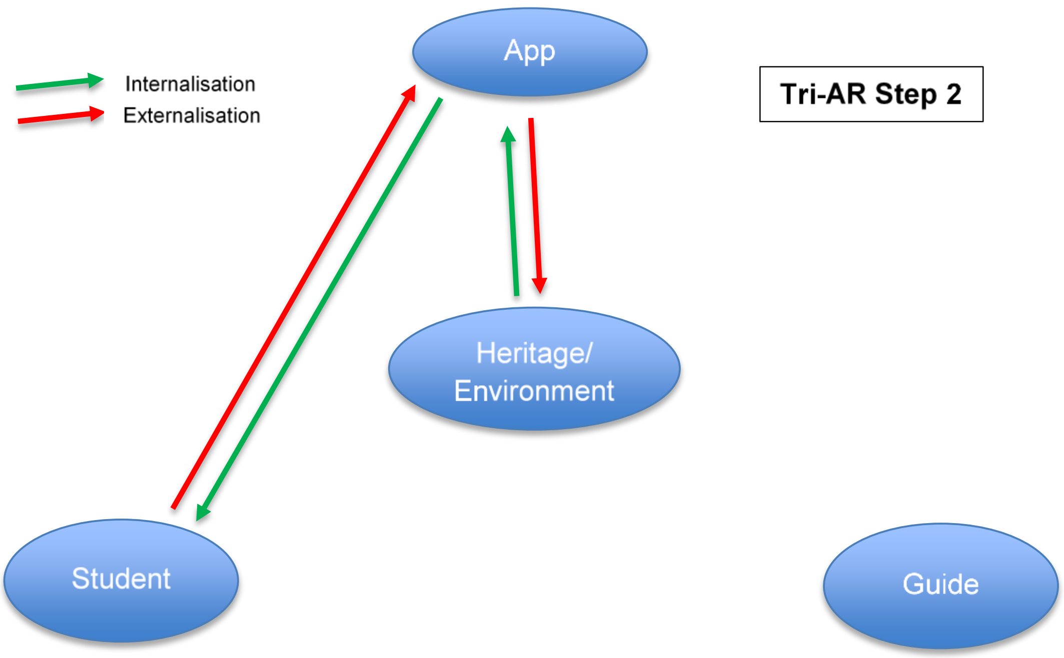

Figure 53: Internalisation and externalisation processes of the student in the second step of the Tri-AR methodology.

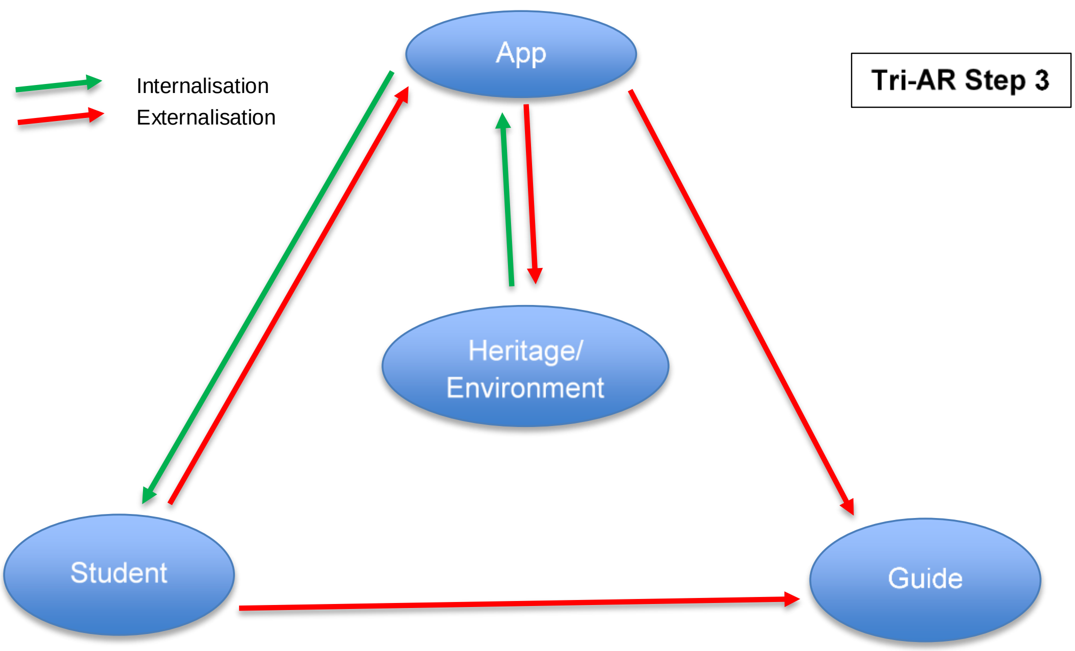

Figure 55: Internalisation and externalisation processes of the student in the third step of the Tri-AR methodology.

During the third step (Figure 54), students provide feedback and, freely exploring the environment through the app, they ask their own questions. Here, the process of externalisation is also at the inter-psychological level. In fact, pupils share their observations and their questions with their classmates and the guide in order to solve them

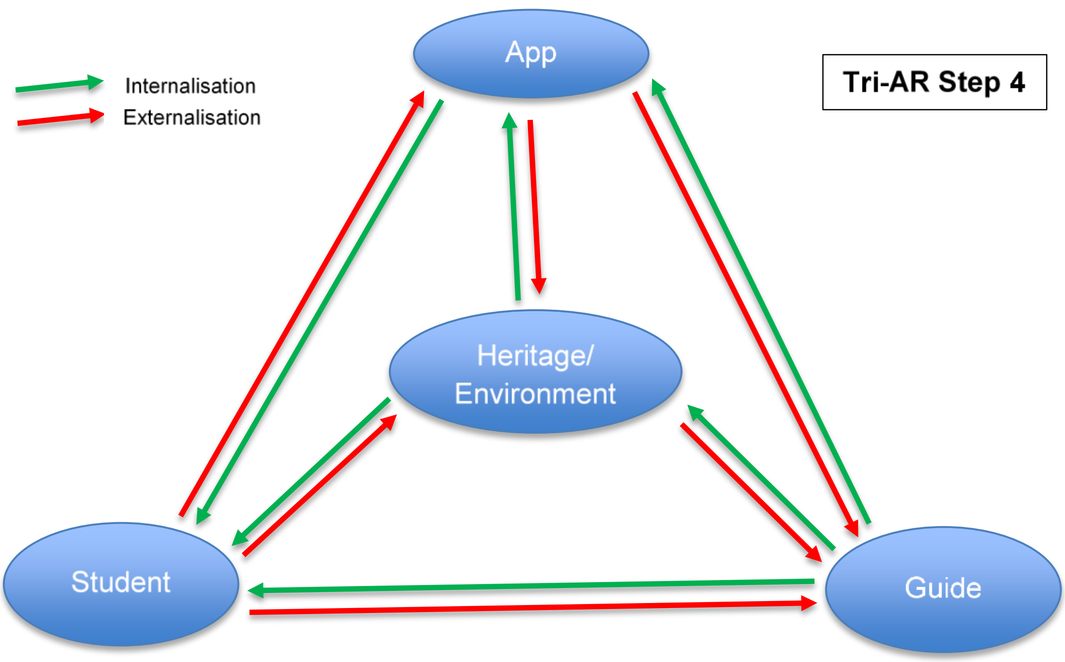

Figure 54: Internalisation and externalisation processes of the student in the fourth step of the Tri-AR methodology

within the community. Once the community finds the answer, it can be internalised at the intra-psychological level.

In the final step (Figure 55), the guide answer students' questions. The guide oftenmakes reference to the app in order to better illustrate answers. Students interact with the guide by referring directly to the artefacts or the environment or by using the app as well when they think it is useful. In this phase, all the previous interactions are possible, as well as more classical ones, including, for the students, using the heritage as a mediator and thus by-passing the app. This means that processes of internalisation and externalisation, both at the mind/behavioural level and at the inter-psychological and intra-psychological levels, could happen depending on the students' level of initiative.

Knowledge about MR app technology in the community and how this knowledge is distributed and accessed

The knowledge about the MR app technology in the community came from the researcher, who transmitted it to the guide, who needed to know how to use it during the visit, to refer to it, and to assist the pupils during this mixed-reality visit. At the beginning of the visit, as already mentioned, the researcher spent some minutes explaining how to use the technology to both the pupils and the teachers. When pupils needed to know more about the technology because of some problem or because they could not complete an action through the device, they had the opportunity to address both their peers and the researcher. Usually, the pupils tended to try to resolve the problem with their peers and only if it was not possible to ask the researcher. The access to this knowledge was always open, except in the first step of every stopover (i.e. the guide's detailed explanation) on the principle that the technology should not distract from the guide's explanation.

Time and effort necessary to master app operations

The Roman Verona MR app was developed to be very intuitive. In fact, it should require just the few minutes of initial explanation and a few clarifications to allow a primary school student to use it because of the very basic kinds of interactions that the users are required to understand and the lack of menus. Interactions involve tapping (the touchscreen equivalent to clicking), dragging, and pointing the device. The following figure illustrates how easy the students found the app to use (Figure 56). The difficulties in using the app did not stem from problems mastering the operation of the app but due to poorly performing devices and bugs in the prototype app.

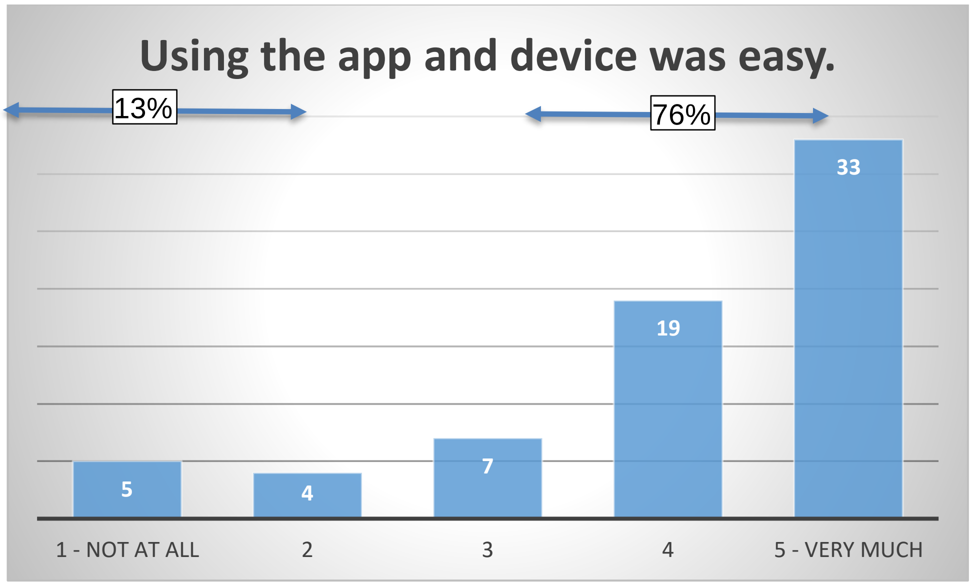

Figure 56: Frequency distribution of the answers to the following statement: 'Using the app was easy.'

Self-monitoring and reflection through externalisation

In the prototype app, it was possible to answer a quick test of three multiple-choice questions to receive feedback at the end of every stopover, but the constraints of time did not allow us to apply this technique. Therefore, feedback was only received after the visit through the answer to the questionnaires, the drawings, and the follow-up test. The drawings, in particular, represent a powerful form of reflection through externalisation, and section6.6 contains an analysis of the differences between the experimental and control groups in the appropriation (internalisation) of the heritage (Einarsdottir, J., et al., 2009).

Use of shared representation to support collaborative work

Since the first part of the project, during the introductory lesson in the classroom, we employed visuals (e.g. paintings and drawings) to discuss Roman civilisation with students. In addition, the historian (who was also the guide during the visit) made them work on the map of Verona collaboratively in order to let them understand the main elements of a Roman city. During the experimental group's visit, shared visual representation was provided from the app and from the heritage itself. During the visit, the collaborative work for pupils consisted of the interaction with the guide and the app, as well as the co-construction of knowledge that resulted from those mediations.

Individual contributions to shared resources of the class

With reference to section 6.7.3.1 and the Tri-AR methodology, one sees the individual contributions to the shared resources in the moment of externalisation in the form of questions, answers, and contributions to the common discussion of the stopover. In addition, the students contributed to their peers. With a pair using one device, when pupils discovered something, they often pointed it out to their partners or other classmates.

6.7.4 Development

Effect of implementing MR technology on the structure of actions

The experimental and the control groups' visits make it possible to acquire a good understanding of what changes in the structure of the action required. Looking at the AT triangle, the only difference between the experimental and the control visits is the mediational tool. Instead of the booklet, in the experimental group we used the device. The content of the booklet is very similar to that in the device, but it just cannot be used in the same way. Every action that passes through the mediator tool changes. Therefore, the action used to pass through a non-interactive mediator comes to have an interactive mediator that requires both a further step in learning operations and a supplementary action, and the latter requires the pupil to point the device and explore the environment in a heads-up attitude. The same exploration must be active since it requires another interaction, which involves tapping on the screen to obtain more information or to see different media. The last level that changes is the one of appropriation or internalisation of the visual media proposed by the MR technology. Using MR technology, a pupil is not merely looking at two-dimensional print but experiencing a three-dimensional re-creation, sometimes immersive. In general, we can affirm that actions are transformed from a passive to an active attitude.

Students’ attitudes towards MR technology and how they changed over time

The attitude of children regarding MR technology was very positive. From Day one pupils expressed a high level of enthusiasm about the opportunity of using devices and the app on a school visit. This enthusiasm did not wane during the visit in most cases. In some cases it did because of problems related with the old devices, which frustrated pupils’ enthusiasm. Among the students, 84% found the technology useful (Figures 57), and an even higher percentage (87%) said that they would not have wanted to use the booklet

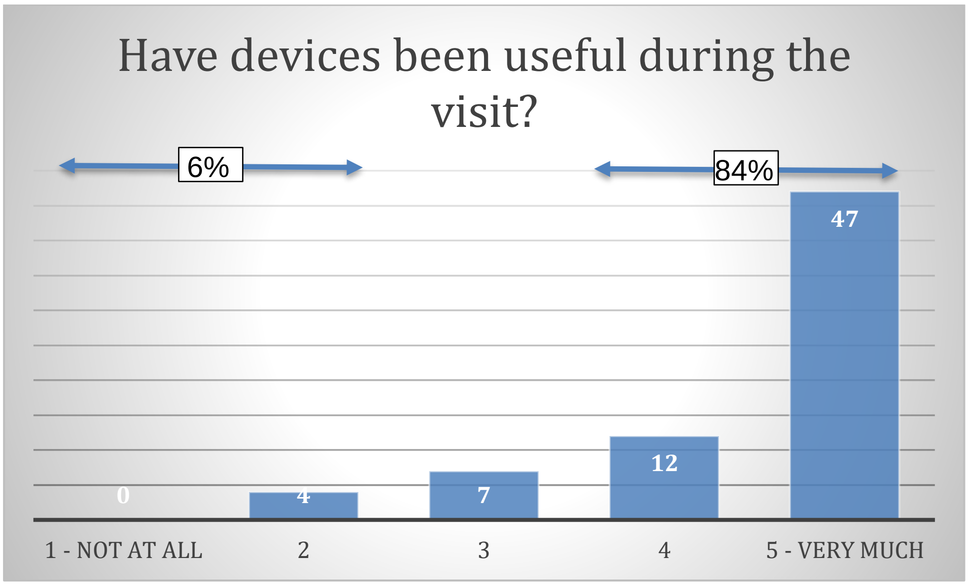

Figure 57: Frequency distribution of the answers to the following question: ‘Have devices been useful during the visit?.’

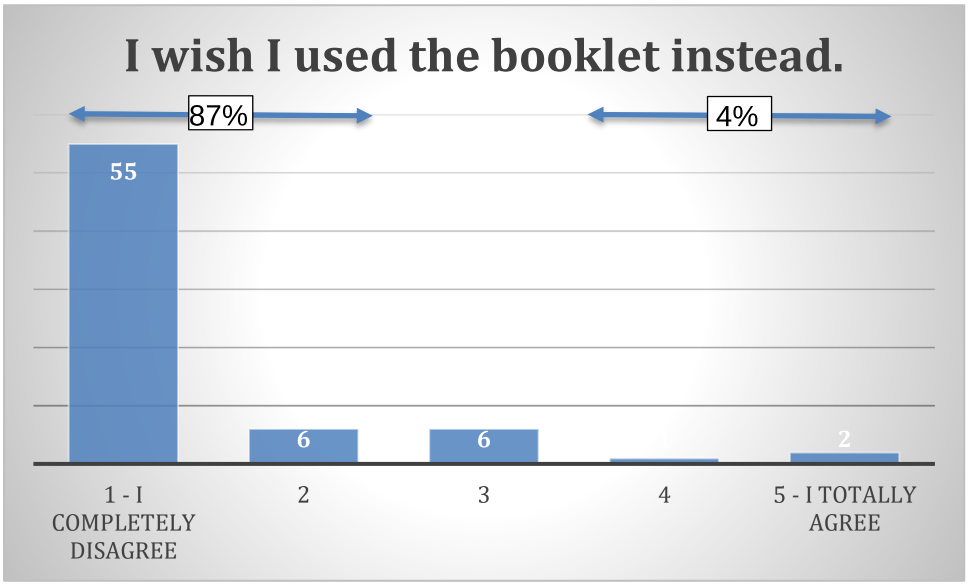

Figure 58: Frequency distribution of the answers to the following statement: ‘I wish I used the booklet instead.’

instead (Figure 58). These are important indicators because they were registered after the experience, and the students had already actually used the technology and found some limitations and bugs. As previously noted, the interaction they appreciated the most was the most immersive one—the exploration of the past using the Google Cardboard VR headset. Another point regarding students' attitudes, the pre-visit questionnaires indicated that no one was tentative or shy about using the devices, and some demonstrated creativity in using it. For example, one student who had a tablet found a way to use it with the Google Cardboard headset even though it was not designed to be used in that way. At the same time, they handled the devices with great care and attention.

Changes in the practice and the level of activity systems they directly influence

When this activity began, it was innovative research for the University of Padua, for the schools involved, and for the Quartiere Attivo association. At the beginning, the idea was to try out this technology and methodology for the benefit of research purposes. At a later stage, we realised that the Roman Verona augmented visit was a 'runaway object' (see Chapter 3) with unpredictable outcomes. By word of mouth, the association received many more requests from other schools for visits such as this one. Some schools happened to have seen the experimental classes in the city, and their pupils asked for a similar experience. This started a format in Verona that now provides experiences for more than 300 children per year. It changed the ways in which the association designs and runs visits and the way in which children from primary schools of Verona learn about the Roman history of Verona. But another unpredicted outcome was also the feeling that one needed to anchor our findings into another ground and test. This was the *raison d'être* for grafting onto the 'Verona App' a second epistemological study so as to increase and improve the validity of our pedagogical science on mixed reality.

Chapter 6

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CHAPTER 7

The Hestercombe Augmented Visit: Georgian Gardens Today?

This case study took place in England in the county of Somerset, where Hestercombe Gardens is located. The experience consisted of a visit with the use of an augmented- (AR) and mixed- (MR) reality app applied with the Tri-AR methodology[30]. This experience took place to test the transferability to a different cultural context and heritage of the methodology and technology of the ‘Verona Romana augmented visit’. For this reason, it does not contain an explanation of the development of the technology and methodology, which consists of the same steps as that in Verona. Instead, this chapter focusses on differences and on adaptations to the model in order to fit it into the Hestercombe context and heritage. Of course, research purposes apart, the desired outcome of the experience is to help primary school pupils understand the historical, artistic, and cultural aspects of the gardens.

7.1 The Georgian landscape garden of Hestercombe

Hestercombe is a property of which records exist since the publication of the Doomsday Book, also known as ‘The Great Survey’, in 1086. In those times, it belonged to Glastonbury Abbey. Sir John Meriet bought it in the early 14th century and sold it in 1392. The buyer was John La Warre, who passed the property on to his descendants, who owned it for more than 300 years. The last of them was Margaret Bampfylde, wife of John Bampfylde. In the early 18th century, John Bampfylde made extensive alterations to the property (Pearson Associates, 1999)[31]. Coplestone Warre Bampfylde inherited Hestercombe in 1750. He was a landowner, a well-known architect, an accomplished painter, and a great landscape designer. He designed his pleasure grounds with originality and ingenuity. He had the opportunity to refine his landscape architectural art by working with his friends Henry Hoare

[30] Tri-AR is a strategy we developed from the AT and applied in the visits with technology. For a complete explanation, see section 6.4.1.
[31] Pearson Associates did one of the first studies on the history of Hestercombe as a contribution to the development of the Hestercombe conservation management plan.

of Stourhead, Wiltshire, and Sir Charles Kemeys Tynte of Halswell, Somerset, who were developing their own landscape gardens at the time. After the death of Bampfylde in 1791, the landscape garden was not maintained. The Portman family made other gardens in different places on the property after they acquired Hestercombe in the mid-19th century: the Victorian terrace and shrubbery in the 19th century, as well as the remarkable Edwardian formal garden in the early 20th, a masterpiece of Edwin Lutyens' and Gertrude Jekyll's garden art. After the Second World War, which saw Hestercombe hosting the British and American armies' personnel and structures, it was sold to the Crown Estate in 1944. Under the Crown Estate, Hestercombe landscape garden was used as a reserve of wood, with wholesale tree felling, and subsequently managed by the Fire Brigade, which had quarters in the house. In the early 1990s, Philip White, who used to walk regularly in the area, rediscovered the garden spotting its remaining features, which lay hidden in an overgrown valley. He decided to restore it to its original glory as it might have been in the 18th century. Since that day, the Hestercombe Gardens Trust has worked to complete the restoration of the garden, including the refurbishing or rebuilding of many of its original structures. Currently, the garden has roughly 100,000 visitors each year, and the number is growing constantly.

7.1.1 'Paradise Restored': The Eighteenth-Century Landscape Garden Features

Hestercombe Gardens (Figure 59) is aligned south to north just 50 metres west of the house. There is a stream at the bottom of the combe that creates small and large ponds, and Bampfylde used this in the design of the garden. The rocky slopes also characterise the location, and they have been brilliantly used in the design of the garden. In the 18th century, and now, after the restoration, three main ponds are present in the combe thanks to the regulation of the water flow by means of dams. The ponds inlcude Mill Pond (used to make the water mill work; see Figure 59, n. 20), Pear Pond (the biggest; see Figure 59, n. 4), and Box Pond (full of fish; see Figure 59, n. 15). Most of the water features are on the floor of the valley, including small water pools in succession with water falls (Figure 59, n. 23), which are ingeniously designed to serve as silt traps. The most noteworthy of these features is the Great Cascade (Figure 59, n. 5), which was artificially created by diverting water from Box Pond into a leat (Figure 59, n. 5), a channel made of bricks. Other notable features include the Rustic Seat (Figure 59, n. 6), reconstructed just in front of the Cascade; the Temple Arbour (Figure 59, n. 8), which stands at the top of a hill and is the original one restored; the Mausoleum (Figure 59, n. 12), which is the original restored as well and listed as grade II* in The National Heritage List for England; the Octagon Summerhouse (Figure 59, n. 1), which was recreated after an archaeological survey; the Chinese Seat (Figure 59, n. 3), which was recreated thanks to the Bampfylde paintings; the Gothic Alcove (Figure 59, n. 14), whose original recreation was subsequently substantially revised after the discovery of a Bampfylde sketch found after the first restoration; the Witch House (Figure 59, n. 9) a root house that was reconstructed and, since the 18th century, has amazed every visitor; and finally, the Turkish Tent (Figure 59, n. 13), reconstructed as well, which is one of those exotic features that were greatly appreciated in the 18th century. The estimated number of seats that were supposed to be in the garden at the end of the 18th century is higher than the count of the restored buildings. At the moment, thanks to archaeological surveys and descriptions of Bampfylde or other 18th-century visitors, it is known that at least four other seats were in the garden, namely, a hermitage (Figure 59, n. 19), a terrace seat (Figure 59, n. 2), a top-of-the-cascade seat (Figure 59, n. 28), and Sybil's Temple (Figure 59, n. 22), the next structure to be restored. In the virtual reconstruction of Hestercombe landscape garden in Georgian times, we have recreated the Hermitage and Sybil's Temple.

The visual structure of the garden has also to be mentioned, notably the view lines, framing, and geometry which, in this garden, conforms with very precise and peculiar criteria. The combe had been heavily modified under John Bampfylde in the first half of the 18th century, as visible in some of the main paths in the garden that we can associate with the 'twinings and windings' that Switzer praised in his *Iconographia Rustica* (1718). Bampfyldes's son, Coplestione Warre Bampfylde, began to develop his landscape garden in 1750, transforming it in a very personalised way, which was certainly influenced by the great themes and artists of the time but also very personal and innovative as well, and, in

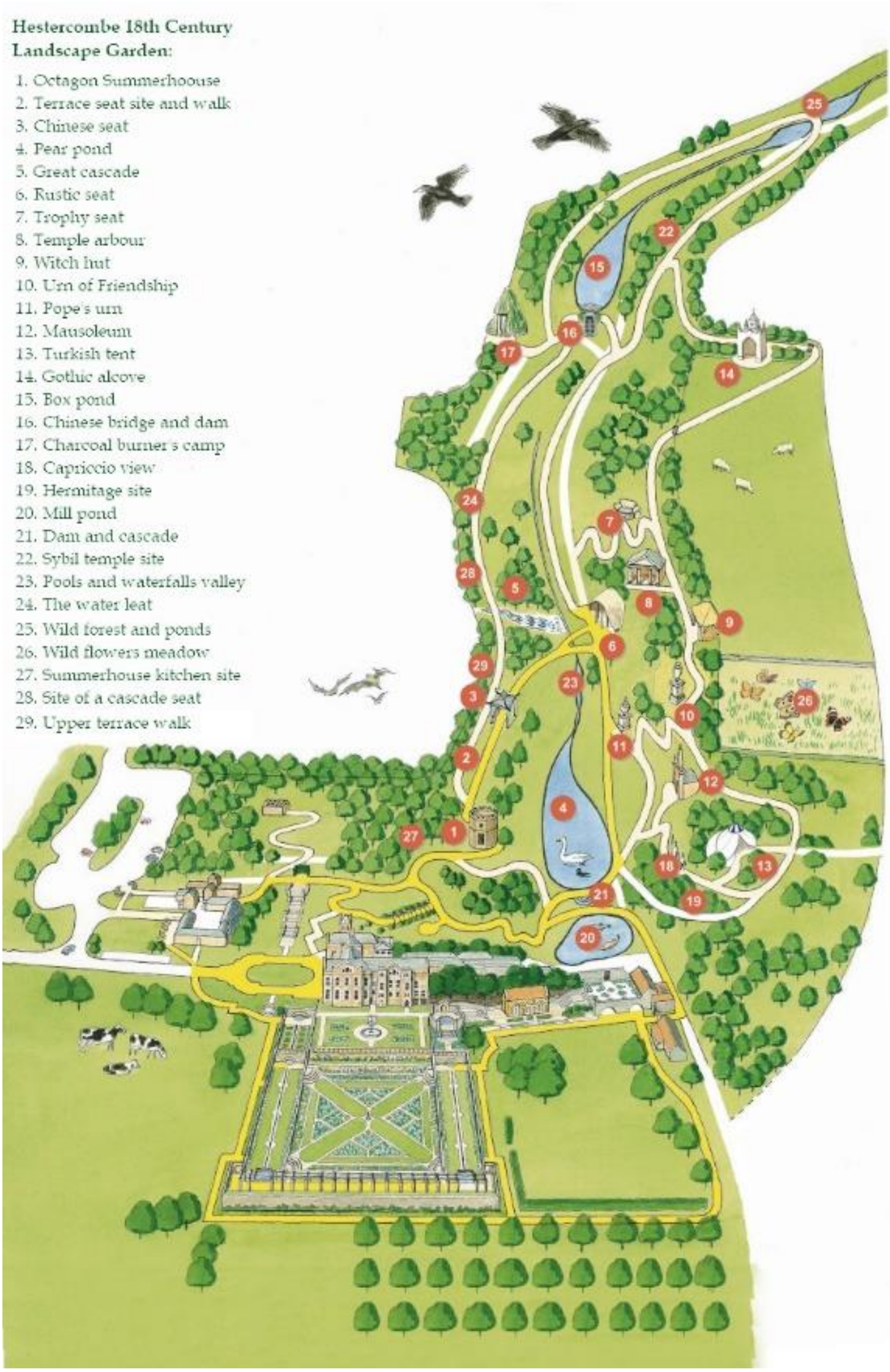


Figure 59: Hestercombe 18th-century landscape garden and seats. (Map from the Hestercombe visit leaflet enhanced and integrated by Daniele Agostini)

some aspects, trailblazing. One can immediately recognise in the garden the theme of travel, illustrated by exotic plants (more numerous in the 18^{th} century than nowadays at Hestercombe), seats (Chinese Seat and Turkish tent), features such as the Chinese Bridge, and the pictorial vision of which Kent was such a successful promoter. Every seat offers one or more views, usually three, which are often framed. The vanishing points of those views are, for the most part, at 45 degrees from one another (Figure 60). For example, from the Temple Arbour, one has three views in front: at zero degrees, Pear Pond; at 45 degrees to the left, the Witch House; and at 45 degrees to the right, the Great Cascade. Those views are framed by vegetation or by parts of the structure, such as columns. Each of the main (central) views in the garden respects the 'three distances' paradigm (Martinet & Châtel, 2001): foreground, middle distance, and background, which Claude had used to compose his paintings only for future generations to act upon it in gardens. Ha-has[32] have been employed in the eastern part of the garden over the shoulders of the combe, where there are extensions of woods and open fields. Another element that has been applied with great skill are transitions, including transitions of scenery: Walking from one seat to another one is a transition, sometimes gradual, sometimes sudden, and a revelation of the next seat. In fact, from one seat, one can never see the next one, but another, further seat appears, motivating visitors to keep walking. This game of alternate concealment and revelation is at the centre of Hestercombe's design. The location also features transitions of lights: During a visit, one often passes from a luminous part of the path to a shady one and, occasionally, a gloomy one. Other transitions involve amplitude: Some transitions also regard the space available both physically and visually. One can pass from a passage through which it is almost necessary to squeeze to a spacious woody chamber from a compression to a decompression. This is the case with the approach to the Great Cascade site. Sometimes, two or more of those transition effects are employed in synergy for a more dramatic effect, a more evident sense of wonder and surprise. A good example of this technique is the Laurel Tunnel on the

[32] The 'ha-ha' is an efficient physical boundary and barrier developed to avoid visible landscape's obstruction and discontinuity. It consists in an artificial depression on the ground-level, usually excavated and reinforced with stones.

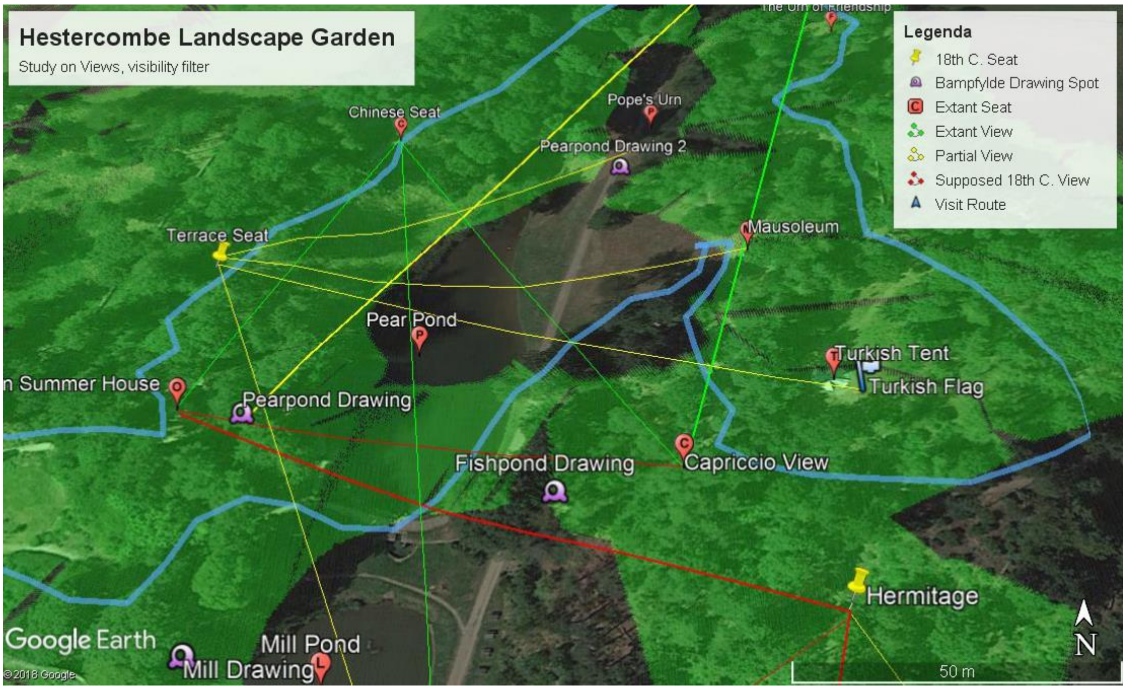


Figure 60: Hestercombe Gardens, study on views. (Copyright Daniele Agostini 2018)

northeast corner of the garden. After walking along a steep serpentine path, one enters the tunnel, which is even narrower and darker than the path. A flow of light comes after 20 metres from the right-hand side and encourages the visitor to approach its source. Passing through a narrow gap between laurels, visitors find themselves in front of an ample, bright, panoramic vista of a flower meadow—Taunton Vale and the Blackdown Hills in the background—and, next to them, the Gothic Seat. Hestercombe, like other pleasure grounds, has been designed as a pre-eminently visual experience, albeit by no means excluding other senses. Thus, it was common to have water features with peculiar elements of white noise, such a water fall, a stream, springs, and musicians who sometimes play in the landscape garden. At Hestercombe, Bampfylde devised seats in a way suitable to capture not only the visuals but sounds as well. For instance, while sitting inside the Witch House, one has a central view of the Great Cascade, framed with trees, on the other side of the combe. Also, visitors can hear the water like as if it were next to them thanks to the apsidal shape of the back wall of the structure (whereas in other cases, the apse shape is made using the natural rock wall behind) and accurate positioning. The same experience is available in the mausoleum, which captures every sound from the part of Pear Pond and the terrace walk in front of the visitors. We see that Bampfylde was able to use the geomorphology of the combe to create unique features. In that way, he was been able to anticipate some elements of the picturesque. Surely, the views are based on pictures (the Capriccio View is emblematic); however, as Bampfylde was a painter, the contrary is also true since he painted the views of his own garden, actually reinforcing this impression of *'that peculiar kind of beauty that is agreeable in a picture'* (Gilpin, 1768, p. X) with a foreground, a middle plan, and a background. Then, there are typical picturesque shapes and textures—if not for the ruins, at least for the debris, bare rocks, different kind of leaves, and games of shadows. In fact, in the author's opinion, elements of Hestercombe Gardens approach the sublime[33], such as the Great Cascade, Box Pond in the upper part of the combe overlooked by Sibyl's Temple where the nature is wilder, and the Witch House, in which we can recognise pre-romantic elements. It is not by chance that Richard Graves' *Columella* (1779), satirising the hermitage mania, was illustrated by C. W. Bampfylde, and in its descriptions, it seems to refer to Hestercombe Gardens (White, 1995).

7.1.2 Hestercombe in the visual arts

What we know about the Hestercombe Georgian landscape garden in the 18th century comes to us from texts from some of its visitors[34], from 19th-century ordnance surveys and inventories prepared for the sale of the estate and from archaeological surveys. Nonetheless, the watercolours by Bampfylde himself serve as the main source of information about the visual appearance of the pleasure ground. The most emblematic is *View of the Pear Pond* with the Temple Arbour and the Chinese seat (Figure 61). Looking at the drawing, it is possible to distinguish different types of plantations as well as people

[33] Sublime is not an extraneous theme to Bampfylde, see his drawings and watercolours like 'Coastal Storm', c. 1770, watercolour (204x272), Private Collection; 'Eddystone Lighthouse. Inscribed on verso; From the South east front built 1758. 90 feet from bottom to hardhorn qu rock.', pen & ink and watercolour (195x280), Private collection and 'The cavern at Wolverley', undated watercolour, Private collections. Arguably, he was influenced from the 1757 text of Burke (1792) 'A philosophical enquiry into the origin of our ideas of the sublime and beautiful'.

[34] Richard Graves' Columella; Edward Knight, 1761; Rev. John Langhorne, 1771; Henry Hawkins Tremayne, 1785.

Figure 61: View of the Pear Pond, Hestercombe. Pen & ink., grey wash. Exh. From View to Vision, 1993. Whitworth Art Gallery, University of Manchester.

enjoying different activities in the garden. There are four other drawings by Bampfylde representing the Hestercombe pleasure ground; two represent the Pear and Mill ponds from different perspectives. Thanks to these paintings, we have a good idea of the original appearance of the area along with its landscape, features, and plantations. One painting, the only watercolour, shows the Great Cascade (Cascade at Hestercombe, Victoria and Albert Museum, London). Another watercolour by C.W.B. (Hestercombe House and Park, 1789, Private Collection) depicts Hestercombe Gardens and its surroundings, providing hints about the vegetation to the south and west of the combe. Other artists have also rendered the site in paintings, such as John Inigo Richards' *Mill at Hestercombe* (1770) and the John Wootton's *Portrait of C.W. Bampfylde in Front of Hestercombe House with his Huntsman* (c. 1740). The last one reveals plantations, alleys, and landmarks no longer exist. Finally, we have other visual sources that lie outside the visual arts, such as photos dating from the end of the 19^{th} to the beginning of the 20^{th} century (De Vesci collection) that display the state of the Pear Pond area in a very overgrown state. From the 20^{th} century, we have photographs of the transformation of the area and the garden in the 1960s when almost all the vegetation in the combe had been cut to the ground, as well as some from the 1990s when Philip White and the Hestercombe Trust began the restoration.

7.1.3 The augmented visit

In order to develop the augmented visit, I adopted various technologies because Hestercombe landscape garden includes a variety of features, ranging from cascades and ponds to trees to buildings, ‘seats’, and urns. All those features needed to be incorporated in the virtual three-dimensional model of the garden, which were to be used on a mobile app since I aimed to show pupils what the garden looked like in the 18th century during Bampfylde’s lifetime.

One needs to bear in mind that the prototype app was developed by focussing on pedagogical principles and, in particular, interactions between the pupils, the guide, and the app; that is where it differs from many other apps that have been developed in recent years. Most of the developers of these apps concentrated on the technology more than on the methodology, and the apps were often designed to serve as a substitute for a human guide rather than to provide an additional, more powerful tool.

7.2 Phases of project development

Table 19 displays the planning of the phases, which led us to create the whole experience and to test it at Hestercombe. For each phase, or step, we specified the activities performed, as well as the aims, tools, participants, and timings.

Table 19: Phases of the research project development at Hestercombe.

Steps	Activities	Aims	Tools	Participants	Timings
1. Programming the experience	Meetings with the person, which usually lead to visits	Knowing how to develop the app, the content needed, and the activities to prepare		Director, guide, the author	2 or 3 meetings
2. Gathering data and contents	Gathering historic data and documents available. Digitalise the available data and documents	Build up the content database	PC, scanner, camera	Director, guide, Laurent Chatel, archivist, the author of this paper	One week, depending on availability of documents
3. Developing AR and VR data	Using documents gathered and other techniques (e.g. 3D photogrammetry with drones and 3D modelling) we developed the 3D Hestercombe environment	Make up the 3D interactive content	PC, 360° camera, a drone with a camera, prospects of the palimpsests, maps	The author and his brother (3D modeller)	One month
4. Developing the app	Using all the content and the 3D environment, the app was developed following the experience criteria	Build up a prototype app to be tested	PC, mobile phone.	The author	Two or three weeks

5. Testing the app	An experimental tour with the app conducted with 15/20 children	Test with children to see if the application and the experience are effective	15/20 mobile phones, booklets of the tour for the control group	Children, teacher, guide, the author	The time needed for a visit
6. Contacting the schools or creating an event	Getting in touch with the schools to find classes that could be interested in that experience; alternatively, we can organising an event 'Hestercombe AR' to find children for our experience.	Gathering participants for the experience		The author, education officer	In the author's free time
7. Improving the app and experience	Analysing the feedback to improve the app and the experience	Bug fixing, as well as improvements of both the app and the visit	Surveys, interviews, drawings	Children, teacher, guide, the author	Depends

7.3 Educational app and visit design

A visit specifically made for pupils with the aim of educating them about the garden, its history, and its importance as cultural heritage had never been designed at Hestercombe Gardens. In general, the English custom seems to be to let school teachers lead the visit and explain everything they consider necessary for the scholastic curriculum. Because of this, we faced the necessity of developing a visit that would suit primary classes. We started with talking to the guides who usually lead tours for the general public, and we also followed and recorded them during a guided visit. That helped us to understand where they usually stop for explanations and to generate a script for the visit, including the informative content and the storytelling (Appendix 4). Thereafter, with the advice of teachers, we managed to understand which parts of the information provided by the ‘standard’ guide would be more useful in relation to the school curriculum, and on which aspects and concepts to concentrate during the visit. We did not want to design a visit on scholastic curricula alone but to highlight the information, content, and concepts of the visit that might have points in common with the school syllabus. We focussed on every concept and aspect as interpretative keys and tools that could help the pupils to understand and appreciate English gardens in general and Hestercombe in particular. At every stopover, each of the concepts and essential pieces of information were integrated into the app to support and mediate the story and the explanation of the guide to facilitate understanding and engagement. If compared with the traditional visit, the augmented visit adds some stops and avoids others. The added stopovers would typically consist of places that used to be significant for the presence of a building or a view but no longer exist, providing no information to the eye of a visitor. For this reason, most visitors ignore these sites; however, now, thanks to the interaction with mixed- and augmented- reality apps, these places are as valuable as the places where the buildings have been restored. The app is the evolution of the one developed for the Roman Verona augmented visit: The project was held in Verona for the first time in 2016 and is now in its third year. The Roman Verona app had already been used by more than 300 primary school year-five pupils. Students, teachers, and guides provided feedback on the app and the visit, which we considered in the development of the Hestercombe app.

The main features of the app are as follows:

- Navigation to a point of interest (POI) through the map.
- Map with directions a and compass always visible.
- Automatic activation of the right stopover thanks to the GPS.
- Display of the contents and information through augmented and mixed reality and not in lists or menus.
- Time travel function: smartphone as a window on the 18th century.
- Cardboard VR function: immersive virtual reality mode.
- ‘Light’ gamification: ‘Find Doc’[35]: finding a fantasy character in the landscape.
- App lock: allows guides to lock the app on all the devices to avoid distractions during certain explanations (in development).

[35] Doc is a fictional character we invented and placed in the App. He is a time-traveller that hides in the views of the 18th Century Hestercombe. Pupils had to find him and in the meanwhile explore the 18th Century Landscape in details.

- Overlay AR camera: allows overlaying the historical view provided by paintings and documents to the present one (in development).
- Only on Android for the moment; an IOS version might come in future.

7.4 The creation of the Hestercombe MR app

When we approached Hestercombe with the idea of developing an AR app for use by school classes visiting the garden, we were not new to this kind of project. We already had a framework developed for the previous experimentation, which had taken place in Verona with the name 'Roman Verona augmented visit' (see Chapter 6). The idea was, in fact, to test the same methodological and technological framework in a different context with a different kind of cultural heritage. The challenge at Hestercombe was the different type of Heritage: In Verona, the remains of the Roman Verona were all buildings; in the case of Hestercombe, we had to deal with buildings but also with the terrain, trees, water features, and views. Therefore, we had to experiment and use a greater variety of instruments to get to the final result. The greatest difficulty was the virtual re-creation of the landscape garden at its best at the end of the 18th century. It is important to mention that the app was designed to be used in a heads-up attitude, thanks to the use of the gyroscope sensor, thus encouraging observation of the environment and the comparison with the AR and MR, instead of cutting out the real environment in a heads-down attitude looking exclusively at the app. Thanks to AR, the students were able to see documents, such as old photos and paintings, seamlessly integrated with the surrounding environment. and thanks to MR and VR, they had the opportunity to see the virtual representation of how Hestercombe appeared in the 18th century.

7.4.1 Heads-up attitude through the use of a gyroscope sensor

We stated serveral times that the gyroscope sensor was a fundamental part of the devices we were using. This section contains a detailed explanation of this device and its importance.

7.4.1.1 What is a gyroscope sensor?

A gyroscope is a device that maintains orientation and angular velocity. It consists of a rotor (a spinning wheel) mounted on a gimbal (Figure 62). The rotor is free to assume any orientation; however while rotating, it is not affected by any of the gimbal tilting or rotation due to the conservation of angular momentum[36]. People in ancient civilisations, such as Greece and Rome knew this principle, but the German Johann Bohnenberger made the first known instrument of this kind in the modern era. Léon Foucault used it in an experiment to 'see' the Earth's rotation movement. Hence, he was the first to name it gyro-scope, from the Greek *gyros*, wich means 'circle' or 'rotation', and *skopeein* which means 'to see'. Since the 19th century, it was used as an aid to navigation, mining, flight, and ballistics, often associated with a compass (Wikipedia contributors, 2018).

Nowadays, the most common version is the micro-electromechanical one (MEMS), which can be found in many smartphones and uses vibrating micro-elements to function. These sensors can detect—with very high accuracy—any movement that diverts from the initial position in any direction. This means that, with this sensor feedback, a software program can keep track of them and calculate, with very high accuracy, any direction the device is pointing towards on three or six axes. A similar effect, but with a much lower accuracy, can be caused by combining the feedback of the accelerometer and compass sensors.

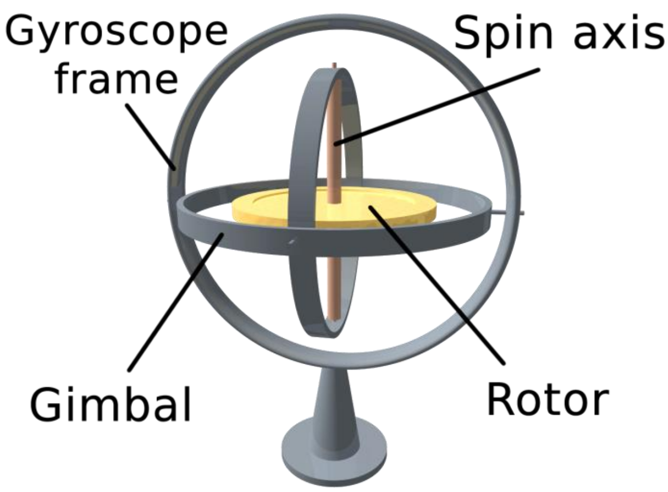


Figure 62: A classical gyroscope. The spinning wheel has freedom of rotation in all three axes and will maintain its spin axis direction regardless of the orientation of the outer frame.

[36] The total angular momentum of a system remains constant unless acted on by an external torque.

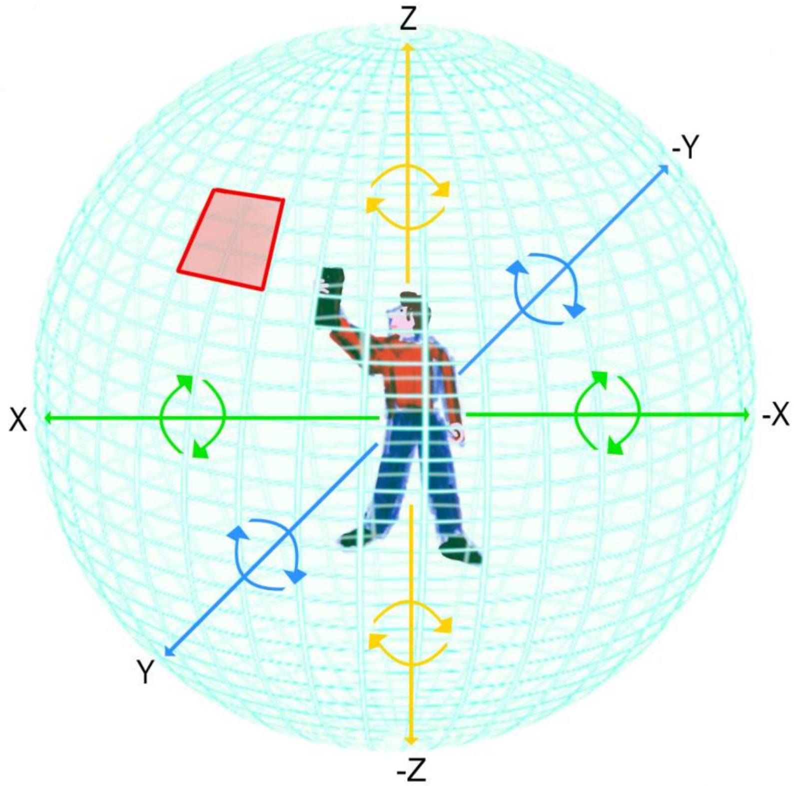


Figure 63: The gyroscope sensor axes. The gyroscope sensor also detects yaw and rotation.

7.4.1.1 Gyroscope and landscape

In practical terms, the gyroscope sensor enables a smartphone app to understand where the device is pointing towards into a hypothetical sphere around it (Figure 63). On the other hand, it cannot understand where one is physically located on the surface of the Earth or in relation to other objects. Therefore, we used other sensors as well. After the gyroscope, the second most important tool was the A-GPS sensor. In the openair, it can pin down a person's location on the surface of the Earth with a precision of roughly 4 metres. We used it in order to trigger AR and VR experiences in the garden. Hypotetically, the third sensor of importance would have been the compass. Its work should have been to align the gyroscope-guided AR and VR systems with the real landscape—in other words, to align the virtual North with the real one. We were disappointed to discover that the compass sensor was too imprecise to do such a job. Eventually, we let the pupils free to manually align it.

Nontheless, the most important advantage of using the gyroscope is to allow a heads-up attitude in using the app and exploring the environment. In a heads-down attitude, which is the usual one people assume when looking for information on a smartphone or even a booklet on the move, one controls the device with one hand, possibly using the other one holding it. Users' eyes see the device screen, and all the rest in the field of view, which most likely consists in the user's own legs, feet, and the floor, remains blurred and unimportant (Figure 64). Eventually, users look up to catch up with the environment around them and to compare the information received from the app with the real environment. By contrast, using the AR with the gyroscope allows users to look at the landscape around them while also looking at the device screen (Figure 64), which displays the same landscape with a layer of contextual information on it. The typical pose of people using this modality is to hold the device with one hand at eye level towards the direction they are looking at. This use of the device permits the brain do the job of fusing reality and AR

(Caudell & Mizell, 1992), triggers cognitive dissonances, and allows users to concentrate on exploring the environment rather than in using the device (see Chapter 3).

Figure 64: Heads-up vs. heads-down attitude. A heads-up attitude integrates the screen content with the landscape, while a heads-down one decontextualises it.

7.4.2 The creation of the virtual Hestercombe

To virtually re-create the landscape garden at its best, as it was meant to be at the end of the 18th century, we made a study of the views from the seats—both existing and not yet restored (Figure 2). In addition, we analysed descriptions from gentlemen who visited the garden during the 18th century, watercolours painted by Bampfylde, 19th-century ordnance survey maps, 19th-century tree surveys, present-day satellite maps, and spherical panoramas. Thanks to the Hestercombe Trust's activity through the years, we had other invaluable documents to help us, such as the historical study on Hestercombe

(Phibbs, 2001), including archaeological surveys, a dendroarchaeological survey (Lear Associates, 1997), and landscape surveys. The last two, in particular, were fundamental in enabling us to recreate the very peculiar shape of the terrain and to place the right species of trees where they used to be in the 18th century. To create the virtual landscape, we used six different programs: Autodesk Autocad, Autodesk 3DS Max, Autodesk ReMake, Adobe Photoshop, Trimble Sketchup, and Unity 3D. Autocad, 3DS Max, and Photoshop were used to create the 3D terrain or, to be more specific, to convert the Autocad terrain survey into a compatible format for Unity 3D. Autodesk ReMake was used to create 3D models, through photogrammetry, of relatively small objects in the landscape (e.g. urns), whereas Sketchup enabled us to build the models of large structures. We hoped to build models of the existing seats by drone photogrammetry, but it proved impossible due to the vegetation around the seats. Unity 3D served as the common ground where all those models from different software programs were assembled in a landscape. The model of the terrain altimetry was created after a terrain survey with contour lines, and the model of the structures was realised starting from archaeological surveys and drawings of the seats. When possible, we referenced existing architectural projects. For planting and trees, we employed prefabricated models of all the species of trees present at Hestercombe in the 18^{th} century. The dendroarchaeological survey provided us the information of the exact location for many of these features. When possible, we compared the surveys with Bampfylde's paintings to better understand the correct disposition.

7.4.2.1 Deriving some truth from Bampfylde's watercolours

The main sources for the recreation of the current landscape garden at Hestercombe were Bampfylde's watercolours and many other documents that, once cross-referenced, brought much truth to light. Nonetheless, watercolours were the only source that gave a visual insight into how Hestercombe looked in the 18^{th} century. Therefore, one of the most important questions to answer was how much those paintings were reliable and realistic, as well as how much artistic licence the artisits took while creating these works. We already knew that C. W. Bampfylde was a landscape designer and an architect, letting us trust, to some degree, his landscape paintings. However, to answer such a question, we gathered information on Bampfylde's painting methods and on other watercolours he created about other gardens of which we have more detailed hystorical information. We took, as a comparison, his watercolours depicting Stourhead. The answer we found is that the Bampfylde's drawings of Stourhead are amongst the most accurate record of the garden in the 1750–1780 period. They are topographically exact (White, 1995), and they were crucial sources of information concerning planting (Woodbridge, 1976) and architecture (Harrison, 2018). We also compared Bampfylde's Hestercombe paintings to ordnance surveys and very accurate modern surveys commissioned by the Hestercombe Gardens Trust, finding the topography, architecture, and proportions exact. Hence, we regarded them as very reliable documents with negligible licence in terms of topography, planting, and architecture. For example, in C.W.B. watercolours, one can guess the type of planting from the shape and textures of the trees depicted. Those, checked against the dendroarcheological survey, were confirmed. Of course, only some kinds of wood can last for centuries. The paintings depict areas of pines, of which few were found in the survey because this type of wood is not as durable as that of an oak. However, knowing that the paintings are reliable, we can safely assume that the artist took no artistic licence. Again, we managed to find remains of solitary trees depicted. A beech tree that was young in 18th

century grew and died (or was dejected), but it was substituted by another one that grew on its stump (Figure 65).

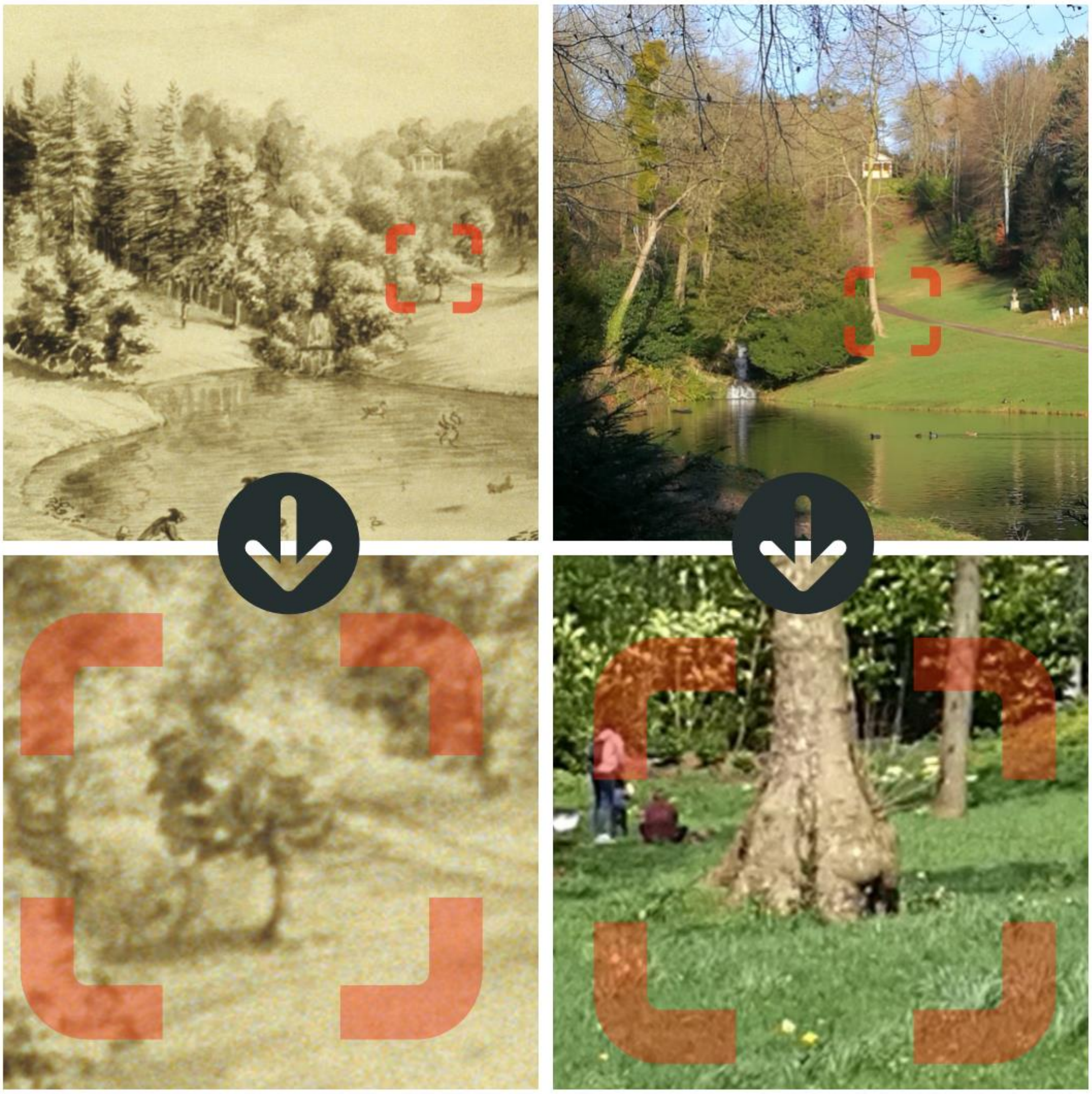


Figure 65: The solitary tree we found both in the painting and that nowadays has been substituted with another one grown on its stump.

7.4.2.2 A new understanding of the heritage landscape through VR

It has been fascinating to realise how building the virtual Hestercombe and placing the three-dimensional models of structures and trees on a precise three-dimensional survey of the terrain could also help the historical process and create new knowledge. Creating ancient views and rebuilding lost seats in the virtual environment offered us the opportunity to understand what each one of them made visible, as the locations of trees opened up different views over the years. Seeing how the place appeared in the past both supports and refines the understanding of the styles employed and also the philosophy underlying the garden. We can provide two examples of these observations. The first one is the visual connection between the Hermitage and the Octagon Summerhouse. The latter has been restored, whereas the former, although archaeologically surveyed, has not. Philip White has suggested that one of the windows of the Octagon Summerhouse points towards the Hermitage direction, but it was not possible to understand if the Hermitage could actually be seen even if the plants obstructing the view were removed. In addition, the peculiar rocky irregularities of the terrain on the shoulders of the combe could obscure the view. Thanks to the virtual model of Hestercombe, we were able to verify that, removing the plants from the view-line, one would be able to see part of the Hermitage from the Octagon Summerhouse, giving additional meaning to one of the views. A second example is the atmosphere at Box Pond. It is not easy to understand what kind of environment Box Pond would have been in the 18th century. A pond in the deepest wilds of the combe surrounded by shady trees and bushes is what we can see now, but it used to have a seat overlooking it, which also used to act as a focal point for the walk on the combe floor. The seat's presence would change the picture dramatically, giving a picturesque and pre-romantic atmosphere to this enclave in the wilderness (Figure 66).

7.4.3 Prototype *bricolage*[37] app tools

In terms of the app development, we used an open-source tool that every person with general coding skills could use (i.e. Thunkable, an MIT App Inventor 2 spin-off). It enables one to quickly develop apps for Android thanks to a web-based designer where one can visually create the app's graphic interface and a web-based coding tool, which uses block coding. Compared to MIT App Inventor 2, at the time of the experiment, Thunkable provided more complete access to sensors, an up-to-date graphical theme that reflects the style of newer Android versions, and it provided new Google Maps-related functions. To develop

[37] See section 6.3.2.2 for explanation of *bricolage* concept.

Figure 66: At the top the Box Pond in the virtual reconstruction. At the bottom the Box Pond as it is now.

the last version of the app, we also took advantage of Kolor PanoTour Pro. Thanks to that software, we were able to manage the 360 x 180-degree spherical panoramas intuitively and to export them in HTML5 code, which we integrated into the app.

7.5 Hestercombe augmented visit

During a school visit, time is always one of the most critical variables. In this context, we had a two-hour timeframe, of which just one and a half could be used for the visit. Both the classes reached Hestercombe by bus. The educational visit was already designed to be shorter than the general public one, but we had to shorten it even more. The range of mediations used for the control stopovers varied between a simple explanation from the guide to the use of pictures and information plaques. On the other hand, for the experimental stopovers, as in Verona, we sometimes used just the AR technology, sometimes the MR technology (AR plus time travel), and the VR technology with Google Cardboard (once). The following section contains a summary of stopovers and the structure of the visit[38].

1. **Introduction**

   An introduction to the Hestercombe landscape garden and his history, the rules of which were followed to use the app (see Tri-AR model, section 6.4.1) as well as the distribution of devices.

2. **Octagon Summerhouse**

   Control stopover. We provided an explanation about the history and reconstruction of the seat as well as general information about English landscape gardens. Pupils could enter the summerhouse and see the framed views from the windows.

3. **Terrace Seat Site View**

   This was the stopover that we used to introduce the use of mobile devices and how to use the app. The guide gave further explanations regarding the views and the seats in landscape gardens.

4. **Chinese Seat**

   Control stopover. The guide recounted the history of the seat and asked the pupils to find the views, thus applying what they just learned in the previous stopover.

5. **Great Cascade and Rustic Seat**

[38] A more detailed version of the visit structure can be found in the Appendix

Experimental stopover using AR technology. The guide explained the history of the seat and the place in general, with related anecdotes. Then, following the same Tri-AR configuration employed in Verona, the guide asked the pupils to explore the surroundings and use the device to discover details and information and to compare the reality with the AR. A dialogue between guide and pupils followed thanks to the mediation of the device.

6. **Middle of the Long Valley**

   Experimental stopover using AR and time-travel technology. This resembles the previous experimental stopovers but with time-travel technology. This is a kind of interaction with the app that allows the students to travel in time through the MR and to use the device as a window on the past.

7. **Box Pond and Chinese Bridge**

   Experimental stopover with AR and time-travel technology.

8. **Sybil's Temple**

   Control stopover with the use of texts and pictures on an information plaque.

9. **Laurel Tunnel and Gothic Alcove**

   Control stopover with pictures as mediators.

   This was conducted in a similar fashion to the other control stopovers, but we distributed pictures to explain how it was the seat when it was recreated the first time.

10. **Temple arbour**

    Experimental stopover with AR and time-travel technology.

11. **Witch House**

    Control stopover.

12. **Turkish Tent (site of)**

    Experimental stopover with AR and VR time-travel technology. This functioned in the same way as the other control stopovers, but here, we offered students the opportunity to use the Google Cardboard VR headsets to have an immersive experience of the past. Also, we added a fictional time traveller to find in the past landscape as a mean of gamification.

13. **The Hermitage (site of)**

    Experimental stopover with AR and time-travel technology.

14. **Pear Pond**

    Experimental stopover with AR and time-travel technology.

7.5.1 Mediating tools

The experimental hardware tools were mostly the same as those used in Verona (see section 6.4.2) with some difference due to the constant upgrades and bug fixes to the prototype. Since the first Roman Verona experience in 2016, the app has continuously evolved due to the constantly increasing number of classes asking for that experience. Hence, at Hestercombe, we used the updated version of the framework of the Roman Verona MR app. Looking at the differences between the first Verona experiment, we have a more straightforward and more comprehensive app, which uses less memory on the device and does not need any Internet connection for its core functions. This streaminlining affects the hardware tools required for a visit: Since the app is no longer web-based, there is no need for the two mobile 4G routers. We used the same devices—smartphones and tablets—and Google Cardboards, just with no Internet access.

As for the booklets we used with the control groups in Verona, because of the issues found at Hestercombe and already addressed in section 5.3.2, we were unable to have control classes, and we did not think it feasible to ask pupils to carry both booklets and mobile devices. Nonetheless, in two of the control stopovers, we used pictures to support the explanation of the guide.

7.6 Quantitative data analysis

In contrast to the analysis conducted in the Verona case, in this one, we employed a standard linear model, which is the analysis of variance (i.e. ANOVA). Indeed, we have not been able to use mixed-effects linear models (MLMs) in England due to the impossibility of keeping track of the same student between one questionnaire and another and because there was no experimental or control group, only experimental and control stopovers. To run the analysis on the data gathered, we used the statistical software 'R' extended with the following packages: *afex* for statistical analysis (Singmann et al., 2017); *MuMIn* to calculate the weight of the model (Bartoń, 2017), and *psych* to manage the descriptive analysis (Revelle, 2017).

7.6.1 Principal component analysis

To begin the statistical analysis, we needed to test the pre- and post-visit questionnaires. In fact, they contained many questions that we needed to reduce to a smaller number of dimensions. In fact, we did divide the questionnaires into dimensions before, but there were still too many to use in the evaluation of the performance of every single student. To solve this issue, the technique of the principal component analysis (PCA) was employed. This technique examines the different questions and merges those with a similar trend in unique components.

Pre-visit questionnaire on technologies principal component analysis

I proceeded with a parallel analysis to understand how many components we could group the questions into. Then, I used the questions 'Do you have an Internet connection at home?' and 'What do you use a smartphone for?' because they have ordinal values. Also, all the questions with answers from fewer than 10 students were removed. The questions that remained are reported in Appendix 2. The results of the parallel analysis (Appendix 2, Figure 1) indicate that we would need five different components. This is different from what happened in Verona, but this was a simplified version of the questionnaire with a reduced set of questions. Hence, I executed the PCA, setting it up in order to have five different components orthogonal between them, so that they were not correlated. To achieve this result, I executed the PCA with a VARIMAX rotation. Doing this renders 'loadings', or weights indicating the importance of single questions for the component in a range from one to minus one. We had to decide on a threshold under which the question is not significant for the component. In this case, we decided to set this limit to 0.4 because we had fewer questions and components compared to the Verona experiment. We numbered the questions of the questionnaire 1–50. From the loading table (see Appendix 2), we created the following five components.

Table 20: Component 1, named 'Use of smartphone and other portable devices to share, communicate, and learn'.

N.	Question	loading

Q45	What do you use a smartphone for? —To share content	0.8399945
Q46	What do you use a smartphone for? —To learn	0.8061584
Q19	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places? —Laptop	0.7380814
Q41	What do you use a tablet for? —To do homework	0.7137574
Q42	What do you use a smartphone for? —To play videogames	0.7087907
Q44	What do you use a smartphone for? —To communicate	0.6801806
Q6	How often do you use the following devices at home? —Laptop	0.6668407
Q39	What do you use a tablet for? —To listen to music	0.5671428
Q9	How often do you use the following devices at home? —Game console	0.5615780
Q10	How often do you use the following devices at home?—Portable game console	0.5060661
Q33	What do you use a tablet for? —To look for information	0.4911477
Q2	Do you have Internet connection at home?	0.4881890
Q21	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places? —Tablet	0.4587976
Q40	What do you use a tablet for? —To create contents like photos drawings videos etc	0.4536838
Q32	What do you use a tablet for? —To play videogames	0.4392143
Q43	What do you use a smartphone for? —To look for information	0.4242534
Q5	How often do you use the following devices at home? —Desktop computer	0.4015422

Table 21: Component 2, named 'Use of tablet and smartphone to watch videos, communicate and get information'

N.	Question	loading
Q34	What do you use a tablet for? —To communicate	0.8694447
Q47	What do you use a smartphone for? —To watch videos	0.7592771
Q38	What do you use a tablet for? —To watch videos	0.7397673
Q31	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit? —Audioguide	0.7306653
Q43	What do you use a smartphone for? —To look for information	0.6931030
Q36	What do you use a tablet for? —To learn	0.5186943
Q14	How often do you use the following devices at school? —Smartphone	0.4535804
Q40	What do you use a tablet for? —To create contents like photos drawings videos etc	0.4364641

Table 22: Component 3, named 'Use of IWB and tablet at school'.

N.	Question	loading
Q18	How often do you use the following devices at school? —Interactive Whiteboard used by you	0.8144944
Q15	How often do you use the following devices at school? —Tablet	0.7131971
Q22	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places? —Portable game console	0.6812119
Q30	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit?—Interactive screen	0.5347015
Q4	How many tablets are there at home?	0.4278452
Q12	How often do you use the following devices at school?—Desktop computer	0.4241491
Q50	What do you use a smartphone for? —To create contents like photos drawings videos etc	- 0.4567935

Table 23: Component 4, named 'Use of laptop and tablet for education'

N.	Question	loading
Q13	How often do you use the following devices at school? —Laptop	0.7773559
Q27	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit? —Tablet	0.6803480
Q29	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit? —Smart glasses or VR Headset	0.6585481
Q17	How often do you use the following devices at school? —Interactive White Board used by teacher	0.5962661
Q28	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit? —Portable game console	0.4864251
Q16	How often do you use the following devices at school? —Smart glasses or VR headsets	- 0.6658486

Table 24: Component 5, named 'use of smartphone and tablet at home'.

N.	Question	loading
Q7	How often do you use the following devices at home? —Smartphone	0.8099812
Q35	What do you use a tablet for? —To share content	0.6096477
Q8	How often do you use the following devices at home? —Tablet	0.5370835
Q20	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places? —Smartphone	0.4911185

Q23	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places? —Smart glasses or VR headset	-0.5432001

The next step required was to recognise the components and naming them. We decided to name them as it follows:

1. Pre C1: Use of smartphones and other portable devices to share, communicate, and learn (Table 20).
2. Pre C2: Use of tablets and smartphones to watch videos, communicate, and receive information (Table 21).
3. Pre C3: Use of interactive whiteboard (IWB) and tablets at school (Table 22).
4. Pre C4: Use of laptops and tablets for education (Table 23).
5. Pre C5: Use of smartphones and tablets at home (Table 24).

Post-visit questionnaire on satisfaction principal component analysis

For the post-visit questionnaire, we repeated the same procedure as the one used for the pre-visit one. We then proceeded with a parallel analysis to understand how many components we could group the questions into. Subsequently, I used ‘They told me all that I wished to know’ and ‘How much did you enjoy the visit from 1 to 5?’ because they have ordinal values. Also, the responses from fewer than 10 students were removed. The remaining questions are reported in Appendix 2. The results of the parallel analysis (see Appendix 2) indicated that we needed just one component. Hence, the PCA was set up in order to have just one component. We kept the threshold to 0.4, and we numbered the questions of the questionnaire 1–15. From the loading table, we created the only component and called it ‘visit satisfaction’.

7.6.2 Analysis of the components

The next step involved analysing the components obtained from the PCA by running the ANOVA linear model analysis on components. The aim was to check if there were differences in the pre-visit characteristics between the two classes in order to take them into account for successive analyses. It is useful to remember here that, in the Hestercombe quasi-experimental design, we did not have control and experimental classes but only control and experimental stopovers. Thereofore, this analysis was not fundamentally necessary, but we thought that, in any case, it would allow us to gather some useful information. I employed an MLM analysis with ’school’, ‘gender’, and ’school-gender interaction' as fixed factors. Moreover, 'school' was used as a random factor. This section only covers the components with significant results.

Component Pre C1: Use of smartphones and other portable devices to share, communicate, and learn.

It turns out that there are significative differences between boys and girls, but only in one of the two classes (Figure 67). At the Bishops Hull school, girls had a much higher 'use of smartphones and other mobile devices to share, communicate, and learn' than the boys. I checked the distribution of the students' answers to exclude flat ones where pupils selected the first answer choice without paying too much attention, but this was not a major issue. On the other hand, at the Blackbrook school the situation was perfectly balanced, and Pre C1 for both boys and girls is comparable to the levels of the girls at Bishops Hull.

Component Pre C2: Use of tablets and smartphones to watch videos, communicate, and find information

This component follows the same schema of the Pre C1. The only difference is that the level of girls and boys at the Blackbrook school is more alike that of boys at the Bishops

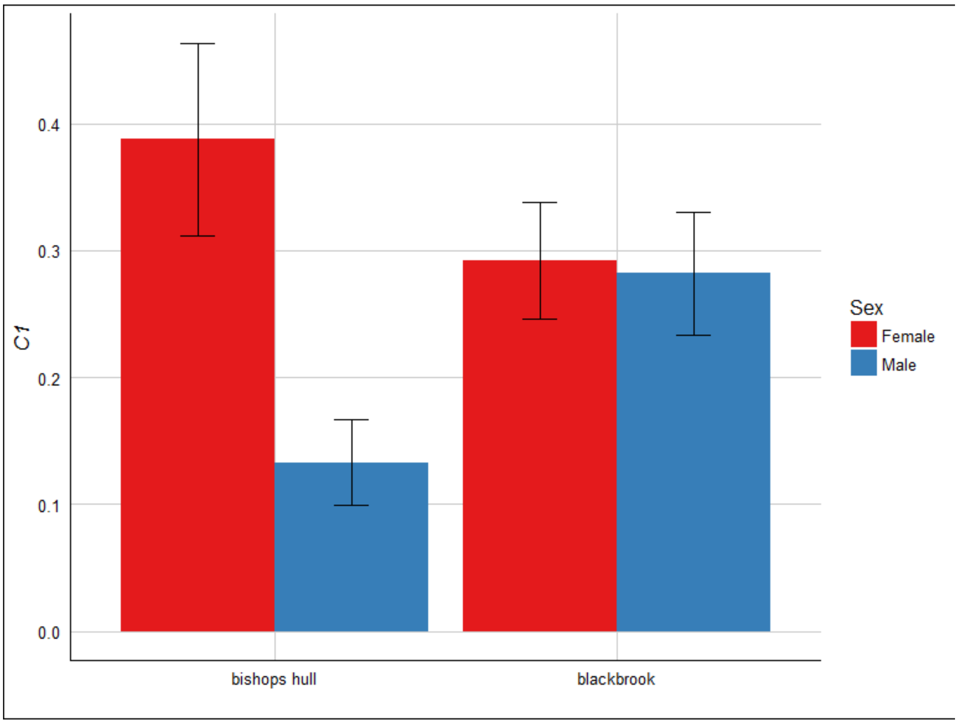


Figure 68: Analysis of the component Pre C1.

Hull school. Girls at Bishops Hull used tablets and smartphones to watch videos, communicate, and find information much more than boys.

Component Pre C3: Use of IWB and tablets at school

Regarding this component, unlike the previous one, the school is not a discriminating factor. The only significant factor is gender. In fact, boys seem to use IWB and tablets at school more than girls (Figure 6).

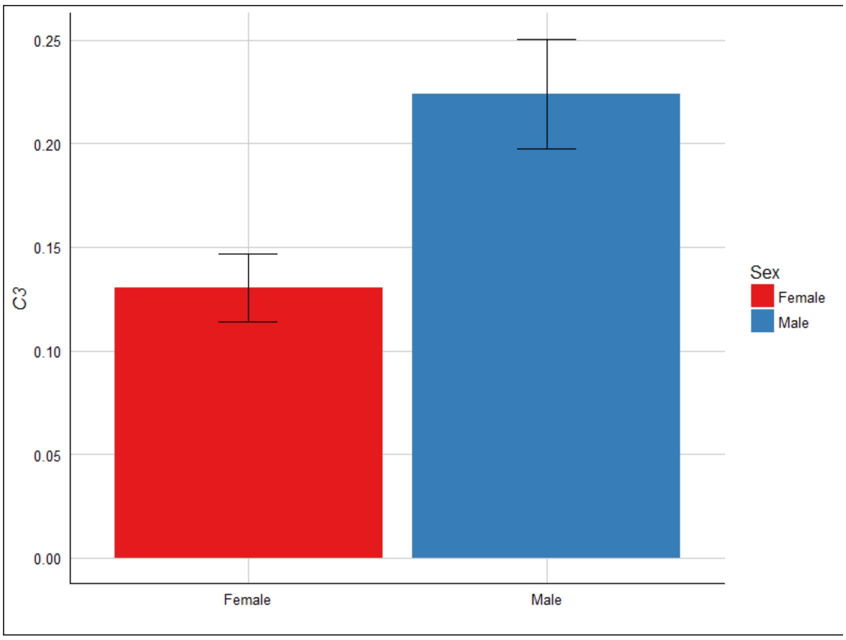


Figure 67: Analysis of the component Pre C3.

Component Pre C4: Use of laptops and tablets for education

The use of laptops and tablets for educational purposes is not influenced by the gender of the student but by the school. Bishops Hull students use laptops and tablets for educational purposes much less than their colleagues at Blackbrook (see Appendix 2 for the table and diagram).

Component Pre C5 and Post C1

Gender and school have no influence at all on the use of smartphones and tablets at home or on the visit satisfaction.

7.6.3 Analysis of the scores of the follow-up test

Follow-up tests were handed over to students two weeks after the garden visit in order to discover how much they remembered of the experience, concepts, and information provided. Because we were not permitted to keep track of students' identities between the tests, coupled with the smaller number of subjects and the fact that there were no experimental or control groups but only experimental and control stopovers, we could not run the same kind of refined MLM analysis used for the Roman Verona experience. Nonetheless, we managed to discover very interesting information by running the ANOVA analysis.

I found that, in general, the best performing school was the Blackbrook school in both control and experimental stopovers. That is related with the data that we already had from the analysis of the components. The only two components in which the school alone is a significant factor are Pre C3 and Pre C4. Hence, it is very probable that use of IWB and tablets at schools, as well as the use of laptops and tablets for educational purposes, has played a crucial role in this result.

Control versus experimental stopovers

The analysis on the data of scorings at stopovers highlights that the only significant factor is the type of stopover (experimental or control) (Table 25). Figure 69 illustrates how the pupils score higher on the follow-up test when it came to questions regarding experimental stopovers.

Table 25: ANOVA analisys on stopovers.

Fixed factor	Df	Sum Sq	Mean Sq	F value	Pr(>F)
School	1	0.016	0.016	0.116	0.734
Gender	1	0.001	0.001	0.008	0.931
Tipo	1	0.544	0.544	3.942	0.050
School:Gender	1	0.489	0.489	3.542	0.063
School:Type	1	0.015	0.015	0.107	0.744
Gender:Type	1	0.000	0.000	0.000	0.985
School:Gender:Type	1	0.208	0.208	1.505	0.223
Residuals	82	11.326	0.138	NA	NA

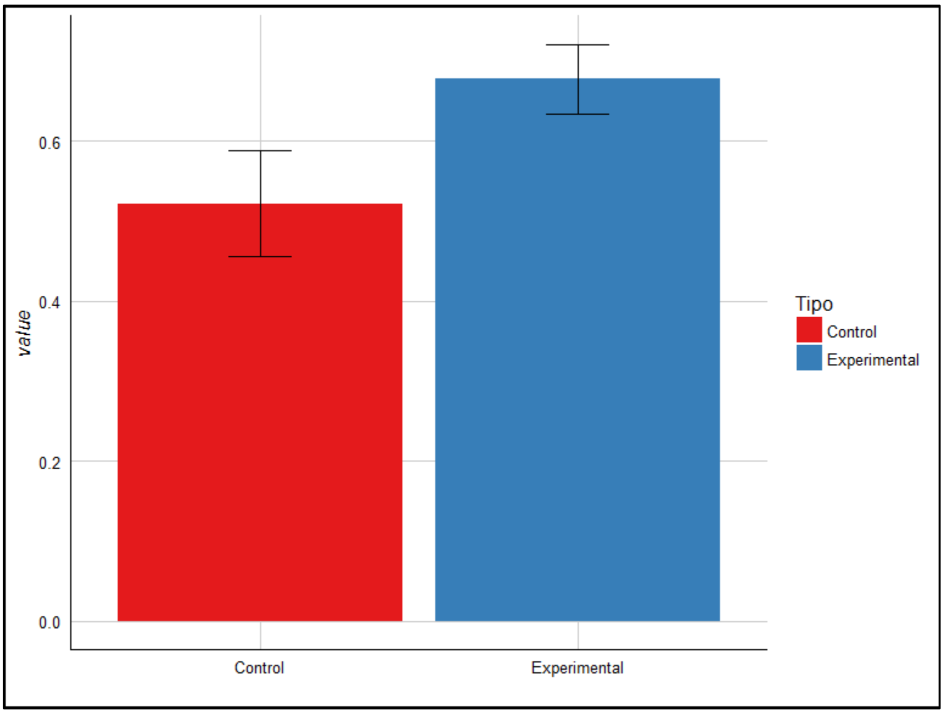


Figure 69: Average scoring and standard deviation at control and experimental stopovers.

7.7 What to make of Hestercombe Sketched?

I asked to all the pupils in both classes to draw a sketch of a viewpoint of their choice and to write why they liked it. These responses eventually provided qualitative insights for a better comprehension of quantitative results and sometimes helped to complete the picture with new information or effects of which we were not aware, on the same basis explained in Chapter 7. We gathered 34 drawings representing different subjects (Figure 70). We gathered all the subjects related to a single stopover in the visit, using the same procedure followed for the Verona analysis. Figure 70 illustrates how the drawings are distributed in stopovers. Overall, the Chinese seat was by far the most drawn seat (41%), followed by the Temple Arbour (14%); the Rustic Seat and cascade and the Witch House are at the same level (12%). Overall, control and experimental stopovers are represented 20 times (59%) and 14 times (41%), respectively. Looking at the motivation pupils gave, the Chinese Seat is the most represented because of the wonderful view one has from the seat and its exotic design, and perhaps because the Chinese Seat essentially consists of four poles and a roof that students could easily draw. The Temple Arbour, the most represented element from the experimental stopovers, was chosen because it was 'big'

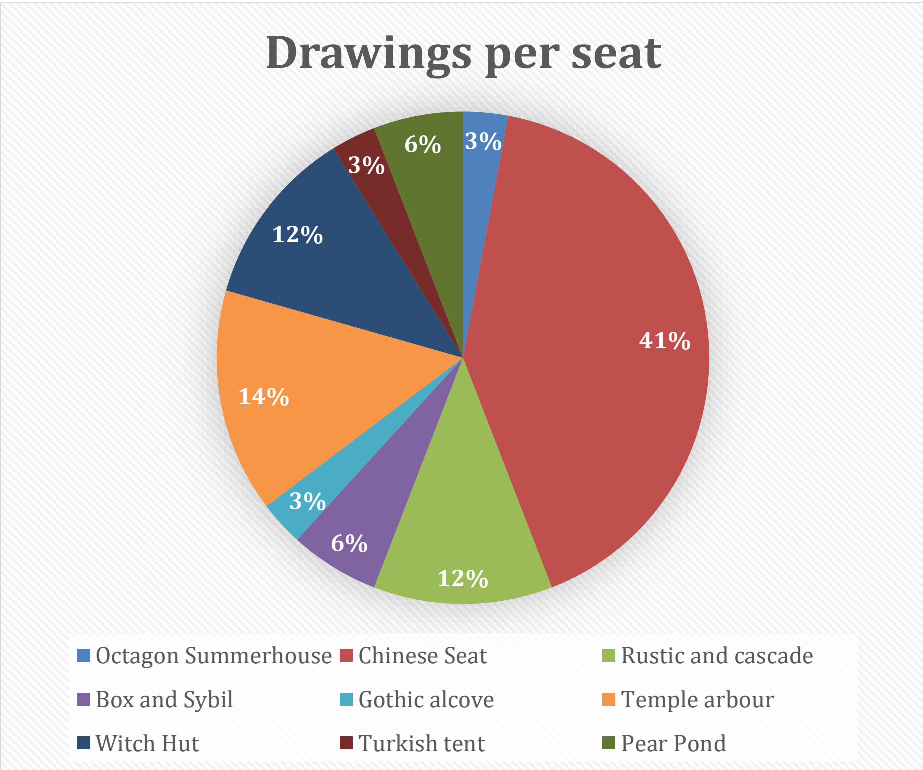


Figure 70: Distribution of drawings per seat.

and 'pretty'. Only one drawing was made because of the technology, namely the Turkish

Tent, which was not physically there, but students could see it using the app with Google Cardboard VR. Due to time constraints, English classes did not have much time to complete the follow-up test, so they could only make very basic sketches of the seats or of the views. None included the technology in the representation, which could mean that it succeeded in being ‘transparent’, and no one drew interactions with the guides or with their classmates. It was not possible to do the same in-depth analysis of the drawings done for Verona because they are too basic, but we could look for significant elements in them.

7.7.1 The role of seats in the landscape garden

Looking at the drawings, one of the first things to be noted is the understanding that pupils had about the functions and characteristics of the seats as a genre of garden building. Looking at Figure 71, it becomes clear that most of the children who drew the Chinese seat (10 out of 14) understood its function as a seat from which to enjoy a view. This is confirmed from the explanations that come with the drawings that pointed out how good the view was from there. Something similar but more advanced happened at the Temple Arbour. Using the AR, the guide explained the students could choose from three views at the Temple: central, right, and left. This has been understood and externalised in the drawings in Figure 72. The ‘triple seat’ or ‘triple view’ concept is visible from the three benches, the three columns, or again the three spaces between the columns. The real temple has four columns (two central and two lateral) and three benches (one central and two lateral). The columns’ position creates three great openings.

7.7.2 Connections between seats

Figure 71: The Chinese seat is represented most of the time with a bench.

Figure 72: The Temple Arbour represented with three seats or columns.

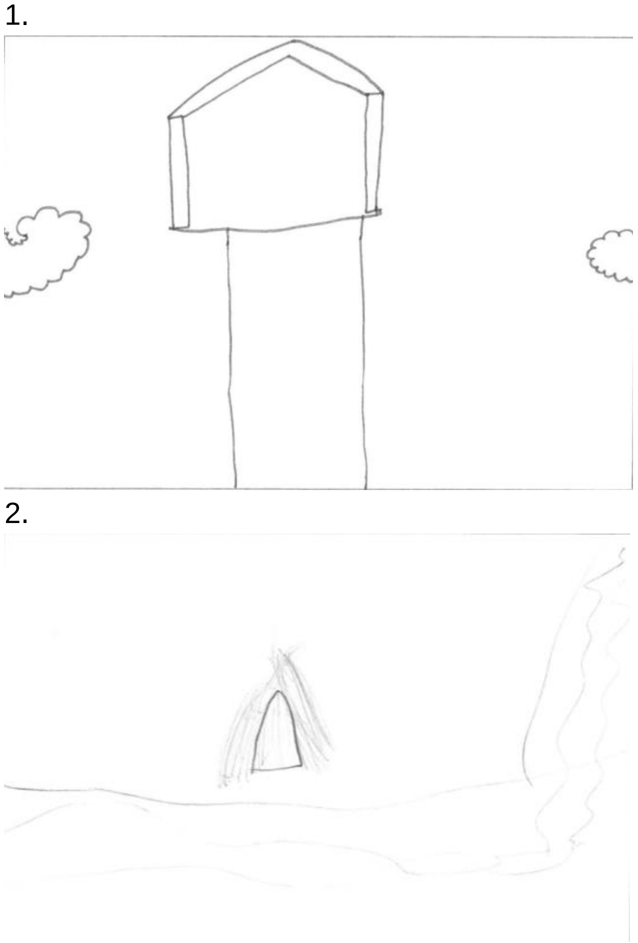


Figure 73: Pictures where the connection between seats, trail, and landscape is visible.

One of the most difficult concepts to understand about an 18th-century landscape garden is the connection between seats and the trail. However, in their sketches, some of the pupils demonstrated an internalisation of this aspect. In Figure 73, we see two examples. In the first one, the trail leads to the Chinese Seat from the point of view of a visitor, who has to pass through plants to reach it. In the second one, the student drew the Witch House and the Great Cascade in the same frame, but the Great Cascade is opposite the Witch House, on the other shoulder of the combe, high over a steep slope. Nonetheless, from the Witch House one can see and hear the Great Cascade. In fact, the Great Cascade is the main view from the bench inside. That means that this pupil did a correct synthesis of the perceptions one can have from the Witch House[39].

7.7.3 Recalling details

It has been difficult for the students to recall many details of the structures and the views of the garden. It could seem strange if we compare those drawings with those of the Roman Verona study. Of course, the English pupils had less time since it was a collateral activity and not strictly part of the school programme, but that is not the only reason. One has to keep in mind that the pupils from Verona had studied Romans beforehand, and they lived in a city where the most famous monuments are Roman. For English pupils, 18th-century

[39] It is interesting to read his comment where he sustains that in the Witch House there was smell of soup. In fact, there was no smell of soup inside, but it is possible that the evocative place triggered the pupil's imagination which created an augmented perception, an olfactory hallucination. See section 8.6.2 for further thoughts about perception and imagination.

English landscape gardens are not a programme priority, to say the least, and for many of them this was the first time they had paid attention to such strange buildings disseminated in the garden. For after all what could be the connection between 'nature' in the garden and architectural fancy elements? In spite of their perplexity, the students were able to remember tiny details related to seats or features that captured their attention, Including the Witch House, the Turkish Tent, and Pear Pond. To some extent, the Chinese Seat and the Temple Arbour are also on this list, but we have already talked about their peculiarities. In Figure 74-1 and 74-2, it is apparent how well pupils remembered a seat in which they had stopped for few minutes because it was not part of the visit. For example, in the case of the Chinese seat, the exotic and mysterious elements, as well as the potential storytelling behind it, captured the attention of the pupils. Figure 74-3 represents the Turkish Tent, again, an exotic element that they did not see in reality, just in VR, because it was not there. In spite of that, the girl who drew this picture was able to remember its distinctive striped appearence and the upper part. Finally, we found only two drawings of Pear Pond (see Figure 74-4). Both of them depict the scene from a high perspective, very similar to the one of the map in the MR app. Their characteristic is

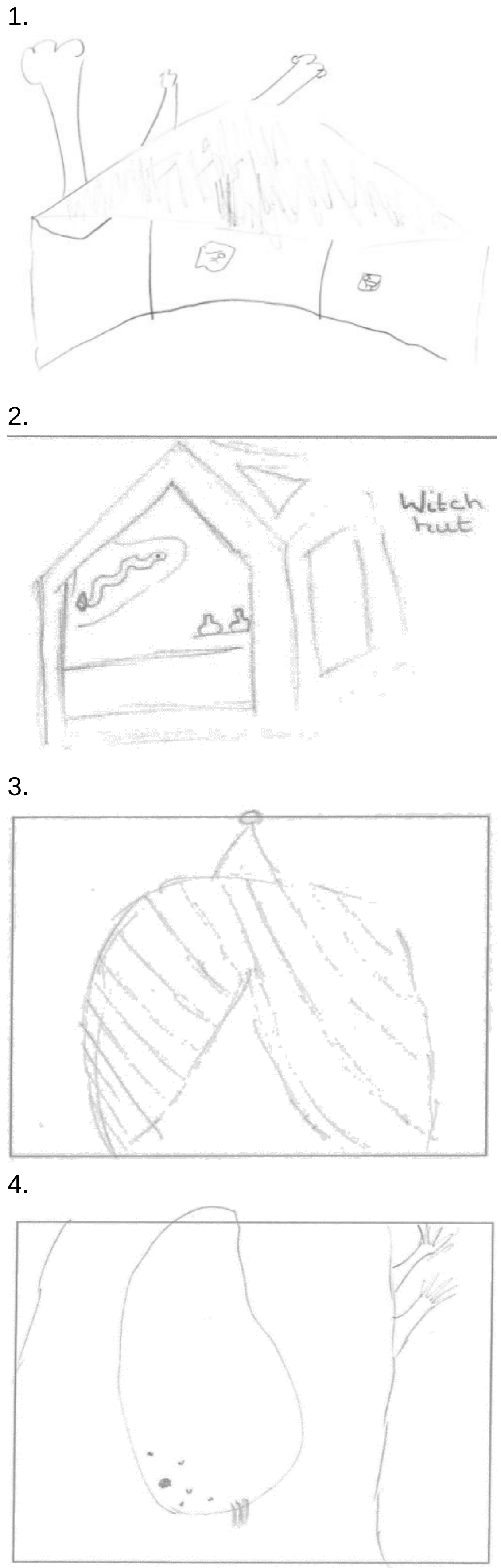


Figure 74: Examples of detail recalling in drawings.

to create an augmented version of their perceived reality that mixes elements from the app and from what the students saw and understood. This picture portrays Pear Pond, shaped perfectly, with the addition of a swan, little wild ducks, a cascade, and trees. This kind of externalisation process is also addressed in the analysis of drawings of Roman Verona—section 6.6.3—and in Chapter 8.

7.8 Evaluation of the experimental visit through the activity checklist

Many parts of this evaluation are similar or the same as the evaluation made for the Roman Verona experience. The reason is that the same procedure, methods, and technology were applied. The case study case of Hestercombe Gardens consisted of a complex interaction between at least four different ASs sharing the same boundary object as the object and another boundary object as a mediating artefact (Figure 75). The shared object was the Hestercombe landscape garden augmented visit, and the mediating artefact was the object of another AS that led to the creation of the MR app. This sub-chapter includes an analysis of the MR visit AS, which is the shared object of the other four systems. In my analysis, I did not forget the interactions between ASs. As was done for Verona, elements of the activity checklist were used integrated in an analysis typical of third-

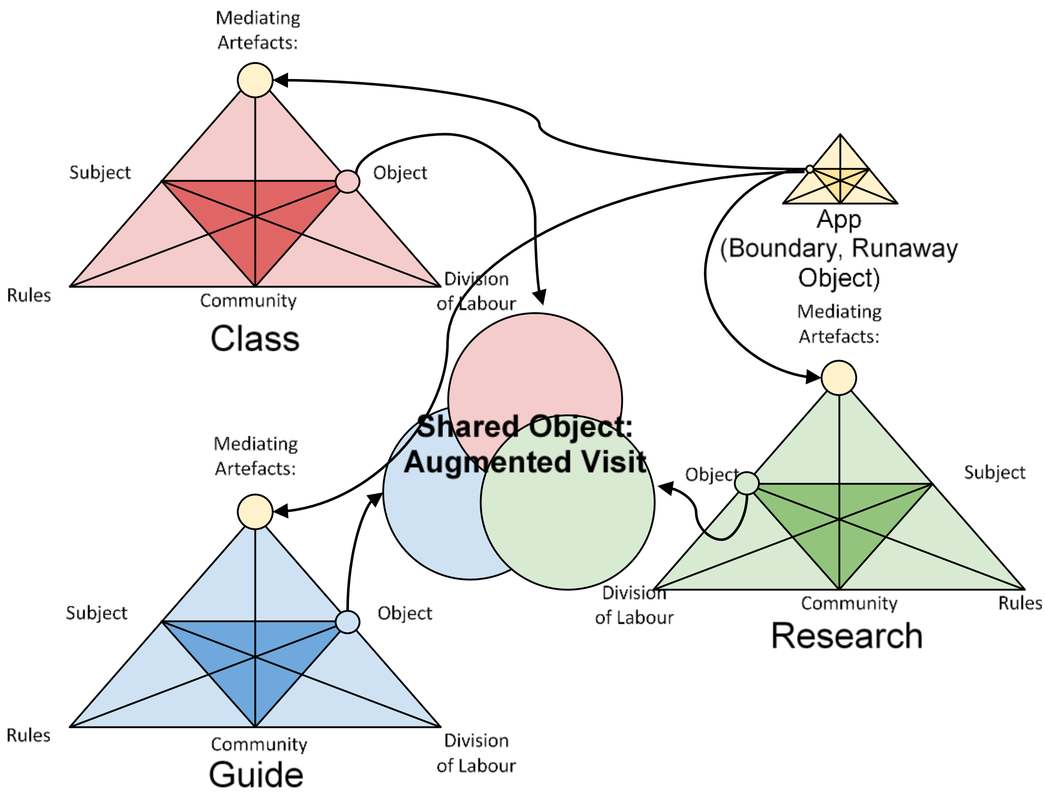


Figure 75: Representation of the ASs involved in the Hestercombe case study.

generation AT.

7.8.1 The augmented visit activity system

The augmented visit class AS (Figure 76) has, as subjects, the students of the classes that participated during the visit and, as the object, the cultural heritage represented by Hestercombe Gardens. As a mediating artefact, which serves as a tool in this case, we have the MR technology; as a community, we have the other classmates and teachers, as well as the researcher and the guides. The rules are those common during every school visit, plus the ones created particularly for this visit, such as the use of the mobile device. The division of labour has to do with the roles that every person in the visit had, as well as with the alternation between the two children in the pair sometimes required in the use of the mediating tool. Finally, the end of this chapter will present the outcomes. The desired outcomes are closely connected with the goals of the activity.

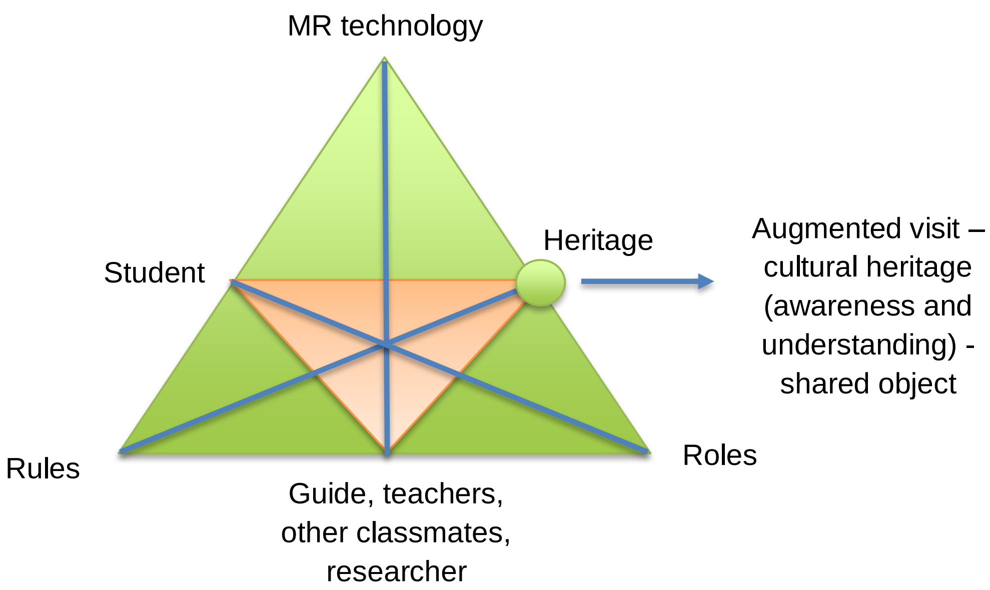


Figure 76: Hestercombe augmented visit—class activity system.

Goals and sub-goals of the activity

The goals of the activity included letting the students know of the story of Hestercombe Gardens and its characteristics. Also, pupils needed to understand that the same concepts could be applied to other 18th-century landscape gardens. The sub-goals consisted of, for example, understanding the seats' role, as well as views and of links between points of interest in the landscape garden. In addition, they had to discern the transformations the garden had gone through over more than 250 years.

Criteria for success or failure of achieving target goals

Success would mean having the majority of pupils remember the main notions and key concepts in the follow-up test, demonstrating that they had understood the basic concept of a landscape garden in general and of the Hestercombe landscape garden in particular. Furthermore, they needed to express themselves in the open questions and drawings spontaneously to express their beliefs and considerations regarding the visit and the heritage. If those indicators revealed hints of an understanding of the importance of the heritage, they could be considered a complete success.

Heritage as an object

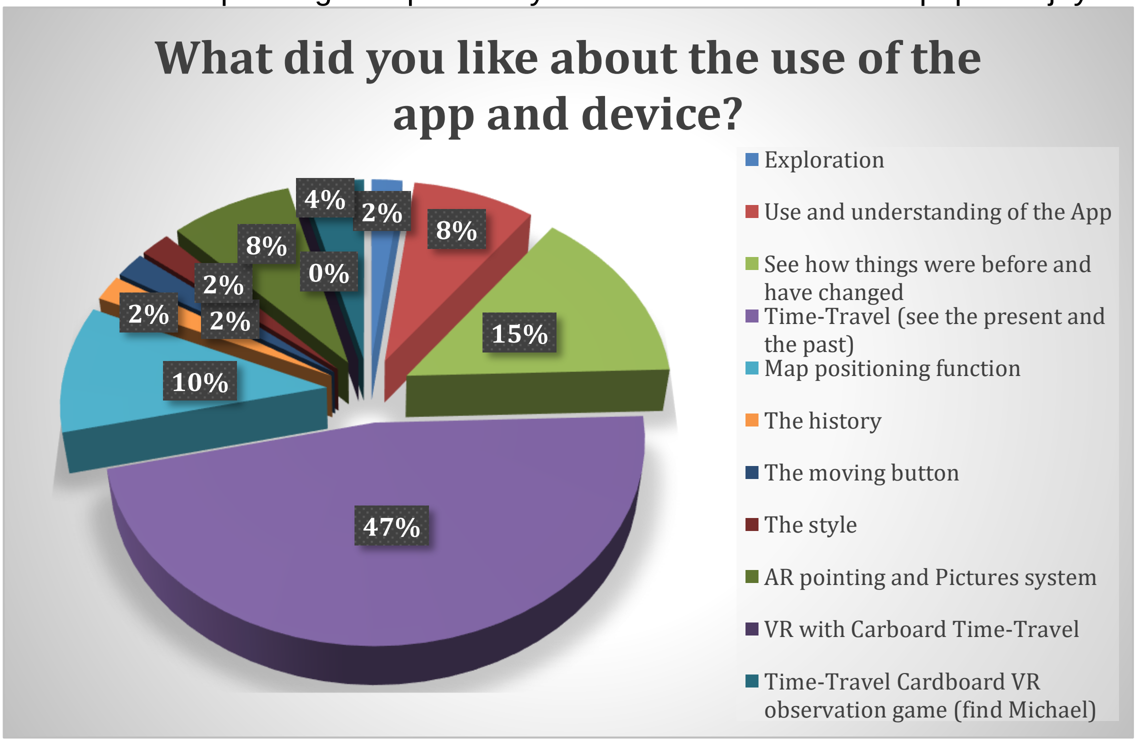
As briefly explained in Chapter 1, and again in Chapter 7, heritage is a particular object to deal with. It could be both the object and the mediating artefact. Furthermore, it could also be also the *objekt* and *predmet*—both the physical object that exists independently outside of the human mind (e.g. a tree) and the kind of object that exists only in relation to human use (e.g. the labour involved) (Kaptelinin, 2005).

MR technology mediation

The mediating technology consisted of the MR app, which was used by the students (in pairs), by the teachers (as auditors), and by the guide. The researcher was there for observation and technical support. To better understand the nature of this interaction between the students and the app, this paper proposes an analysis using Engestrom's mediating artefacts hierarchy. The MR app seems to cover more than one place on the hierarchy in this case. The first class is represented by the 'what' artefacts, and the MR app is part of this category because it is a mean of achieving the object, and is also part of the 'why' class since it provides motivation and engagement for the achievement of the object. Finally, the MR app belongs to the 'where-to' class as well since it helps to foster an evolution of all elements of the AS.

Students–MR technology relationship

Regarding the interaction between students and the tool, the students exhibited active behaviour while using it. They were actively looking for information and correspondence through the app (Kuutti & Arvonen, 1992), so every action of the activity mediated by the technology required an active attitude to reach the goal. For instance, in terms of the sub-goal of understanding how Box Pond had once been and what had changed, the students needed to use the mobile phone, look around, and explore the virtual scene to find all the differences and connect what they saw with the guide's explanations. We aked the students about this relationship to understand which kinds of actions they preferred (Figure 77). In total, 47% of the students enjoyed the time-travel interaction the most, 15% liked seeing how things were before and have changed (which is part of the time-travel experience), 10% expressed a preference for the map-positioning function, and 8% said they most valued the AR pointing and picture system. At least 66% of the pupils enjoyed the action



of seeing the past through the MR app.

Figure 77: Graphic on the question of the post-visit questionnaire of Hestercombe: 'What did you like regarding the use of device and app?.'

Nevertheless, from observation and feedback, we found that there has been a conflict in this relationship because of several problems the app had in terms of bugs, lags, and crashes (Figure 78). Pupils using the less up-to-date devices experienced this issue severely. Not every child (39 out of 56) answered the question ‘What you disliked of the use of device and app?’. Several others only answered the positive question or wrote that they found nothing bad in the device and the app. However, 70% still found something to dislike, and 85% of them had problems with slowness, freezing, and glitches. This, together with pupils that had general difficulties in the use of the device, brought the percentage to 90%. It is significant to know that 5% of pupils complained about the obligatory landscape orientation, while they would have preferred the portrait one. Interestingly, some (2%) requested to have people in the app. As for the big issue of slowness, freezing, and glitches, we could not really solve that problem (i.e. tension) because we did not have funding to buy newer and more powerful devices.

Troubleshooting strategies and techniques

Having anticipated the kind of problems with the devices and the app, we decided that the researcher, a technology expert, would participate in the visit as technical support and for observation purposes. Of course, the framework app was optimised since the first

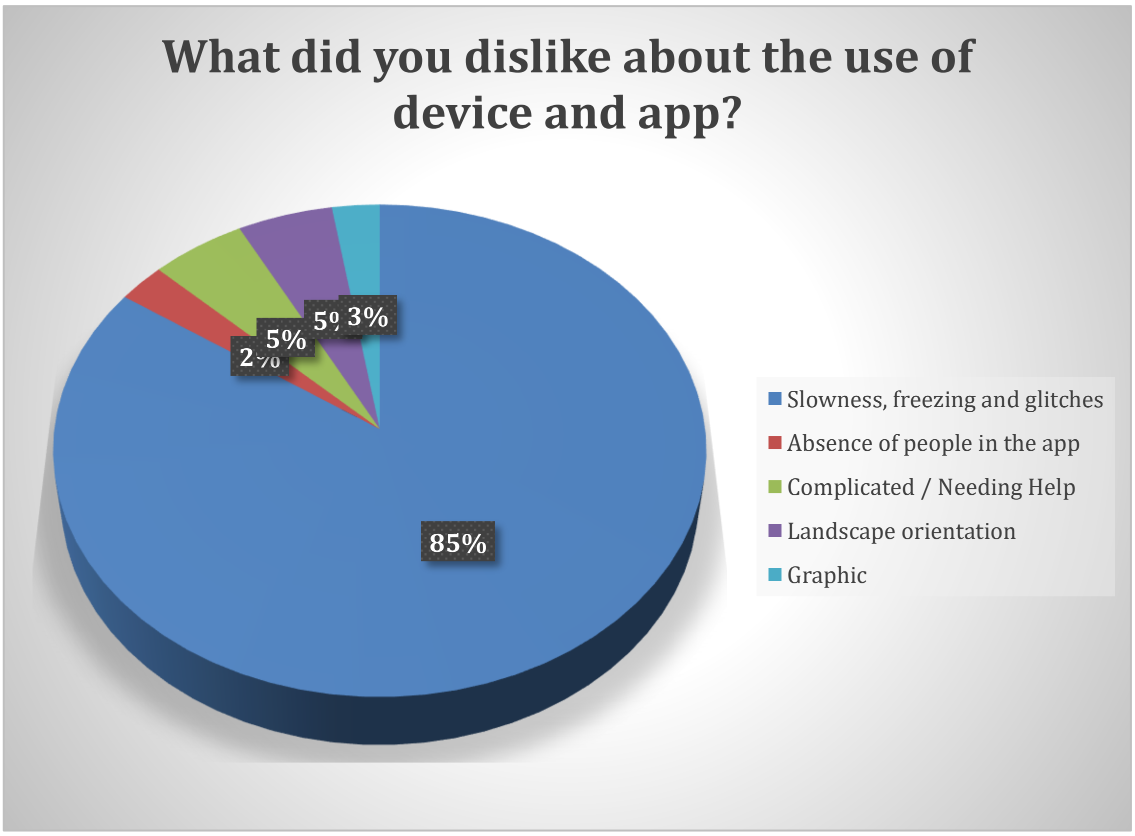


Figure 78: Graphic on the question of the post-visit questionnaire of Hestercombe: ‘What you did not like about the use of device and app?.’

Verona visit following feedback and the most urgent problems between the ones we could solve. For this reason, we actually had just a fraction of the problems compared to the first Roman Verona visit.

Support and mutual transformations between actions and operations

At the beginning of the visit, during the explanation of the Tri-AR method and the use of app and the device, students learnt to use the device and the app, as well as to respect the phases of Tri-AR. The students had to learn almost everything regarding the use of the app's interface in those training moments at the terrace walk stopover. For example, the pupils learnt how to navigate and explore their surrounding using the app, as well as how to activate hotspots and time travel. After this short training, and for all the length of the visit, those actions became operations since they were automatically activated to execute an action(e.g. exploring the Turkish Tent). However, in the case described in the previous section, in which some pupils needed further help, we had to bring back those operations to the action level in order to perfect the procedure and help them to use the app correctly.

7.8.2 The relationship of environment and heritage with the MR app and students

Role of MR technology in reaching the goals of actions and relating with the object of the activity

Rarely has the concept of a 'functional organ' been more appropriate than in this activity. A functional organ is, in fact, the result of the temporary fusion of internal and external resources, human capabilities, and tool properties to attain goals that could not be attained otherwise (Ukhtomsky, 1978; Leontiev, 1981; Zinchenko, 1996; Kaptelinin, 1996). Looking at the MR technology used in this research (extensively explained in Chapter 3), which allows for the use of smartphones or the device to merge a virtual visual layer with the reality, we can understand how it fits into the functional organ definition. Without such a technology, it would have been very difficult for the students to understand and imagine views and seats that have not been recreated yet. In addition, the technology contributes to the engagement of students, creating internal conditions conducive to learning (Figure 80). It is interesting to notice how the students managed to evaluate the engagement of their classmates as well (Figure 79) in a more critical way than their own. In this case, they had a very critical view of it. They saw their classmates as not particularly engaged. As already illustrated in Chapter 3, MR technologies can present very contextualised information that can contribute to the construction of knowledge providing 'just-in-time' information. Finally, MR forced the students to work to normalise the cognitive dissonance between the reality and the mixed and augmented reality through a process of reinterpreting the reality by means of the newly acquired knowledge.

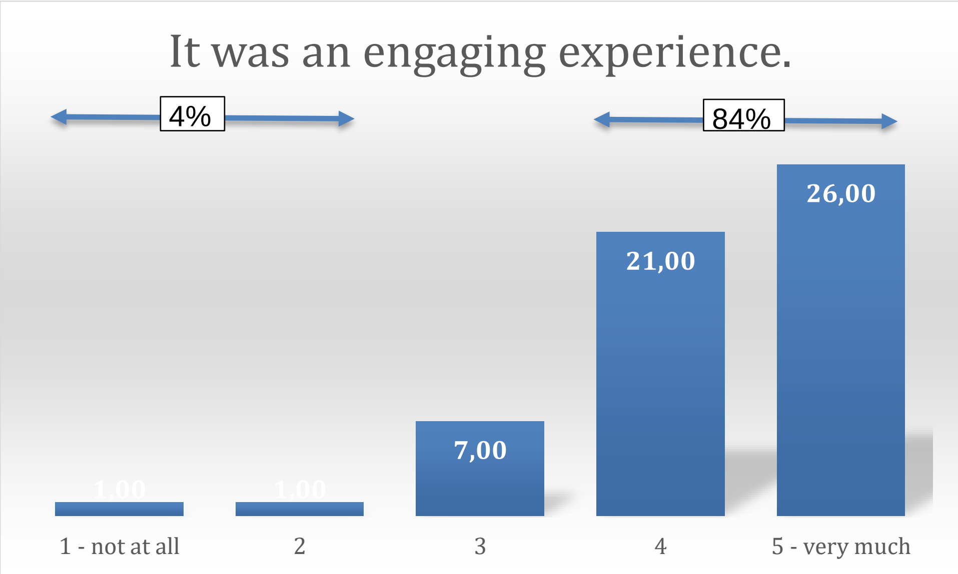


Figure 80: Frequency distribution of the answers to the following statement: Has this been an engaging experience for you?'

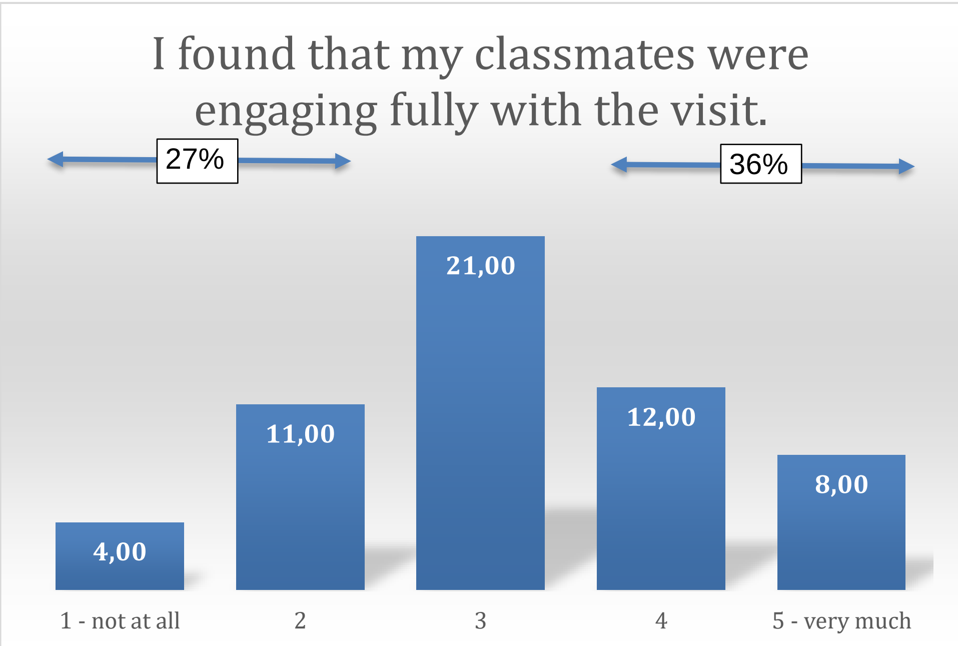


Figure 79: Frequency distribution of the answers to the following statement: 'I found that my classmates were engaging fully with the visit."

Heritage as a mediator

More than once in this dissertation, we have expounded the concept of the heritage as a mediator and object at the same time. Therefore, in this section, we highlight that heritage acted as an additional tool available to the students. Following the instructions of the guide and their own visual exploration and manipulation of the artefacts, they were able to understand cultural meanings and symbols. This happened through the artefacts (the remains) as mediators of the heritage, the result of the crystallisation of social meanings. As an example, during the explanation of the guide at the Chinese Seat, the guide invited pupils to enter the seat, to sit down, and to look at the views. It resulted one of the most successful stopovers (see sub-Chapter 7.7) even without the use of the any MR technology.

Tools and materials shared between several users

Both the devices and the heritage itself were shared tools. But, while heritage is inherently shared, the shared use of a device may sometimes be an issue. Each device was shared between two children. Part of the initial instructions were dedicated to telling that at every stopover the device must be shared with the other half of the pair. During a stopover, both had to complete the same activites with the device and the app, beginning with carrying the device. In England, in contrast with Italy, we did not receive complaints about the need to share a device or because the swapping had not been respected.

Division of labour, the roles during the visit

During this detailed analysis, the description of the roles and the division of labour was partly done. Four main roles exist here. The guide leads the visit, explains the site to the children and interacts with them, sometimes through the app, following the patterns of the Tri-AR model (Section 6.4.1). The teachers of the class had to ensure that the pupils behaved well, and they dealt with all the students' requests that fell outside the strict conduct of the visit. The researcher was an observer for most of the time, except when a technical problem with a device arose. In that event, the researcher's job consisted of finding a fix it or substituting the device to allow the visit to proceed as smoothly as possible. Of course, the students had their role, which was to listen, understand, explore, and ask questions. In addition, they had collateral roles for organisational purposes (e.g. to agree on and form pairs and to carry mobile devices and Google Cardboard headsets).

Rules, norms, and procedures regulating social interactions and coordination related to the use of target technology

It is normal that a visit involving a school class has a defined set of rules regarding the safety of the pupils, as well as the responsibilities of the adults and (notably) the teachers. There are rules that specify how many teachers are needed for a certain number of students; moreover, the students had to wear high visibility vests and a document with all the information needed in case they got lost. For this particular visit, as already mentioned, we took some minutes at the beginning in order to explain the rules for the interactions between the guide, the student, and the technology. The rules are included in the Tri-AR model and described in section 6.4.1. In brief, the development of every single experimental stopover (stopover with the use of MR technology) was split into four phases. When the phase changed, the rules changed. The rules related to whether or not the students could interact with the app, with the guide, or between each other. It began with a first phase, when pupils needed just to listen (if they were not specifically questioned by the guide), to the last phase, when they had the initiative and the freedom to interact with both the guide and the app.

7.8.3 Learning/cognition/articulation

Internalisation and externalisation processes in the visit

Internalisation and externalisation processes existed on two different levels in the activity: at the mental processes/external behaviour level and at the inter-psychological/intra-psychological level (Vygotsky, 2012). That is, constituted external mental processes shared with the community (inter-psychological) and mental processes inside one's own mind (intra-psychological). During the visit, those processes were continuously occurring and were especially appreciable at every stopover during the Tri-AR routine. For simplicity, this dissertation only covers the internalisation and externalisation processes from the perspective of the students.

In this first step (Figure 81), the guide provides an introductive description of the seat or the view and its history. Furthermore, the guide highlights the differences between the place as it is now and how it was in the 18^{th}, 19^{th}, and 20^{th} centuries if relevant. In this phase, the students—always the subject of the action simultaneously internalise information directly from the guide as well as information and meanings mediated from the heritage in front of them.

In the second stage (Figure 82), the guide encourages students to use the app to

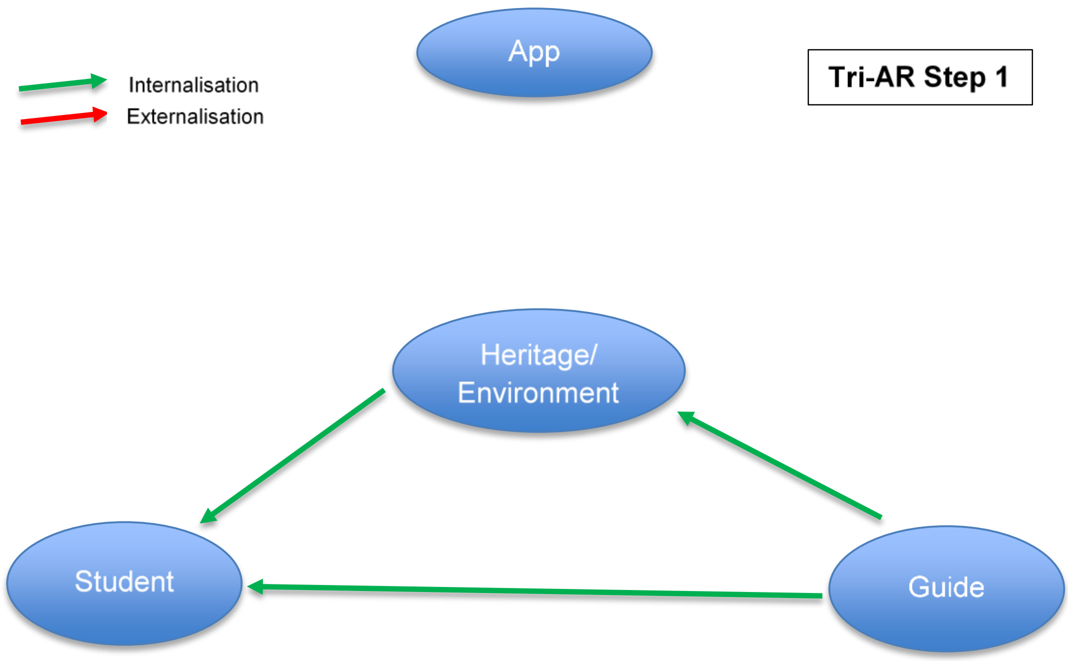


Figure 81: Internalisation and externalisation processes of the students in the first step of the Tri-AR methodology.

discover said the elements discussed in the initial explanation in the actual environment. Then, the guide asks the students to discover details and AR or MR content, eliciting feedback by posing particular questions. In this phase, the student is called to respond actively by using the app as a mediator with the heritage. This process makes the students externalise, at the action level, the information that they have just acquired from the guide. While looking for correspondence between what they have just learnt and the information on the app, they internalise information and meanings.

During the third step (Figure 83), students provide feedback, freely explore the environment through the app, and ask their own questions. Here, the process of externalisation is also at the inter-psychological level. In fact, pupils share with their classmates and the guide their observations and their questions in order to solve them within the community. Once the community finds the answer, it can be internalised at the intra-psychological level.

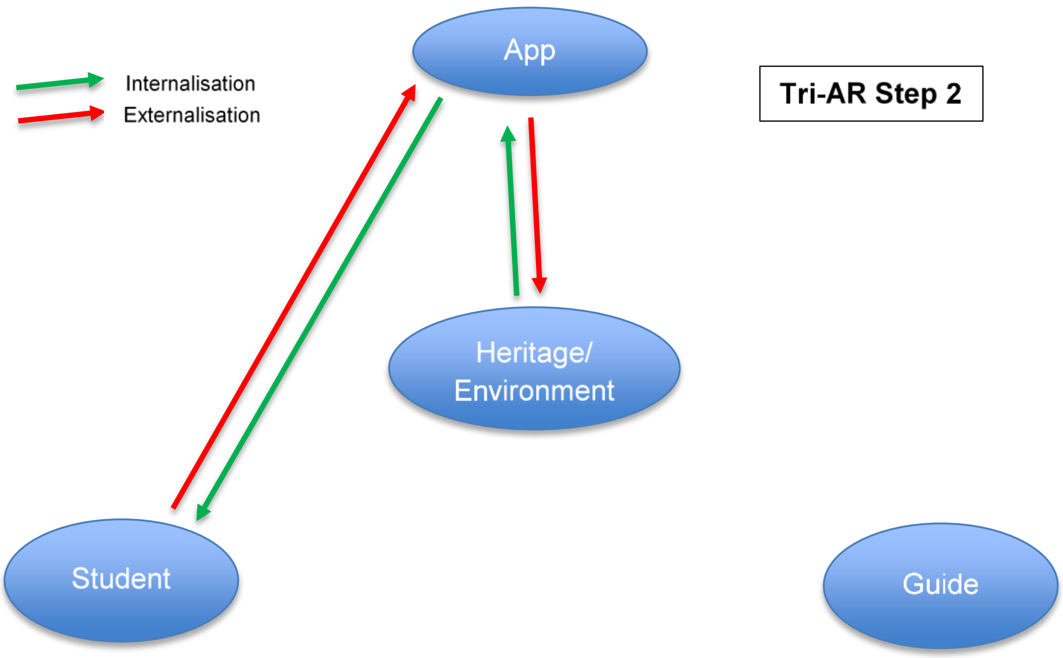


Figure 82: Internalisation and externalisation processes of the student in the second step of the Tri-AR methodology.

In the last step (Figure 84), the guide answers the students' questions, if required, by using the app. Students interact with the guide, referring directly to the artefacts or the environment or using the app as well when they think it will be useful. In this phase, all the previous interactions are possible, as well as more classical ones, including (for the student) using the heritage as mediator bypassing the app. This means that processes of internalisation and externalisation, both at the mind/behavioural level, as well as at the

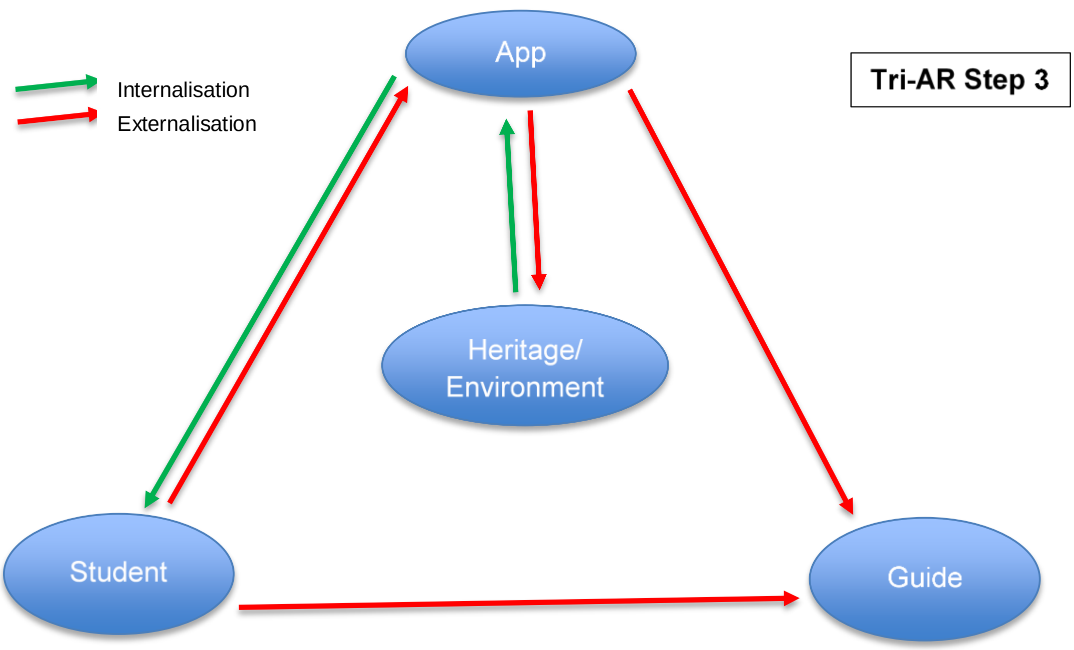


Figure 83: Internalisation and externalisation processes of the student in the third step of the Tri-AR methodology.

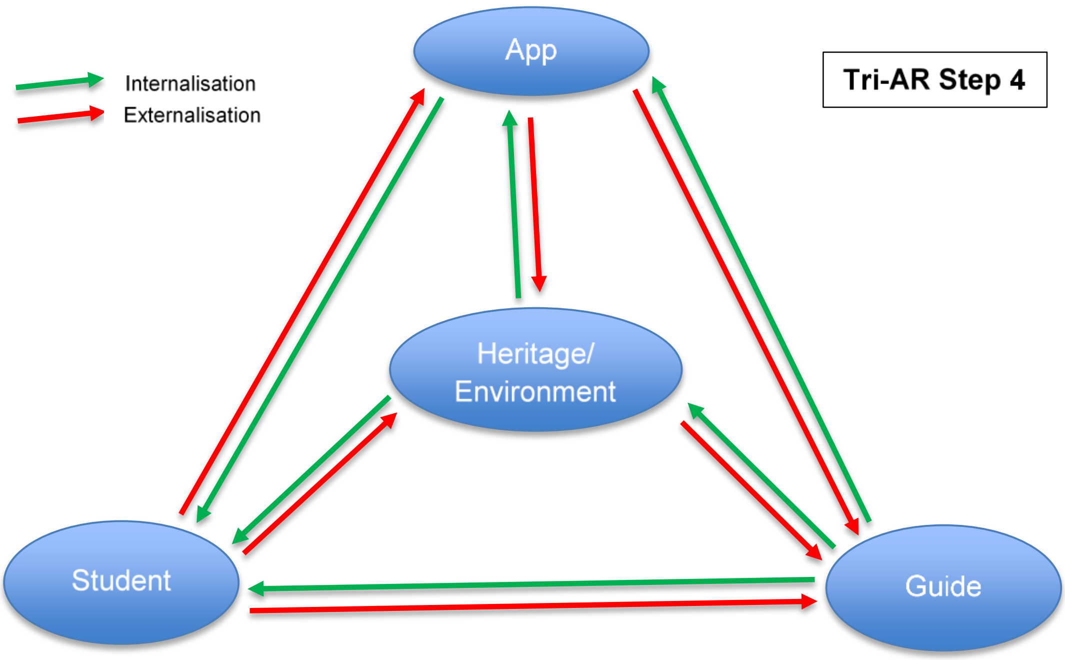


Figure 84: Internalisation and externalisation processes of the student in the fourth step of the Tri-AR methodology.

inter-psychological and intra-psychological level, could happen depending on the students' level of initiative.

Knowledge about MR app technology that resides in the community and how this knowledge is distributed and accessed

The knowledge about the MR app technology in the community came from the researcher, who transmitted it to the guides. The guides needed to know how to use this information during the visit—to refer to it and to guide the pupils during this mixed-reality visit. The researcher, as already mentioned, at the beginning of the visit spent some minutes explaining how to use the technology. When the pupils needed to know more about the technology because of some problem or because could not complete the action using the device, they could either to address their peers or the researcher. Usually, the pupils tended to try to resolve the problem with peers, but only if it was not possible to ask the researcher. The access to this knowledge was always open, except in the first step of every stopover—during the guide's detailed explanation. This approach allowed us to adhere to the principle that the technology should not distract from the guide's explanation.

Time and effort necessary to master app operations

The Hestercombe MR app was developed to be very intuitive. In fact, it only required the few minutes of initial explanation and a few clarifications to allow a primary school student to use it because of the very basic kinds of interactions that the users had to understand, as well as the lack of menus. The interactions included tapping (the touchscreen equivalent of clicking), dragging, and pointing the device. The following graphic show how easy the students found the app to use (Figure 85). The difficulties in using the app did not stem from a problem in mastering the operation of the app but due to poorly performing devices and bugs on the prototype app.

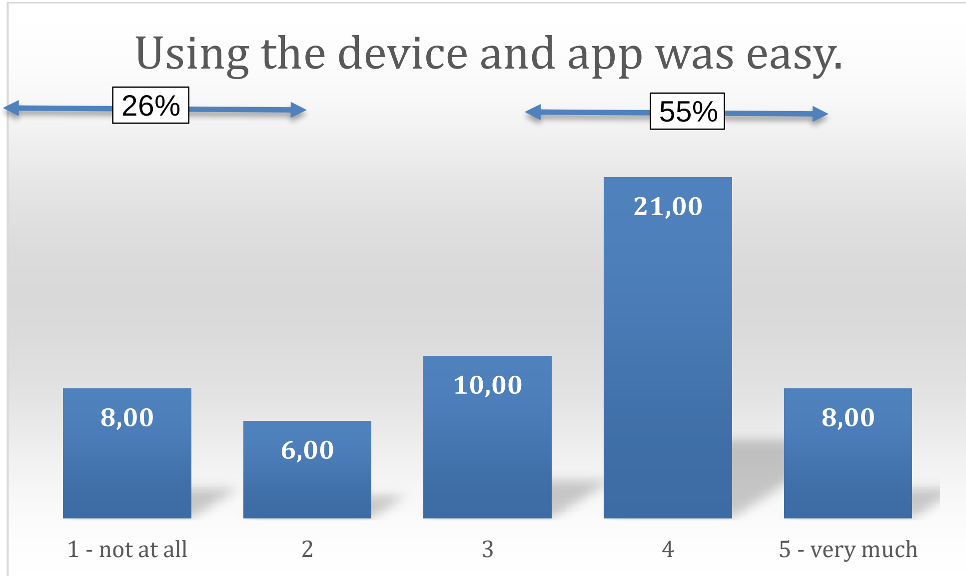


Figure 85: Frequency distribution of the answers to the following statement: 'Using the device and app was easy.'

Self-monitoring and reflection through externalisation

In the prototype app, it was possible to answer to a quick test of three multiple-choice questions to receive a feedback at the end of every stopover, but the time constraints did not allow us to apply this approach. Therefore, following the visit, we had to rely on the answer to the questionnaires, the drawings, and the follow-up test. In the author's opinion, the drawings, in particular, represent a powerful form of reflection through externalisation, and the differences between the experimental and control groups' drawings were analysed to tease out the level of appropriation (internalisation) of the heritage (Einarsdottir et al., 2009).

Use of shared representation to support collaborative work

During the experimental visit, shared visual representations were provided from the app and from the heritage itself. During the visit, the collaborative work for pupils consisted of the interaction with the guide and the app, as well as the co-construction of knowledge that resulted from those mediations.

Individual contributions to shared resources of the class

With reference to section 7.8.3.1 and the Tri-AR methodology, we see the individual contributions to the shared resources in the moment of the externalisation in the form of questions, answers, and contributions to the common discourse of the stopover. Another contribution that has been remarked upon is the contribution between peers. In the pairs that used the device, when pupils discovered something, they often pointed it out to their classmates.

7.8.4 Development

Effect of implementation of MR technology on the structure of actions

If we compare experimental and the control stopovers, we can arrive at a decent understanding of what changes in the structure of actions are required. Looking at the AT triangle, the only thing that changes between the two types of stopovers is the mediating tool. Instead of providing a plain explanation, we used the device. Every action that passes through the mediating tool changes. If it is true that the heritage itself is a mediating tool, it is not interactive; more specifically, it is not reactive if not used in conjunction with the guide. The guides constitute shared resources who, although being interactive and reactive, can only answer to one child at a time. On the other hand, the use of the tools requires both a further step in learning operations and a supplementary action, and the latter requires the pupil to point the device up and explore the environment in a heads-up fashion. The same exploration must be active since it requires another interaction, which is to tap on the screen to have more information or to see different media. A final level that changes is the one of appropriation, or internalisation, of the visual media proposed by the MR technology. Using MR technology, a pupil is not merely looking at two-dimensional print but experiencing a three-dimensional re-creation, sometimes immersive. Overall, we affirm that actions are transformed from a passive to an active attitude, from waiting for information to looking for information.

Students' attitudes towards MR technology and how they changed over time

The attitude towards the MR technology was very positive. Since the first moment, the pupils were very enthusiastic about the opportunity to use the devices and the app during a school visit. This enthusiasm did not wane during the visit in most cases. In some cases it did because of problems with the old devices that frustrated the pupils. In total, 82% of the students found the technology useful (Figure 86); 52% said that they would not to have a traditional visit, compared to 20% who would have preferred it (Figure 87). Those are

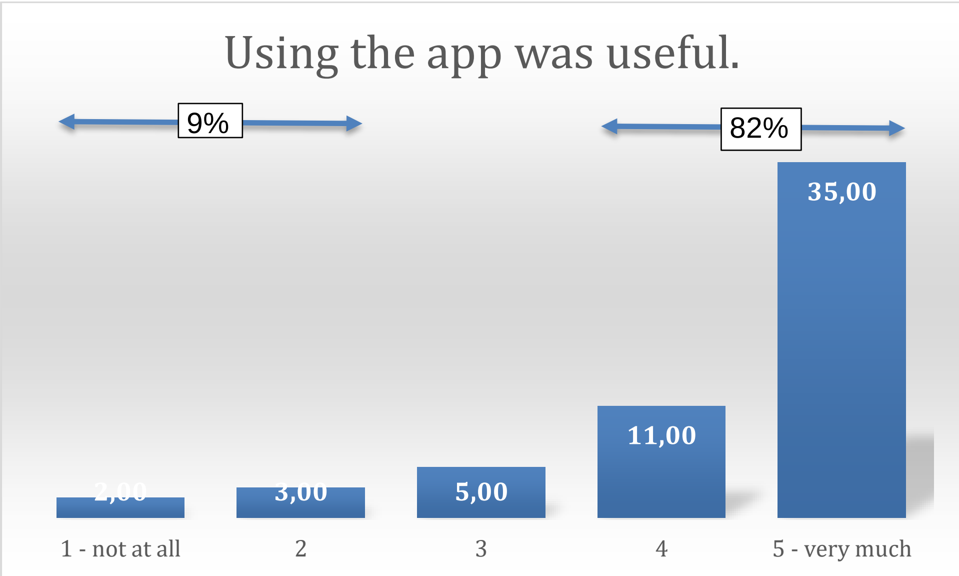


Figure 86: Frequency distribution of the answers to the following assertion: 'Using the app was useful.'

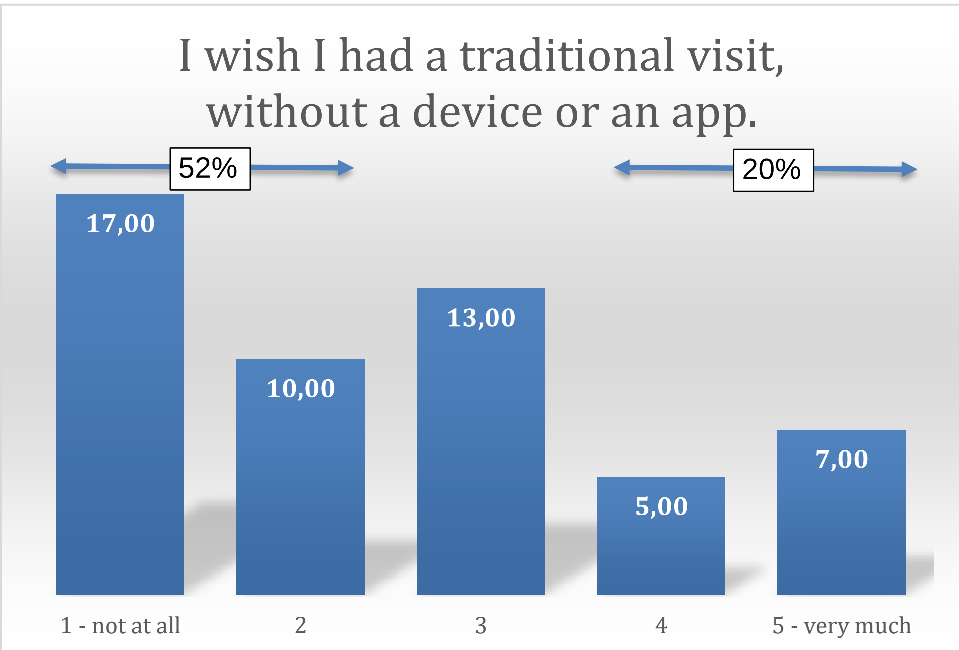


Figure 87: Frequency distribution of the answers to the following statement: "I wish I had a traditional visit, without a device or an app.'

important indicators because they have been registered after the experience when the students had actually used the technology and found some limitations and bugs. As previously noted, the interaction they appreciated most was the most immersive one, the exploration of the past using the time-travel MR mode. Furthermore, as we were expecting, based on the pre-visit questionnaires, no one was in any way tentative or shy while using the devices. At the same time, they handled the devices with great care and attention.

Changes in the practice and the level of activity systems they directly influence

When this activity began, it was an extension of an innovative research study for the University of Padua and the University of Lille, while for the schools involved and for the Hestercombe Trust, it was a complete novelty. After the experience of Verona, we knew that the augmented visit was a runaway object with unpredictable outcomes. In fact, by word of mouth, we had an interview and an article in the Somerset County Gazette, highlighting how the experience had been appreciated and, potentially, how much those kinds of visits could engage schools and the general public. This experience, especially the research part with the Hestercombe Trust, boosted their interest in having an easily searchable digital archive. In fact, digital photos, and surveys in standard formats have been of the highest importance for creating the virtual model of the 18^{th}-century English garden.

Chapter 7

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CHAPTER 8
Thinking Forward

This chapter contains a discussion of the findings and main contributions, as well as a review of the initial aims of the thesis. While some of the expected things did not happen, some unexpected ones in fact did. This chapter underlines the limitations and constraints that affected the research and elaborates on different emerging findings. The role and the future direction of the concepts that lie behind the development of MR technologies are often overlooked by educational and technological researchers, but their influence is crucial to achieve a better understanding of behaviours and outcomes. They are discussed here, as they are the basis on which to create the perspective to move on, finally, towards reccomendation for future research.

8.1 Reorienting future objectives

This research sought to understand whether or not the use of mixed-reality mobile technology used with appropriate didactic methodologies could improve the experience and the learning of primary school pupils visiting outdoor heritage sites. Engaging, understanding, and remembering were the three parameters tracked on various cohorts of pupils. The idea was not to limit the research in discovering 'whether' but to extend it in exploring 'why' and 'how' the change was possible. Finally, I did not want to overlook the 'where' factor. Thus, I tested the same technology, methodology, and format in different places, cultures, and heritage contexts. I was surprised to discover that, while pursuing those main goals, other sub-goals emerged. These needed to be reached in order to gain access to the main goal and were not inferior in terms of complexity and the amount of work required. A good example is the app and the embedded issue of the virtual world. At the outset, I had no intention of building an MR app, but it turned out to be necessary since no existing app had all the necessary features. Once I had created the framework of the app, the next necessary step was to create a virtual world of the Roman Verona and then of Hestercombe in order to have the time-travel function. To create such virtual worlds required more knowledge and understanding of both Verona and Hestercombe heritage than anticipated. Meanwhile, the Roman Verona app needed updates and bug fixes based on the feedback because other classes asked to have the same visit experience. It is evident that this became a substantial additional part of the research, adding questions such as ‘Which is the best device to use for the visit?’, ‘Which is the MR interaction that best supports the goals of the visit?’, ‘How can we better represent the Roman Verona or the 18th-century Hestercombe Gardens?’, and ‘Which sources should be used?’. The visual sources used to create virtual reality had to be analysed and understood, adding to the case studies a research study focussed on the visual arts. The drawings made from children closed this circle in a sort of *ring-struktur* (Leont’ev, 1981), where the researcher used the original visual source to create the virtual and mixed reality, and pupils derived an augmented version of the original source, together with a ‘supplement of interpretation’.

Developing a specific methodology and, format for this kind of augmented visit—as well as a tool, a practical translation of AT, and socio-constructivist principles—was as important as the creation of the app. I realised this fact with the creation of the name ‘Tri-AR’. It needs perfecting, but it represents a step in the right direction.

8.2 Taking stock of findings

The experiences of the Roman Verona augmented visit and the Hestercombe Gardens augmented visit could be considered as ‘runaway objects’ (Engeström, 2008) since they opened and expanded the scope of this doctorate in unpredictable ways. This section presents a synthesis of these objects and revolves around the questions that guided the research and the last sub-section addresses unexpected findings.

8.2.1 Question 1: effectiveness

Can the use of mobile mixed-reality technology for outdoor cultural heritage education, along with an adapted teaching methodology, support the learning and interpretation processes better than traditional tools? How effective is it in terms of engagement, remembering, and understanding?

This was the first and main question of the research, as well as the one explored the most with both quantitative and qualitative research tools. By addressing those three criteria in turn, I found the following.

8.2.1.1 Engagement

Both Hestercombe and Verona classes provided important feedback on engagement during the visits. The question in the post-visit test on whether it was an engaging experience in Verona had 38% positive and 25% very positive answers (total positive =

63%), compared with only 12% negative or very negative answers. The same question at Hestercombe had 84% between positive and very positive answers, compared to 4% negative/very negative responses. Two questions were related to engagement. In the first one, students had to evaluate their own levels of engagement, while in the second one they considered the engagement of their classmates. That way seemed to offer the chance to achieve a better overall balance of students' impressions for an index based on the average of the two. This engagement index is in the 0–1 interval, where 0 means everyone has voted very negatively, and 1 signifies the opposite. The engagement index of the Verona experimental classes was 0.71, but for the Hestercombe experimental classes, it was 0.68. The control classes in Verona resulted in an index of 0.71, which is the same as that of the experimental classes. Does this mean that they like to have a visit away from school no matter what? It might seem so, but the answer is probably more complicated. As highlighted in the analysis on the components of the Verona visit, the second, stronger correlation between components was an inverse one between Pre C1 and Post C1, which are, respectively, the 'use of mobile devices for learning' and the 'visit satisfaction', including engagement. The MLM analysis of the components also indicates that girls have been slightly—but significantly—more engaged than boys. These hints suggest that the more the students become accustomed to mobile technologies for learning, the less excited they feel about using them. This negatively impacts the engagement of these students, causing them to be, to some extent, distracted by other things that they could do with the device. On the other hand, students who are not used to those technologies are not distracted because they tend to follow the rules of usage and, at the same time, they become more excited and attentive. This kind of interaction is also supported from some statistical trends I came across during other analyses. For instance, there was a slight inverse correlation between the score in answers relating to the organisation of the Roman city and the usage of the IWB. The organisation of the city has been explained using the IWB during the introductory lesson. This data confirms and expands what researchers have found until now: Mobile technology can act as a distractor in teaching contexts (McCoy, 2016), but it can also play the opposite role in the same context, depending on the student. In our case, distraction and engagement factors balanced, resulting in the same high level of engagement for both the experimental and the control groups.

8.2.1.2 Remembering

Bloom's taxonomy (Bloom et al., 1956) distinguishes knowledge functions from comprehension. In its revision (Anderson et al., 2001), the words regarding remembering and understanding were changed. Remembering is a lower-level function compared to understanding; it is the base of the cognitive processes pyramid. One of the main objectives of the study was to ascertain whether mixed-reality mobile technology could help students recall information better than the normal booklet available for a cultural heritage visit. From the results of follow-up tests in Verona and Hestercombe, I can affirm that adopting the same base teaching methodology for both the experimental and control contexts enhances the recall performance. This enhancement can be minimal or considerable depending on a couple of factors. The most important is that the best level of recall was achieved when AR technology were used—even if not combined with MR. In fact, I registered the highest scores in both Verona and Hestercombe when AR technology was used exclusively. This could be because of AR effectiveness or because of a cognitive overload when using both AR and MR modalities. The second most important factor was whether the pupils were accustomed to to game devices. The more familiar they were, the higher the score on the follow-up test became. This is probably attributable to the game-like interaction with the app. Pupils who had already used to it were not impeded from the interaction and had the opportunity to access the information easily.

8.2.1.3 Understanding

About the subject addressed in section 5.4.1, drawing is an activity that involves processes of selection, reorganisation, and integration of information. These processes do not only involve the remembering and understanding function, as described in the revised Bloom taxonomy, but they also add the analysing function, which is of a higher level. Because of that, drawings were among the best tools available to test whether the mobile MR and AR technologies helped in fostering a better understanding of the cultural heritage. From the data I extracted from the pupils' drawings (see sub-Chapter 6.7), it seems that the understanding of the cultural heritage and its context played a more important role in the experimental group in the following areas (as suggested by Jonassen et al. [2005] in their "rubrics for assessing systems dynamics models", see section 5.4.1):

1. Quality of models: The experimental group members (who participated in the experimental stopovers) drew the monuments with a higher resemblance to the

original structure and with a more corrected projection of the three-dimensional object on the two-dimensional paper medium.

2. Quality of relationships: The context was better represented in the experimental group and for experimental stopovers. Interactions between the monuments and the surrounding space, included people, emotions, the city or garden system, and the past, were represented in higher quantity and quality.

8.2.2 Question 2: Changes in relations

Contrasting the classic visit, where the mediating tool is the booklet, with the augmented visit, where the mediating tool is the smartphone, what are the changes identified in the relations between student—tool— guide—heritage?

During the research, I realised that, with the complexity required in order to answer the first question, this second question had already been partially answered. Thus, I rephrased it, focussing on the relations in the activity, employing the AT analysis in order to answer this question in detail both for the Verona (section 6.7) and Hestercombe studies (section 7.8). I discovered that, using the MR tool, a whole new level of interactions was enabled—not just between the student and the tool but also between the student and the guide and the student and the heritage through the tool. The main reason for this is because of the affordances of the MR tool, especially the fact that, unlike the booklet, it is capable of interaction and is responsive to the actions of students. This interaction raised the interest and the motivation for the visit. Also, looking at the answer to question 1, the interaction enhanced understanding and remembering.

On the other hand, I discovered critical issues that needed to be addressed. It was paramount to pinpoint them because they represent the so-called 'tensions' or 'discordances' in the ASs (Figure 88), which are a fundamental part of an AT analysis. At the basis of the tensions between the student and the MR tool, there is the fact that the latter was less transparent to the pupils than the booklet. In other words, sometimes it is noticed too much, thus causing distractions. During the research, I was able to isolate two factors that correlate with those problems:

1) Too much interest in the device: Some pupils who were very interested in technology and knew how to use the device very well would tend to try to test the device and find other functions and consequently lose concentration during the visit.

2) Technical problems in the tool: Devices and software that were not running smoothly for different reasons frustrated the students and distracted them from the visit.

Those two reasons, by the transitive property, were also the source of tension in the relationship between student and rules, as well as between MR tool and rules. Students who were distracted by the device, or who were experiencing problems with, it did not always follow the rules despite the procedures adopted to tackle those eventualities. The community is involved in this tension because the student is always with another classmate using the same device. The classmate acted as a first help; if that failed, the student asked the researcher for troubleshooting assistance.

In the English case study, I found an additional tension between the community and the objectives that was not present in the Italian one. In fact, the Hestercombe visit, although intended to fit in broadly with the school's work programme, in the event, it did not do so, which resulted in less involvement of teachers and less effort by and motivation for pupils in completing the test. This tension would have existed regardless whichever mediating tool might have been involved.

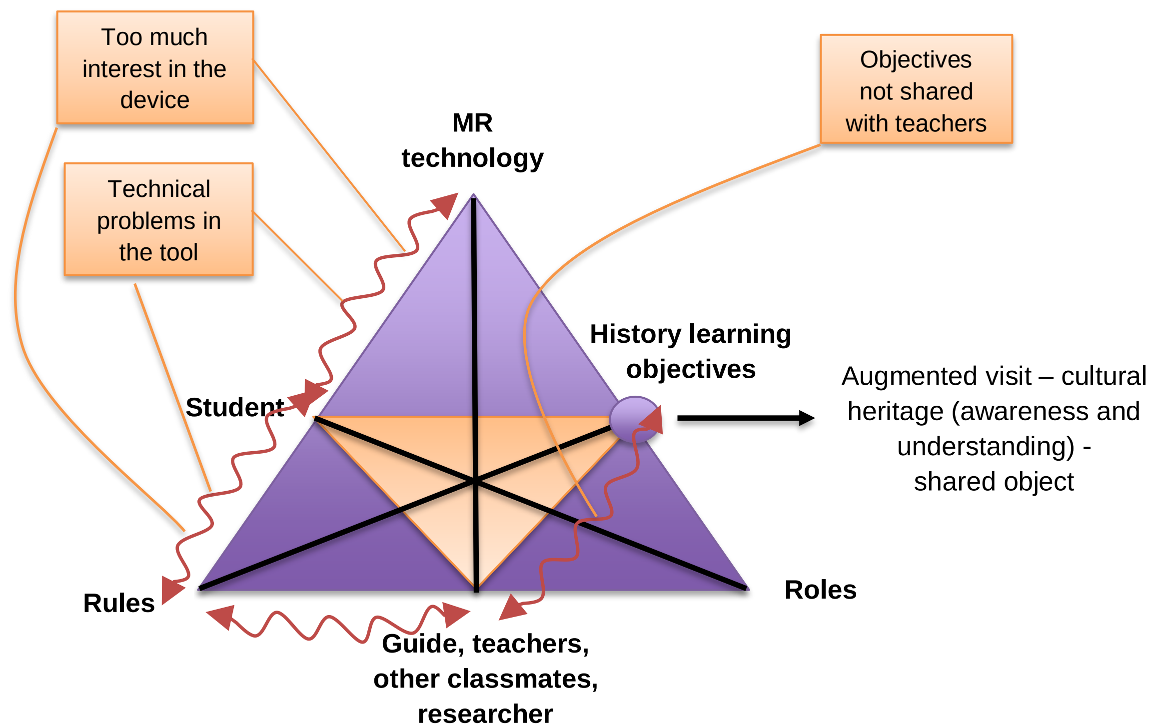

Figure 88: Visit activity system of experimental classes. Tensions are represented by wavy lines.

8.2.3 Question 3: Transferability to other cultures and heritage

Are the technology and methodology transferable to other cultural contexts and heritage?

Notwithstanding the difficulties encountered in replicating the experience of Verona, I was able to put Hestercombe to the test both in terms of the technology and the methodology. The only other variable that I kept was the age group. The cultural context and cultural heritage both changed. The results of the two case studies allowed us to answer this question positively. Applying the same methodology and technology to different cultural contexts and heritages produced similar—positive—outcomes. The transferability of the technology and the methodology seems to be therefore confirmed, at least by the two case studies in this research. Nevertheless, to strengthen this point, more case studies should be carried out.

8.3 Main contributions of the thesis

1. While many researchers have used augmented and mixed reality, few have concentrated on the real impact of this technology or its reliable models of use (Pribeanu, Balog, & Iordache, 2016). This dissertation contributes to the debate on the benefits of using new technology.
2. The dissertation took into account the level of familiarity of pupils with mobile technology and cultural heritage inside and outside school contexts in order to avoid any bias.
3. Drawings from children from the experimental and control groups were used to understand the appropriation of concepts through the images mediated by MR or simple booklets.
4. To the best of the author's knowledge, this dissertation stands out in its use of mobile MR app for heritage education—not as a substitute for the guide but as a more powerful mediator at the guide's disposition. Furthermore, the app was developed following historians' and guides' suggestions and after analysing the already existing visit format. So, it is the technology which was adapted to education and not the contrary.
5. This thesis formalises the ways between students, guides, technology, and heritage in terms of interaction and mediation, which can be applied to other contexts.
6. The research tested the same technology and methodology in two completely different cultural environments and heritage to understand the technology and methodology transferability.

7. This research serves as a first step towards the use of new MR technologies to allow pupils from different European countries to share their heritage and recognise common roots as a motive of cohesion for all European citizens.

8.4 Limitations

Case studies' development has diverged from the ideal research design because of several practical limitations that are almost inevitable in real-life contexts, especially with schools and children. The first limitation was the impossibility of having a randomised sample of pupils to attain an experimental design. This happened because I had to work with classes and schools that agreed to be part of the research. The second limitation was related to the timings of the research and the schools. It was necessary to run the first experimentation in the Spring of 2016, so the time was limited to only a few months to organise the case study and create the MR tool. There was a similar problem in England. These issues resulted in MR tools that were not bug free and caused several technical problems. Three other limitations were related to each other and with the MR tool: money, developers, and devices. Since this research was conducted to complete at the PhD level, the financial support available did not cover the cost of devices on which to run the MR software. Even investing personal funds, the funds were just enough to buy used devices that ran the MR software but in a sub-optimal way. The second limitation involved the lack of professional software developers and computer science researchers. With their help, the MR tool could have had fewer bugs, and the overall experience could have been better. Another class of limitations were those caused by contingent organisational issues that made it difficult to follow the research protocol correctly. One example of those is the modification I did to the research design in England. Unable to find control classes, I was forced to create experimental and control stopovers within the same visit. This prevented me from comparing in parallel the two case studies as envisaged.

8.5 Eyes on the horizon: The mirage of the 'new'

Mirages are optical effects caused by the refraction of the light in a medium, usually the air, of which the density varies, usually because of the different temperature. They are a phenomenon that occurs naturally with the effect of displacing or modifying elements of the visible landscape. Typically, they could give the impression that there is a body of water where it does not exist, with reflections of the distant landscape; they can show reflection of things that lie even further ahead, behind the horizon, or make elements of the landscape look as if they were fluctuating in the air or bigger than they are. It would be fascinating to consider them as a natural form of virtuality, of an optically modified perception of the landscape. It is not known how and when people took this idea from the natural world to use it in their crafts, but it is known that those natural virtualities have profoundly influenced stories and legends of civilisation until about 100 years ago. To distinguish 'perceived reality' from virtuality is never easy. Oases in the desert, flying ships, flying islands, immense coasts and islands, impossible sunrises, and even mysterious fading cities have been only a few of the examples of these phenomena incorporated in the literature throughout the ages.

Augmented and mixed reality are technologies that are commonly considered new. While researching, I realised that, if the word 'new 'is suitable for the devices in use nowadays, it is not applicable to the ideas of augmented and mixed reality. The final effect recreated by means of those devices has been pursued for centuries but is not yet as perfected as the imagination would like. Even the newest incarnation of those ideas, the one that gave the name to them, is 26 years old. In 1992, Thomas P. Caudell and David W. Mizell, researchers at Boeing Computer Services, Research, and Technology, created a headset with integrated heads-up display (HUD) and sensors to help engineers in repairing the Boing 747 airplane. In 1975, 17 years earlier, Virginians David A. Bosserman and Charles F. Freeman patented a device called a 'toric reflector'. It consisted of a headset that puts a semi-transparent screen in front of one eye, projecting on it information as distant virtual images which are superimposed on the real world (U.S. Patent No. 4,026,641). This thechnology seems to be at base of products such as modern HUDs and even Goggle Glasses. Looking back a little further, most rangefinders and viewfinders on consumer and professional cameras since the second decade of the 20th century sport a sort of augmented reality system that allows the photographer to better compose, focus, and expose a picture. They superimpose an informative layer on the view. One can find an ancestor of it in the 'drawing frame', in use since the 17th century, which helped painters in framing the landscape and that, with the 'grid' gadget, worked as a guide to the eye to maintain the right proportions and distances while drawing (Martinet & Châtel, 2001, pp. 61-2). In the 18th century, the 'Claude Glass'[40], also known as 'black mirror', was a convex

[40] It was named after Claude Lorraine, 17th Century landscape painter, because it was supposed to help the painters to achieve similar results.

hand mirror tinged with colours, which were usually dark. It was used by tourists and painters for its effect of framing the landscape, softening the lines, and emphasising tonal variations. Some of its variations included having a transparent coloured glass instead of a mirror (Kinsley, 2016). It is captivating to notice how both the Claude Glass and smartphones bring the traveller to forgo the real, natural view of the landscape for a mirage for a mediated version of it rendered by a device that changes, improves, or re-interprets it. Those technologies have always been controversial. Thinking about how Instagram and other apps work, allowing anyone to use 'filters', one can think that some critic may refer to them as 'one of the most pestilent inventions for falsifying nature and degrading art which was ever put into an artist's hand', except that is a John Ruskin quote against the 'black convex mirror', which was so effectively promoted by Thomas Gray, Thomas West, and William Gilpin. This seems to suggest that not only the ideas, but even the fears and the critics, are legacy of the past[41] (Willim, 2013).

Humphry Repton, one of the major English landscape designers, active in the second half of the 18th and beginning of the 19th century, had his original idea about the augmented representation of the reality. In his 'red books', which he often made when he was asked to landscape a garden, he drew detailed maps of the estate but also views of the garden before and after proposed modifications. The technique he used consisted of drawing a page with the new landscape on it and covering part of it with paper flaps on which he drew the existing landscape. The result was a transition effect leading to an actual *dis*-covery of the imagined landscape. The mechanism of transition and the type of content are very similar to the ones I used in the app, while the medium differs. Anamorphosis, *trompe-l'œil*, and matte paintings[42] are other techniques that were developed over the centuries with the aim of somehow augmenting the reality by placing a virtual layer (of objects, people, or landscapes) on the real environment. In fact, their use nowadays is widespread and acknowledged thanks to artists who share their works through social networks. In particular, anamorphosis has been broadly used for advertising in cities, on means of

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[41] For current crictics example read 'Instagram is debasing real photography', Kate Bevan https://www.theguardian.com/technology/2012/jul/19/instagram-debasing-real-photography

[42] The definition of anamorphosis by the Encyclopaedia Britannica is particularly related to all the main topics of this argument: *"Anamorphosis is, in the visual arts, an ingenious perspective technique that gives a distorted image of the subject represented in a picture when seen from the usual viewpoint but so executed that if viewed from a particular angle, or reflected in a curved mirror, the distortion disappears and the image in the picture appears normal. Derived from the Greek word meaning "to transform," the term anamorphosis was first employed in the 17th century, although this technique had been one of the more curious by-products of the discovery of perspective in the 14th and 15th centuries."* The Editors of Encyclopaedia Britannica, 2019, https://www.britannica.com/art/anamorphosis-art

transport, and on the perimeter of various sportsgrounds, such as football and hockey. The relationship of this phenomenon with AR is confirmed by the fact that AR is slowly replacing those techniques in advertising. In my app, it is the software that does this kind of spatial transformation by mapping bi-dimensional pictures in three-dimensional or spherical spaces.

This brief overview demonstrates how, deepening the research, especially in the Georgian landscape gardens domain, I began to be aware of these parallel ideas, techniques, and ultimately, of tastes between the contemporary new media technologies and applications and the 18th century. Those ideas seem to have propagated from the 18th and 19th centuries throughout the 20th up to the present day.

I see in this fact an expansion of what Manovich et al. (2001) called 'the fractal[43] structure of new medias'. Like a fractal, a media object has the same similar structure on different scales[44] and, as I learnt from my research, also on different time frames throughout the centuries. It is as if there were a recursive self-similarity in these ideas and technologies that should enable one to better interpret and organise reality[45]. This seems to be confirmed by historical studies that found that self-similarities are 'footprints' of iterative processes (Farmer et al., 1997). They tend to emerge in systems that are continuously transformed by recursive operations, meaning that the result of each prior transformation becomes the starting point of the subsequent one (Mandelbrot, 1982). Nonetheless, this does not mean that a medium, or an idea of media, would be the same over and over. Variability and flexibility would be the keys, thanks to new technology. Given the abundance of content and the relative ease of its creation,- it would be sufficient to think about the quantity of photos, videos, three-dimensional models, and general information we have at our disposal; therefore, the focus of new media technology is to help in creating content, as well as in storing, organising, and providing efficient access to it. I found the use of AR and MR in this research went in this direction.

[43] The fact that they speak about fractal is interesting also because in eighteenth century the fractal math and theory had just been theorised by Gottfried Leibniz with the name of 'recursive self-similarity'. See historical notes in *The Fractal Geometry of Nature* (1982).

[44] Fractal mathematic is used nowadays in the recreation of virtual photorealistic landscapes. This technique has been tested since 1981 (Carpenter et al.).

[45] I see the same fractal-like structure is inherent the tool I used to analyse my research process: the Activity Theory. AT systems, as explained in Chapter 3, can be embedded as part of other activity systems.

8.6 Looking forward with eighteenth-century eyes and taste

I have just defined the similarity I observed between current ideas and technologies and those in eighteenth-century Britain as a congruence of tastes. During the research, I identified—and discuss here—some elements that form the basis of this taste. Five concepts seem to link both the English 18th century visual discourse and that of the Western 21st century, and they are also fundamental to the meaning and reception of this research. The first one is immersion, the second is imagination, the third is imaging, the fourth is ekphrasis, and the last one is storytelling. The last one is an across-the-board concept that links all the others in the transmission and creation of artefacts.

8.6.1 Immersion

Immersion is the sensation of being physically present in a virtual reality. The immersion can be more or less complete depending on the number of human senses involved and the quality of their digital reproduction. A virtual reality that is hardly distinguishable from the actual experience of the 'real' takes the name of 'simulated reality'. Simulated realities are the next step of immersion, still, the immersion is not limited to the involvement of senses in a computer-based virtual reality. The engagement, or the sense of presence, depends on other factors as well, and VR headsets and computer technology are not the only way to achieve immersion. We are able to create artificial realities in virtual spaces as well as artificial realities in real spaces, which can deliver the same or a better level of immersion, albeit at greater cost. It was already argued that 18th-century English landscape gardens were created after paintings and descriptions of landscapes from the Grand Tour, capriccios, italianates, and so forth. The Georgian landscape garden itself was an artificial reality made to allow a person to become immersed in those kinds of paintings and atmospheres, into an English Arcadia, with the addition of some exotic oriental elements.

The panorama, patented by the Scottish portraitist Robert Barker in 1787, is another example of immersion in real space. It is a technique very similar to the one in use for virtual panoramas. The image is displayed in a 360-degree view on a circular canvas that surrounds the viewer. As the modern panoramic pictures requires a virtual spherical space on which to be located or, sometimes, a physical semi-cubic or toric space in the case of virtual caves[46], the panorama requires a circular building made specifically for it. Spectators need to be on a central platform half the height of canvas; an object could pop-out from the canvas to provide an immersive foreground, and light must be provided from above and concealed at the same time to seamlessly merge with the image by means of a canopy.

The pantoscope, known in Italy as *Mondo Nuovo* (Italian for new world), in England as a peep box, or raree show, and in German as *Guckkasten*, was an instrument known since the 15th century but mainly used in 17th, 18th, and 19th centuries. The earliest specimens were created by Leon Battista Alberti in the 1430s. Generally, it consisted of a box with one or several holes, with or without lenses, allowing one to look inside. Inside, it was possible to see drawings on paper, usually landscapes with monuments or large public events, with effects of transparency, often a night-day effect, and sometimes, animated figures such as little puppets. The light was provided from one or more candles, the brightness of which was managed by an ingenious aperture system. However, size and weight apart, it was somewhat similar to a modern headset (akin to Google Cardboard): the observers looked with one or both eyes in a dark box to see a luminous screen and immerse themselves in a scene.

Finally, my view is that technologies and instruments are not the only ways to achieve immersion. Imagination, our natural, non-technological, device with which we are all endowed, can also be used to attain the same goal. The technique, in this case, resides in the correct ways of storytelling and engagement that activate it. Good stories, books, plays, films, and music are capable of immersion thanks to their capacity to activate the imagination and, at the same time, focus the attention of the audience while excluding most of the surrounding environment. In this respect, they are lesser forms of hypnosis[47]. Finally, dreams and dream-like situations, such as daydreams, are other situations where the imagination attains immersion without the help of external agencies.

8.6.2 Imagination

'I am enough of an artist to draw freely upon my imagination. Imagination is more important than knowledge. For knowledge is limited, whereas imagination encircles the world'.

[46] Virtual Caves are rooms where the virtual reality is projected on the walls. Usually, on four sides of a cube. Thanks to special glasses, one is able to move in the world and interact with 3D objects. The TORE of Lille University is similar, but it has the unique feature of a toric surface of projection, resulting in a seamless and more consistent projection.
[47] Hypnosis being *"a state of focused attention"* reduced peripheral awareness, and better capacity to respond to suggestion *(Elkins et al.—APA Division30—, 2015).*

Albert Einstein as quoted in 'What Life Means to Einstein: An Interview by George Sylvester Viereck' in The Saturday Evening Post (26 October, 1929).

In contrast to the lesser animals of this world, humans are endowed with a powerful imagination. Although recent studies suggest that chimpanzees and gorillas can pretend that an object is something different and that rats can try to calculate how to get a reward on the basis of previous experiences (Ólafsdóttir et al., 2015), the animal kingdom comes nowhere near the complexity of the human imagination. Humans can simulate extremely complex scenes and use the imagination to solve problems, plan, invent, and understand, starting from the basis of their experience and knowledge but going far beyond them. When we see a phenomenon, our imagination is immediately at work to interpret and explain it, as well as to consider other comparable phenomena. Without that ability, research and knowledge building would not be possible. This is the sense of the Einstein's statement quoted above. An excellent example of this is science fiction, which emerged in the 17th and 18th centuries only to go mainstream in the 19th and 20th centuries. Through this genre of literature, various writers, scholars, philosophers, and scientists have the opportunity to use their imaginations to create, develop, and spread their ideas about the future of society and technology, as well as about many things yet to be discovered, such as the existence of other worlds, alien civilisations, and celestial bodies[48,49]. Science fiction literature is one example of the use of imagination to create alternative worlds and realities that we could call 'fantasy'. Fantasy as a continuous work of imagination to create alternative realities, as argued, was at the centre of English Enlightenment taste. The debate about alternative realities was continued in the 20th century by J.R.R. Tolkien, who in his essay *On Faery-stories* (1947), called them 'secondary worlds' and 'sub-creation'—the real world being the primary 'creation'-. By means of these stories, humankind has two powers. The first is that of the 'sub-creator', who can make visions of fantasy effective by the exercise of will. The second is the one of 'escape', which creates the possibility of escaping from reality, to find refuge in fantasy.

[48] See Francis Godwin's *The Man in the Moone* (1638), Margaret Cavendish's *The Blazing World* (1666), Bernard le Bovier de Fontenelle's *Conversations on the Plurality of Worlds* (1686), Samuel Madden's *Memoirs of the Twentieth Century* (1733), Voltaire's *Micromégas* (1752), Louis-Sébastien Mercier's *The Year 2440* (1771) and all Jules Verne's novels (starting from 1851 with *A Voyage in a Balloon*).
[49] It is interesting to highlight the supposed link between the science fiction *Frankenstein, or the modern Prometheus*, written by the British author Mary Shelley (1818), and Andrew Cross (1784-1855) of Fyne Court, a property in the Quantocks Hills, near Hestercombe. He was a scientist fascinated with electricity, known locally as "the thunder and lightning man" was known for an electrocrystallisation experiment which made insects appear. Newspapers claimed he created life, which it not what he sustained. Some believe the account of this experiment may have inspired Shelley's novel. (Haining, 1979)

These powers are at the core of the modern IT industry. They have been recently enhanced by new technologies that provide the ability to actually design and edit 'secondary worlds' or, as we call them now, virtual worlds. Software programs such as Second Life[50], OpenSimulator, and Minecraft have democratised sub-creation, allowing people with reasonable computer expertise to easily create virtual worlds from scratch: shaping sky, terrain, and environment or deciding on vegetation, buildings, objects, and inhabitants. Once created, a virtual world can be open to other people; it can be shared. People can enter it, meet other visitors, share experiences, and contribute to the world. The capabilities of this technology have quickly been recognised, and these worlds have been used for entertainment, training and educational purposes[51].

Imagination lets us swiftly adapt to any scenario, when necessary, augmenting and accommodating our perceptions accordingly[52]. In fact, this is what distinguishes reality from actuality, for the first is always a mainly subjective experience mediated by perceptions, while the second is the physical event as a camera might record it (Derrida, 1971). Drawing a parallel with the reality–virtuality continuum, I could propose an imagination continuum where, on one pole, one finds 'actuality' and, on the other one, 'fantasy'. Perception would, in that case, take the place of an actuality with a mild amount of imagination in it, resulting in an augmented—or interpreted—actuality (Figure 89).

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[50] Second life, created in 2003, is one of the most famous Multi-User Virtual Environment (MUVE) where people can run a parallel existence. They have jobs, earn money, have friends, go 'out' for cultural activities. Real companies and industries have their shops and their representatives in the Second Live World. On the other hand, Minecraft is a so called 'Sandbox Game', which can also be multi-user, where one can shape the world freely, not having any particular goal. It has widely adopted from education institution for the ease of use and its capabilities.

[51] It is interesting how these virtual, secondary, worlds change the primary reality and peoples' behaviour within it. There are huge number of experiences, for example, in the field of the safety in the workplace and training or the use of machines, not to mention driving and flight simulators. Several skills, trained in the secondary world, translate with some accommodation to skills in the primary world (skill transfer process). Of course, the most effective method is to blend virtual simulation with real world training (Sitzmann, 2011; Korteling et al., 2017).

[52] There is a joke, in Italy, that sometimes adults play on children, or even among themselves. The game starts with the adult pretending he has a rubber band in hands, moving them as if he actually had one and encouraging the other person to do the same or to follow closely his movements. Suddenly, he mimes the movement of aiming and snapping the band against the other person. If not already aware of this joke, the other person will close his eyes and protect his face before realising that there is no rubber band to be thrown. This is an example of how our imagination can augment our perception of reality. This unconscious mechanism is observable in many situations, like enjoying a mime artist show, but it is a crucial device for the survival of humans, their brains continuously trying to simulate, predict and interpret what is going to happen.

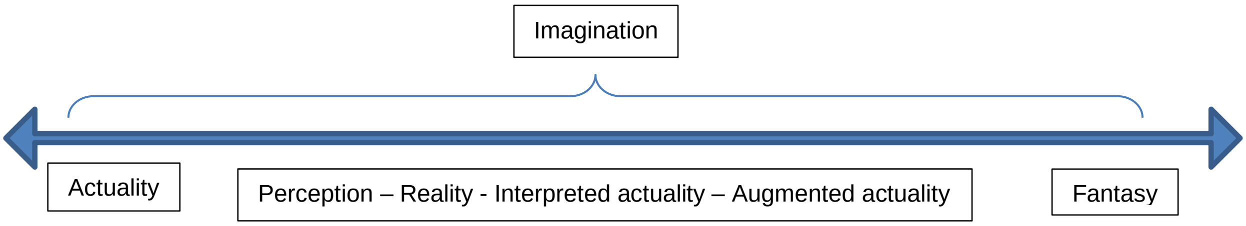

Figure 89: Actuality–fantasy continuum

The power to share imagination and fantasy is today greater than ever, thanks also to AR and VR apps and headsets that provide these technologies a ubiquitous character. The next sub-chapter underscores how imaging is at the base of this revolution.

8.6.3 Imaging

According to a research study conducted by InfoTrends Worldwide, since 2015, more than 1 trillion photos have been taken in the world every year. In 2017, the number was expected to reach 1.2 trillion, and a total of 4.7 trillion photos are stored in devices all over the world. In the peak year of analog photography, the year 2000, approximatively 85 billion photos were taken. In 1990, there were about 57 billion, in 1980, 25 billion, in 1970, 10 billion, in 1960, 3 billion, and in 1930, 1 billion. Before 1930, only a few million photos were taken[53]. Overall, until 2012, about 3.8 trillion photos had been taken since the invention of photography in 1822, 190 years earlier. At the current photo rate, we will match that number in three years. That is a direct consequence of the advent of digital photography but, in particular, of the diffusion of smartphones and picture sharing platforms. Statistics show how about 85% of the photos in recent years were taken using a smartphone, while only 10% were taken with digital cameras. It is to the 21st-century taste to use smartphones for imaging. They are ubiquitous because, unlike many cameras, they fit in a pocket, and they also allow the user to apply enjoyable effects to every picture with ease and to share them with friends and wider audiences instantly. As argued above, for imaging purposes, they are the modern version of the 18th-century black mirror[54] and camera obscura. This is just

[53] Amongst them, the De Vesci collection contains photos of the Portman family shoot at Hestercombe at the very beginning of the 20th Century.
[54] The title of the 'Black Mirror' TV drama, which reflects on collateral outcomes of new technologies in the near future, comes from the observation of the author Charlie Brooker : "*The 'black mirror' of the title is the one you'll find on every wall, on every desk, in the palm of every hand: the cold, shiny screen of a TV, a monitor, a smartphone*" (Charlie Brooker, 2011).

the most recent evolution of the process that started in the late 18th century with the British inventor Thomas Wedgwood experimenting with camera obscura and paper painted with silver nitrate in order to achieve a photo-etching. He never succeeded in recording more than shadows. Subsequently, in 1822, Nicéphore Niépce was the first to succeed in obtaining a detailed photo-etching, and Louis Daguerre improved the process. After Niépce's death, Daguerre was able to enhance the method further, shortening the exposure times from hours to minutes and improving the development and the fixing processes. This process was named a 'daguerreotype' after its creator. This link between the 18th and the 21st centuries is solid because it represents an uninterrupted evolution of imaging technologies and a constant widening of the sort of people using them. As discussed, AR technology provides tools to use part of this massive picture heritage and to create a visible link between the present and the past. Smartphone AR applications such our 'Hestercombe Augmented visit', the Museum of London's 'Streetmuseum' (Figure 90), and Chicago00's 'The Eastland Disaster' allow the visitor a journey in real historical places, showing historical imagery superimposed to the view of the smartphone camera. In my research, I discovered that this is amongst the most powerful AR capabilities for educational purposes. The pictures, being virtually tagged to a place, open windows on a different time, new meanings, and new stories for today's visitors, especially when they portray people of a different time in the same place. If photos and AR are compelling together, they would be hugely diminished without an underlying story of the people involved, which is one of the reasons I decided to keep the human guide in our experiences instead of trying to replace them with technology. Storytelling is not only what keeps a series of photos together; often, it is the reason why they have been taken in the first place. In this complex relationship between imaging, technologies, and storytelling there is another aspect that deserves to be addressed, and it played a crucial role in my research: the ekphrastic account of visits and monuments.

8.6.4 Ekphrasis

Ekphrasis was defined in the 1^{st} century BC by Theon as an ‘expository speech which vividly brings the subject before our eyes’. It is remarkable that one of the earliest examples of ekphrasis we have in literature is the description by Homer in the Iliad of Achilles’ shield. Before the duel with Hector, Homer describes the shield that Hephaestus forged for Achilles in every detail of its mighty appearance and spectacular decoration. This created such a vivid image of the mythological object that it moved artists to depict it in paintings (e.g. Angelo Monticelli, from *Le Costume Ancien ou Moderne*, c. 1820; Kathleen Vail) and even to forge it (W. H. Auden; The King of Hanover's Silver-Gilt Shield of Achilles, Philip Rundell for Rundell, Bridge & Rundell, London, 1823, John Flaxman's design, modelled with scenes from the 18^{th}-century book of the Iliad) turning a shield that once was the fantasy of a single man into a real object. It happened thanks to the externalisation and projection in the reader’s mind achieved by the author by means of ekphrasis. Ekphrasis worked in ancient times as a sort of ‘backup copy’ of important works of art and monuments.

Figure 90: A screenshot of the Streetmuseum app of the Museum of London.

It is a known fact that Romans recreated Greek sculpture masterpieces on the basis of descriptions.

A more modern definition of ekphrasis is 'verbal representation of visual representation' (Heffernan, 1991, p. 299) while a contemporary, radical one is 'representation in one medium of a real or fictitious text composed in another medium' (Bruhn, 1999, p. 296). The former definition can well fit with the classic use of ekphrasis which was popular in the 18th and 19th centuries[55]. It is thanks to 18th-century ekphrastic texts that my virtual reconstruction, and in fact the actual reconstruction of the Hestercombe Georgian landscape garden, were possible. As already mentioned in section 7.1.2, the texts were by various visitors of the estate, of which the most important were Edward Knight, Arthour Young, John Langhorne, Henry Hawkins Tremayne[56], the second Viscount Palmerston, and Richard Graves. However, the process of rendering such texts in a virtual reconstruction is better reflected by the latter definition. In point of fact, I did not create a visual representation verbally, at least not at that stage: I represented in a virtual reality a verbal representation that was, in turn, a representation of a real garden and real structures. Using the terms of the second definition, I represented, in a digital three-dimensional visual medium, an analogic hand-written verbal medium. This process brought to evidence three main points:

1. Virtual reality, augmented reality, and 3D modelling are easier to achieve on an everyday basis. Nonetheless, all of them require programming languages, such as HTML, CSS, Javascript, C# and Swift to cite just some of them. Vectorial and 3D software also use a basic language that the graphic engine is able to translate into pictures and models. Hence, the programmer or the graphic designer has to deal with a translation—a description of the object in computer language. This is, in my view, a form of ekphrasis inherent to most of the digital technologies in use today.
2. While creating the augmented tours of Verona and Hestercombe, as I was noticing that the virtual recreations were simplifications and a synthesis of all the

[55] Famous amongst them in England is the "Ode on a Grecian Urn" by John Keats, written in 1819.

[56] His ekphrasis of the Witch House is an exquisite specimen *"after walking thro' a wood some time and ascending a hill when you reach the summit being still in the wood and surrounded by it you come to a building called the Witches Cave it is composed of the Stocks and roots of Trees. It is half an octagon on the outside. The dead branches of Trees ore twisted in the most fantastic shapes two statues whose heads are just at the entrance and other such grotesque forms not copied but merely done by pieces of wood of proper shapes rudely nailed together. Inside in one division of the Octagon is the figure of an old witch with her Beard high crowned hat and Broom. In another nick is painted an Owl, and in another a Cat. On the opposite hill a beautiful cascade of several falls seems to pour out of the wood and down the opposite hill. You see nothing but this cascade for which purpose a vista is cut through the wood from the Cave. The murmur of the water the gloom of the wood the faciful ornaments of the Cave renders this spot a piece of poetic scenery that is infinitely pleasing."* Henry Hawkins Tremayne, squire of Heligan in Cornwall, (1785) as reported in White's (2013) *Hestercombe. An Illustrated History and Guide*. p. 11)

data at my disposal, I also grew aware that this process was bringing to the light details that would have otherwise been invisible. For a detailed example, refer to the discussion in Chapter 7.4.2.2, which represents the clear idea of what it was possible to see from each seat. This is the signature of an ekphrastic process.

3. I discovered what I could call 'augmented ekphrasis' as a robust learning process. During the augmented visit, students are encouraged to explain what they see, to ask questions, and to give answers. Fulfilling these obligations requires an ekphrastic process not only of the view that the students have in front of them but of the whole augmented reality with its layers of information, imagery, and models as part of the process of externalisation expected by the Tri-AR methodology. The ekphrasis produced is a synthesis of information from the real and the virtual environments in the same verbal representation.

8.7 Future developments

In the future, it would be interesting to carry out further research addressing the limitations I encountered where possible, in particular, by using a more advanced version of the MR tool and more up-to-date devices to minimise the crucial, negative points that pupils encountered in the experience: bugs, glitches, and crashes in the MR tool. There is the possibility that, having solved that problem, the results could be even more positive. The research could then be extended to a broader population in other countries and different age groups following the same format as that of the experience in Verona. There are already classes in the USA (thanks to the Immersive Education Initiative) and in Brazil ready to run case studies, as well as many other classes in Italy. In addition, in this research, I have seen how some pupils succeeded in making the most of AR and MR technology, whereas others did not. I gathered some data on the possible reasons, but there is more to be discovered. I was able to isolate a few factors, such the gender of the child, which partly explained it, but I did not find consistent data about this issue. Following the lead of other researchers who made tests on VR (Cutmore et al., 2000; Ford, 2000; Chen et al., 2000; Yoon et al., 2015), the suspicion is that, even with AR and MR, more could be explained with the help of data about cognitive styles of the pupils. This seems to be confirmed with respect of AR games for learning (Hsu, 2017; Tsai, 2017). Other researchers could employ different research instruments, such as videos and statistics from the app (such as heat maps, tap counts, and immediate feedback) to better understand the learning process behind the use of AR and MR technology during a visit.

On the same subject, one of the most intriguing collateral clues found during this research is the apparent superiority of AR over MR when used with the methodology used for this dissertation. From the data of both the case studies, it seems that the AR was much less engaging than MR but also more effective with respect to the results in the follow-up test. On the other hand, the MR seems to have been more effective in rendering the past environment and letting pupils understand it. Therefore, further research on these aspects is vital to identify the best tool to use for specific learning objectives.

For example, the use of VR seems very promising in the phase of a future work where virtual cultural exchanges between classes from various countries participating in a project can be organised. The class from one country can virtually guide the class of another one to discover their cultural heritages together, learning about them in the process. A logical one would be the exchange between a class from Verona and a class from Taunton because the virtual environments have already been created.

Following the perspective traced by the reasoning on ekphrasis and imagination, I realise that I must, in the future, create more space for the students in the experiences. I will revise my methodology in order to integrate a stronger storytelling element, expanded moments of 'augmented ekphrasis', and time and instruments to let the pupils use their imaginations to work on the topics of the visit. I already have some evidence of the benefits I would have thanks to the Hestercombe experience, where I registered how much the story of the Witch House and the time traveller impacted pupils' imagination (see section 7.6). In this research, most of the organisation of the visit was left to the guides (in Verona) or based on standard visits (at Hestercombe), with two changes represented by the MR tool and the Tri-AR interaction. Now that I have gathered enough information, I would change the approach, implementing visits with more emphasis on the aforementioned principles. Finally, drawings have proved to be an excellent tool for pupils to externalise what they actually understood about the heritage. Thinking about further research employing the drawing analysis, it would be interesting to interview pupils about their paintings after the analysis. It would also be interesting to explain to children aspects of the heritage (e.g. Roman architecture or landscape gardens architecture) through paintings and to see how this pictorial 'translates' in their paintings and helps them in interpreting and describing graphically the cultural landscape.

Chapter 8

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Conclusion

The thesis has explored the use of mixed-reality mobile technology for outdoor cultural heritage education, along with an adapted teaching methodology and its capacity to support the learning and interpretation processes. I focussed on its efficacy in terms of engagement, remembering, and understanding while paying attention to the changes between the classic visit, where the mediating tool is the booklet, and the augmented visit, where the mediating tool is the smartphone. Likewise, I tested the transferability of the technology and methodology from the Italian to the English context and heritage.

The MR tool and the methodological format are adequate supports for heritage education adequately and to enhance the engagement, ability to remember, and understanding of the pupils. The introduction of the MR mediator increased in quantity and quality the interactions between the students and the heritage, as well as between the students and the context. The MR tool and the methodological format were successfully transferred to the English context with similar results.

I described the contributions to heritage education and educational technology, underlined the limitations of this research, and envisaged possibilities for further development. In particular, this dissertation proposes a didactic methodology for the use of mobile MR technology for outdoor heritage education that starts from the pedagogical basis and retains the vital role of the guide in the educational experience. Thanks to this bundle of methodology and technology, the boundaries between formal, non-formal, and informal contexts were blurred, thus allowing the knowledge gathered from one or another of those contexts and from the different levels of the mixed reality to contribute to the educational experience and the learning process.

As mentioned at the beginning of this work, one of the fundamental European documents underlying the defense of heritage is the CHCfE (Cultural Heritage Counts for Europe) developed by the Council of Europe. Three of the ten key findings of the CHCfE study are central to the work I have presented here. I was able to corroborate at least two of them.

- *Cultural heritage is an important source of creativity and innovation, generating new ideas and solutions to problems, and creating innovative services—ranging from the digitisation of cultural assets to exploiting the cutting-edge virtual reality technologies—with the aim of interpreting historical environments and buildings and making them accessible to citizens and visitors.*

- *Cultural heritage provides an essential stimulus to education and lifelong learning, including a better understanding of history as well as feelings of civic pride and belonging, and fosters cooperation and personal development.*

- *Cultural heritage combines many of the abovementioned positive impacts to build social capital and helps deliver social cohesion in communities across Europe, providing a framework for participation and engagement as well as fostering integration.*

(CHCfE Consortium, 2015, pp. 24–29)

The first one was wholly confirmed: This research has produced precisely this effect, creating new services in the augmented visits to Verona and Hestercombe, and the Verona one continues, thanks to an association that offers this service for schools.

The second one was met only partially at the conclusion of this research. I was able to detect feelings of civic pride and belonging in the Italian children's feedback after the visit to the Roman remains in Verona, as well as an improved understanding of history. Additionally, this research fostered the cooperation between different social actors, such universities, schools, and associations. At Hestercombe, the research sparked the interest of the local community as well and the local newspaper, the *Somerset County Gazette,* which dedicated an article to the augmented visit experience.

Finally, this research has created cooperation between Italy, France, and England involving people from academies, schools, associations, and trusts that worked together. I hope that, in the future, it will be possible to make of this format an opportunity for a genuine collaboration between sister countries in terms of education and culture.

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Appendices

Appendix 1: Questionnaires and tests

Questionario affinità a nuove tecnologie e beni culturali:

NB: il questionario inglese è stato accorciato sensibilmente per restrizioni di tempo per la compilazione.

Dimensioni: Accesso alle tecnologie, Accoglienza e Utilizzo Tecnologie, Esposizione al patrimonio culturale, Accoglienza e fruizione dei beni culturali, Efficacia percepita strumenti di educazione ai beni culturali, Utilizzo tecnologie beni culturali.
Anagrafica:
Nome (- non nel questionario in inglese -), Cognome (- non nel questionario in inglese -), classe, scuola, anno di nascita

Dove non diversamente specificato si tratta di scale likert 5 auto ancoranti o scelte multiple.

Accesso alle tecnologie:

- Hai la connessione internet a casa?v
- Quanti smartphone ci sono in casa tua?v
- Quanti tablet ci sono in casa tua?v
- Quanto usi i seguenti dispositivi a casa?v
- Quanto usi i seguenti dispositivi a scuola?v
- Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all'aperto?v

Accoglienza e Utilizzo tecnologie:

- Quanto pensi di essere capace ad usare i seguenti dispositivi?
- Per cosa usi il Computer? (Portatile o fisso) - non nel questionario in inglese -
- Per cosa usi il Tablet?v
- Per cosa usi lo Smartphone?v
- Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare?v
- Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all'aperto? (una città, un parco, ecc)

--- Sottodimensione BYOD (Bring Your Own Device)

- Quali dei seguenti dispositivi potresti portare da casa per imparare all'aperto? (ad es. in un parco o in una città) - non nel questionario in inglese -

Esposizione al patrimonio culturale:

- Quanto spesso vai al museo o alle mostre? (historical places and gardens in en)

- Quanto spesso ti capita di andare a visitare la tua o altre città per conoscerne meglio la storia, i monumenti o l'arte?
- Quanto spesso guardi trasmissioni sulla storia e la cultura delle civiltà?
- Quanto spesso leggi libri, parti di libri o articoli (anche su internet) sulla storia e la cultura delle civiltà?

Accoglienza e fruizione beni culturali

- Quando visiti una città per conoscerne la storia, l'arte e i monumenti… - non nel questionario in inglese -
- Quanto ti piacciono le trasmissioni sulla storia e la cultura delle civiltà? - non nel questionario in inglese -
- Quanto ti piacciono libri, parti di libri o articoli (anche su internet) sulla storia e la cultura delle civiltà? - non nel questionario in inglese -
- Quanto ti piace l'insegnamento di storia nella tua scuola? - non nel questionario in inglese -
- Ti capita di andare a cercare delle informazioni sulla storia e le civiltà per tuo interesse personale (non per compiti)? - non nel questionario in inglese -

Efficacia percepita strumenti di educazione ai beni culturali (sostituita nel questionario en dalla sola domanda "Come impari meglio durante la visita in un sito culturale?")

- Quanto impari dalle audioguide di musei e mostre, città e parchi? - non nel questionario in inglese -
- Quanto impari dalle guide professioniste di musei e mostre, città e parchi? - non nel questionario in inglese -
- Quanto impari dai libretti di musei, mostre, città e parchi? - non nel questionario in inglese -
- Quanto impari dai cartelli e le didascalie di musei, mostre, città e parchi? - non nel questionario in inglese -
- Quanto impari dalle App di musei, mostre, città e parchi? - non nel questionario in inglese -
- Quanto impari dalle trasmissioni sulla storia e la cultura delle civiltà? - non nel questionario in inglese -
- Quanto impari da libri, parti di libri o articoli (anche su internet) sulla storia e la cultura delle civiltà?
- Quanto impari dall'insegnamento di storia nella tua scuola? - non nel questionario in inglese -
- Quanto impari dalle tue ricerche sulla storia e le civiltà per tuo interesse personale (non per compiti)? - non nel questionario in inglese -
- Dove vai a cercare queste le informazioni per le tue ricerche sulla storia e le civiltà per tuo interesse personale (non per compiti)? - non nel questionario in inglese -

Utilizzo tecnologie beni culturali:

- Quando sei andato al museo o ad una mostra, quanto spesso hai usato i seguenti dispositivi per avere informazioni o imparare cose? v
- Quando hai visitato la tua o altre città, quanto spesso hai usato i seguenti dispositivi mentre eri all'aperto per recuperare informazioni o imparare cose? - non nel questionario in inglese -

Domanda aperta (analisi qualitativa):

Perché secondo te è importante sapere la storia della nostra civiltà, la storia dei monumenti, della cultura e dell'arte? - non nel questionario in inglese

Questionario fine visita

Anagrafica: Nome (non in questionario en), Cognome (non in questionario en), Sesso, Anno di nascita, Classe e sezione, Scuola
Dimensioni:

Soddisfazione contenuti:
- Hanno spiegato tutto quello che avevano promesso all'inizio. (non in questionario en)
- Hanno spiegato tutto quello che avrei voluto sapere.
- Ho imparato cose che mi saranno utili in futuro.
- Hanno dato delle informazioni corrette. (non in questionario en)

Percezione interesse:
- Sono stato molto coinvolto dall'esperienza. (Ho partecipato attivamente, con interesse, con emozione).
- I miei compagni sono stati molto coinvolti dall'esperienza.
- Gli insegnanti sono stati molto coinvolti dall'esperienza.

Soddisfazione conduzione:
- L'educatore/lo storico hanno condotto bene l'esperienza.
- Hanno gestito bene il tempo della spiegazione.
- Hanno risposto alle domande e agli interventi.
- Sono stati chiari e comprensibili nelle spiegazioni

Soddisfazione materiale:
- Hanno utilizzato abbastanza materiale didattico. (presentazioni power point, schede, libretti, dispositivi, applicazioni, ecc...) (non in questionario en)
- Hanno utilizzato del buon materiale didattico. (presentazioni power point, schede, libretti, dispositivi, applicazioni, ecc...) (non in questionario en)
- Il materiale fornito è stato utile. (non in questionario en)
- Il materiale fornito è stato facile da usare. (non in questionario en)

Soddisfazione strumenti mediatori sperimentali vs classici:
- I dispositivi sono stati utili durante l'uscita. (solo per chi li ha usati)
- I libretti sono stati utili durante l'uscita. (solo per chi li ha usati) (non in questionario en)
- I dispositivi sono stati facili da usare durante l'uscita. (solo per chi li ha usati)
- I libretti sono stati facili da usare durante l'uscita. (solo per chi li ha usati) (non in questionario en)
- *qualitativa * Se hai usato il dispositivo, scrivi la cosa che più ti è piaciuta nell'usarlo. Poi scrivi anche quella che ti è piaciuta meno.
- Avrei preferito usare i libretti e non il dispositivo. (solo per chi ha usato il dispositivo)
- Avrei preferito usare il dispositivo e non il libretto durante l'uscita. (solo per chi ha usato il libretto) (non in questionario en)

- Quanto sai usare gli smartphone Android, cioè i dispositivi che hai usato in uscita? (solo per chi li ha usati) (non in questionario en)

Soddifazione generale:
- Vorrei ripetere un'esperienza come questa.
- Quanto ti è piaciuta l'esperienza di Verona Romana da 1 a 5?

*solo nel questionario inglese*qualitative*
- What did you like the most in the whole visit? What didn’t you like?
- Tell us what you would like to see or do, and have not seen or done in this visit.

Test follow-up Verona

Test comprensione e contenuti finale Verona Romana

NB: Strumenti per tappe, classi sperimentali:
AR: ARENA - PORTA LEONI - PORTA BORSARI - ARCO DEI GAVI
VR: ARENA (interno arena solo VR) - PORTA BORSARI
Normale tecnologia mobile: PIAZZA ERBE, PONTE PIETRA/POSTUMIO
Solo spiegazione toccando i resti: MURA, PIAZZA SIGNORI
Gioco classico: STATUE PIAZZA ERBE, ARCO GIOVE AMMONE, ARCO DEI GAVI

Strumenti per tappe, classi di controllo:
Solo spiegazione toccando i resti: MURA, PIAZZA SIGNORI
Gioco classico: STATUE PIAZZA ERBE, ARCO GIOVE AMMONE, ARCO DEI GAVI
Spiegazione e libretto: PIAZZA ERBE, PONTE PIETRA/POSTUMIO, ARENA - PORTA LEONI - PORTA BORSARI - ARCO DEI GAVI

Dove non specificato domande a scelta multipla o vero falso.

Anagrafica: Nome, Cognome, Scuola, Classe

Tappa Porta borsari:

- In antico Porta Borsari era conosciuta come Porta Iovia per via di un monumento che sorgeva nelle sue vicinanze, appena fuori dalle mura. Di cosa si trattava?
- Porta borsari al tempo dei romani aveva solamente la facciata che vediamo anche oggi
- Da porta borsari si potevano vedere l'Arena e l'Arco dei Gavi
- Porta Borsari e Porta Leoni viste dall'alto sembravano dei quadrati *(anche tappa porta leoni)*
- Le porte della città di Verona erano staccate dalle mura *(anche tappa porta leoni)*

Tappa Porta Leoni:

- Al giorno d'oggi si può vedere tutta la facciata imperiale di Porta Leoni
- Porta Leoni, quando è stata costruita, aveva due torri ai lati

Organizzazione della citta:

- Cosa sorgeva all'incrocio delle due vie principali della città, dove oggi è situata Piazza delle Erbe?
- Il Decumano Massimo e il Cardo Massimo erano le due vie principali della città
- I cardi erano le vie che andavano nella direzione Nord-Sud
- Il Decumano Massimo e il Cardo Massimo partivano dalle porte secondarie della città
- Il Decumano Massimo attraversava il fiume Adige per mezzo di un ponte
- Il Decumano Massimo partiva da porta Leoni e arrivava alla piazza principale
- La via Postumia quando entrava nella città di Verona diventava il Decumano Massimo

- I decumani erano più di uno, ma solo uno era quello Massimo
- In epoca romana, Verona era una città fortificata, cinta ai lati da alte mura. Quante erano le porte principali che permettevano l'ingresso in città? Quante sono visibili ancora oggi?

Mura:

- Oltre alle grandi porte principali, lungo le mura c'erano anche delle porticine secondarie. Come si chiamavano?

Tappa Piazza erbe (foro):

- Piazza Erbe era una volta la piazza centrale della città romana di Verona. Quanto era grande?
- Come per molte altre città romane, il tempio più importante di Verona si chiamava Campidoglio (Capitolium) ed era situato nella piazza principale. A quale o quali divinità era dedicato?
- Il culto del dio Giove era molto diffuso nella Verona dell'epoca. Quale monumento situato all'interno delle mura e di cui oggi rimangono solo i resti era dedicato a Giove Ammone?
- Da piazza erbe sono visibili ancora due statue romane originali. Scegli fra le seguenti quali sono.

Piazza dei Signori:

- La città romana era allo stesso livello di altezza dell'attuale manto stradale

Tappa Ponti e Teatro:

- Importante via di commericio, nonché di difesa, era il fiume Adige. Esso risultava attraversato da diversi ponti, alcuni dei quali oggi scomparsi. Come si chiamava quello edificato alla fine del decumano massimo, che permetteva di raggiungere il teatro situato sull'altra sponda del fiume?
- Il ponte di marmo sul quale passava una delle principali vie della città era il ponte più antico di Verona
- Il teatro romano è stato costruito alle pendici del colle in seguito nominato San Pietro, sul quale trova ora spazio una caserma austriaca. In epoca romana, cosa si trovava in cima a questa altura?

Tappa Arena:

- L'Arena è stata costruita dentro le mura della città
- L'Arena appena costruita era più grande di adesso
- L'Arena e altri monumenti romani sono stati usati in seguito come cave di pietra
- Anche oggi si vede dove poggiava l'ala più esterna dell'Arena.
- L'Arena, dopo i lavori dell'imperatore Gallieno, è stata usata anche come fortezza
- Nell'Arena, come in tutti gli anfiteatri, gli spettatori erano sempre esposti al sole e alla pioggia
- La vasca che c'è dentro l'Arena serviva per simulare battaglie nell'acqua
- L'acqua piovana che cadeva sull'Arena era trasportata da un complesso sistema fognario fino all'Adige.
- Nella Verona del tempo non mancavano edifici costruiti per ospitare spettacoli ed intrattenere la popolazione. Quale di essi riusciva a contenere più spettatori?

Mura:

- Anche al giorno d'oggi si possono vedere le Mura di Gallieno
- L'imperatore Gallieno costruì una cinta muraria completamente fatta di mattoni, come quella precedente.

Arco dei Gavi:

- Verona in età romana occupava una posizione strategica, servita da un'efficiente rete stradale che attraversava tutto il Nord-Italia. Come si chiamava la via che arrivava sino a Porta Borsari e sulla quale fu costruito un arco munumentale in onore della famiglia dei Gavi?
- L'Arco dei Gavi si trova al giorno d'oggi vicino a Castelvecchio, a un lato di Corso Cavour. Come mai?

Hestercombe follow-up test

Test: how much do you remember of the Hestercombe Landscape Garden visit?

This is a test just to know what you remember of the visit.

It is not to evaluate you (it is anonymous), it is to evaluate the visit, so please, just write and answer as you remember.

Name of the School:

Year of birth:

Boy or Girl?

An English Landscape Garden...

check only the statements that you think are true

used to have gardeners working into it every day.
is like an open-air gallery of framed views.
pretends to be a natural environment.
used to have sheep into it helping to keep the grass low.
is designed to have many flower beds into it.
was usually built in the 20th century.
used to have some exotic features into it.
was usually designed to resemble paintings by famous artists. is a place just to look at, it doesn't inspire any emotion.
it is something rare in England.
Was designed to deliver emotions to the visitors.
Was designed to gain money from the visitors.

What's the shape of the biggest pond in the garden?

Circular
Square-ish
Pear-like
Banana-like

How many big ponds have you seen during the visit?

1
2
3
4

How many cascades (even little) have you seen in your visit to the garden?

1
2
3
4
5
6
7
8

Seats, alcoves, arbours are:

buildings in the garden made to remember our cultural heritage.
buildings made to be admired and to look beautiful.
buildings made to protect the visitors from rain and other adverse weather while walking.
buildings made to look at and that are the best place to sit in and look at the garden.

The Hestercombe Landscape Garden:

check all the correct answers

Have always been as we see it now.
At the beginning was a wood.
In 1960 they cut all the trees.
100 years after its creation was overgrown.
Nowadays is like what it used to be in the 18th century when it was created.

Octagon Summerhouse

Which views from the Octagon Summerhouse? (check all the correct)

Taunton Vale
The Chinese seat
The big Pond
The Great Cascade
The Witch House
The Temple Arbour
The Mausoleum
The Gothic Alcove

Was it already there when Philip White rediscovered the Garden?

No
Yes

Which are the features that make it different from other seats?
(answer very briefly, do not repeat the question)

What other interesting information do you remember about that seat?
(answer very briefly, do not repeat the question)

The Rustic Seat

Which views from the Rustic Seat?

Taunton Vale	The Witch House
The Octagon Summerhouse	The Temple Arbour
The big Pond	The Mausoleum
The Great Cascade	The Gothic Alcove

Was it already there when Philip White rediscovered the Garden?

No Yes

Which are the features that make it different from other seats?
(answer very briefly, do not repeat the question)

What other interesting information do you remember about that seat?
(answer very briefly, do not repeat the question)

Gothic Alcove

Which views from the Gothic Alcove?

Taunton Vale	The Witch House
The Octagon Summerhouse	The Temple Arbour
The big Pond	The Mausoleum
The Great Cascade	Fields

Was it already there when Philip White rediscovered the Garden?

No Yes

Which are the features that make it different from other seats?
(answer very briefly, do not repeat the question)

What other interesting information do you remember about that seat?

(answer very briefly, do not repeat the question)

Temple Arbour

Which views from the Temple Arbour?

Taunton Vale
The Octagon Summerhouse
The big Pond
The Great Cascade
The Witch House
The Chinese Seat
The Mausoleum
The Gothic Alcove

Was it already there when Philip White rediscovered the Garden?

No
Yes

Which are the features that make it different from other seats?

(answer very briefly, do not repeat the question)

What other interesting information do you remember about that seat?

(answer very briefly, do not repeat the question)

Your choice:

Write what you remember of a seat or a viewpoint of your choice in the garden (different from the four above). What's its name? Why did you like it?

Just using your pencil, do a little sketch of it.

Appendix 2: Statistical Analyses

Verona Statistical Analysis

Principal Component Analysis

Questionario pre-visita

Informazioni cronologiche
ID
Nome
Cognome
Sesso
Anno di Nascita
Nome scuola
Classe
Sezione
Tipo
Hai la connessione a internet a casa
Quanti smartphone ci sono in casa tua iPhone Samsung Galaxy ecc
Quanti tablet ci sono in casa tua iPad Samsung Galaxy Tab ecc
Quanto usi i seguenti dispositivi a casa Computer fisso
Quanto usi i seguenti dispositivi a casa Computer portatile
Quanto usi i seguenti dispositivi a casa Smartphone
Quanto usi i seguenti dispositivi a casa Tablet
Quanto usi i seguenti dispositivi a casa Console fisse
Quanto usi i seguenti dispositivi a casa Console portatile
Quanto usi i seguenti dispositivi a casa Smart glasses o visore realtÃ virtuale
Quanto usi i seguenti dispositivi a scuola Computer fisso
Quanto usi i seguenti dispositivi a scuola Computer portatile
Quanto usi i seguenti dispositivi a scuola Smartphone
Quanto usi i seguenti dispositivi a scuola Insegnante usa la LIM Lavagna Interattiva Multimediale
Quanto usi i seguenti dispositivi a scuola Tu usi la LIM Lavagna Interattiva Multimediale
Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Computer portatile

Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Smartphone

Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Tablet

Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Console portatile

Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Smart glasses o visore realtÃ virtuale

Quante spesso vai al museo o alle mostre qualsiasi tipo di museo o mostra

Quanto spesso ti capita di andare a visitare la tua o altre cittÃ per conoscerne meglio la storia i monumenti o l arte

Quanto pensi di essere capace ad usare i seguenti dispositivi Console sia fissa che portatile

Quanto pensi di essere capace ad usare i seguenti dispositivi Smartglasses Visore realtÃ virtuale

Per cosa usi il Computer Portatile o fisso Per giocare

Per cosa usi il Computer Portatile o fisso Per cercare informazioni

Per cosa usi il Computer Portatile o fisso Per comunicare con gli altri

Per cosa usi il Computer Portatile o fisso Per condividere informazioni e contenuti

Per cosa usi il Computer Portatile o fisso Per imparare

Per cosa usi il Computer Portatile o fisso Per guardare video

Per cosa usi il Computer Portatile o fisso Per ascoltare musica

Per cosa usi il Computer Portatile o fisso Per creare contenuti testi immagini video

Per cosa usi il Tablet Per giocare

Per cosa usi il Tablet Per condividere informazioni e contenuti

Per cosa usi il Tablet Per imparare

Per cosa usi il Tablet Per guardare video

Per cosa usi il Tablet Per fare i compiti

Per cosa usi lo Smartphone Per giocare

Per cosa usi lo Smartphone Per cercare informazioni

Per cosa usi lo Smartphone Per comunicare con gli altri

Per cosa usi lo Smartphone Per condividere informazioni e contenuti

Per cosa usi lo Smartphone Per imparare

Per cosa usi lo Smartphone Per guardare video

Per cosa usi lo Smartphone Per ascoltare musica

Per cosa usi lo Smartphone Per creare contenuti testi foto immagini video

Per cosa usi lo Smartphone Per fare i compiti

Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare Computer sia fisso che portatile

Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare Tablet

Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare Smartphone

Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare Console sia fissa che portatile

Quanto pensi che quello che fai di solito con i seguenti dispositivi ti aiuti ad imparare Smartglasses Visore realtÃ virtuale

Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all aperto una cittÃ un parco ecc Computer portatile

Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all aperto una cittÃ un parco ecc Tablet

Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all aperto una cittÃ un parco ecc Smartphone

Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all aperto una cittÃ un parco ecc Console portatile

Quanto ti piacerebbe utilizzare i seguenti dispositivi per imparare mentre visiti un luogo all aperto una cittÃ un parco ecc Smartglasses Visore realtÃ virtuale

Tablet lo potresti portare da casa per imparare all aperto

Smartphone lo potresti portare da casa per imparare all aperto

Console portatile lo potresti portare da casa per imparare all aperto

Quando visiti una cittÃ per conoscerne la storia l arte e i monumenti

Quanto impari dalle audioguide di musei e mostre

Quanto impari dalle guide professioniste di musei mostre cittÃ e parchi

Quanto impari dai libretti di musei mostre cittÃ e parchi

Quanto impari dai cartelli e le didascalie di musei mostre cittÃ e parchi

Quanto impari dalle App di musei mostre cittÃ e parchi

Quanto spesso guardi trasmissioni sulla storia e la cultura delle civiltÃ

Quanto ti piacciono queste trasmissioni

Quanto impari da queste trasmissioni

Quanto spesso leggi libri parti di libri o articoli anche su internet sulla storia e la cultura delle civiltÃ

Quanto ti piacciono questi testi

Quanto impari da questi testi

Quanto ti piace l insegnamento di storia nella tua scuola

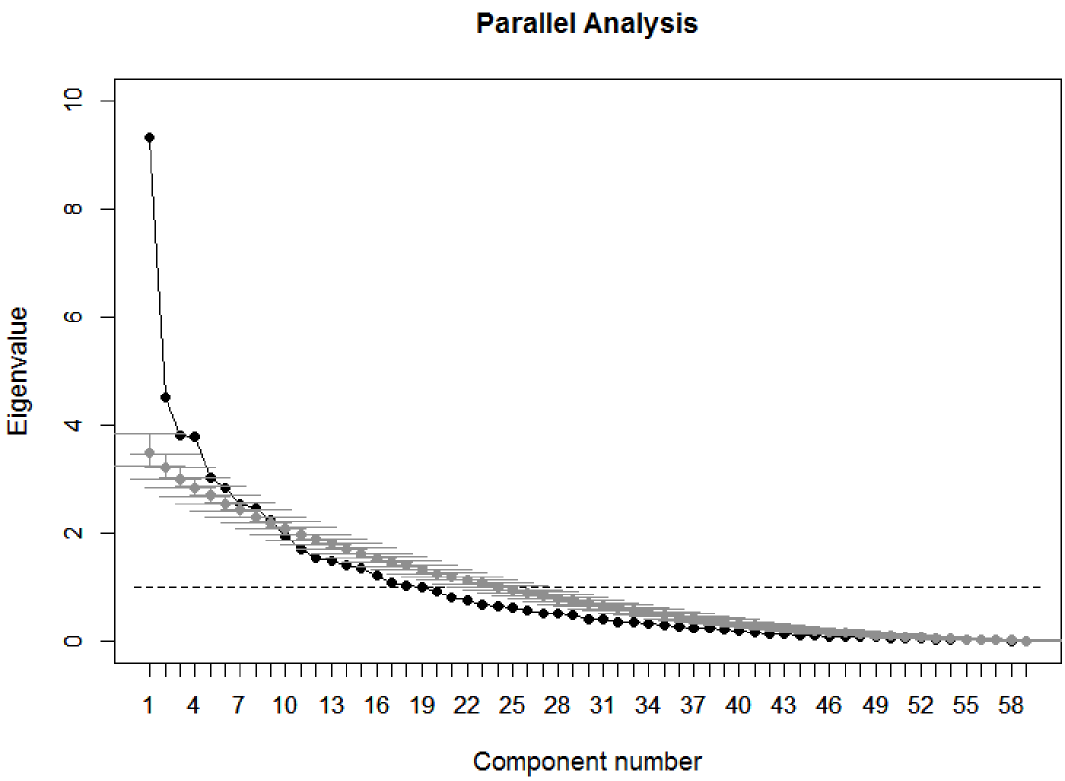
Quanto impari dall insegnamento di storia nella tua scuola

Ti capita di andare a cercare delle informazioni sulla storia e le civiltÃ per tuo interesse personale non per compiti

Quanto impari dalle tue ricerche

Dove vai a cercare queste informazioni

PerchÃ secondo te Ã importante sapere la storia della nostra civiltÃ la storia dei monumenti della cultura e dell arte



Loadings table with cut off at 0.5

	RC1	RC3	RC2	RC6	RC4	RC5	RC9	RC7	RC8
Q1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q3	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q5	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q6	0.653	NA	NA	NA	NA	NA	NA	NA	NA
Q7	NA	NA	NA	NA	NA	NA	NA	0.513	NA
Q8	NA	NA	0.534	NA	NA	NA	NA	NA	NA
Q9	NA	NA	0.641	NA	NA	NA	NA	NA	NA
Q10	NA	NA	NA	NA	NA	NA	0.581	NA	NA
Q11	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q12	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q13	NA	NA	NA	NA	NA	NA	NA	NA	0.556
Q14	NA	NA	NA	NA	NA	NA	NA	NA	0.691
Q15	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q16	NA	NA	NA	NA	NA	0.546	NA	NA	NA
Q17	NA	NA	NA	NA	NA	0.693	NA	NA	NA
Q18	NA	NA	NA	NA	NA	NA	0.726	NA	NA
Q19	0.570	NA	NA	NA	NA	NA	NA	NA	NA

Q20	NA	NA	0.567	NA	NA	NA	NA	NA	NA
Q21	NA	NA	0.716	NA	NA	NA	NA	NA	NA
Q22	NA	NA	NA	NA	NA	NA	0.814	NA	NA
Q23	NA	NA	NA	NA	-0.696	NA	NA	NA	NA
Q24	NA	NA	NA	NA	-0.557	NA	NA	NA	NA
Q25	0.567	NA	NA	NA	NA	NA	NA	NA	NA
Q26	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q27	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q28	NA	NA	NA	NA	NA	NA	0.724	NA	NA
Q29	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q30	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q31	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q32	NA	NA	NA	NA	NA	NA	NA	0.602	NA
Q33	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q36	NA	NA	NA	0.611	NA	NA	NA	NA	NA
Q37	NA	0.685	NA	NA	NA	NA	NA	NA	NA
Q38	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q39	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q40	NA	0.780	NA	NA	NA	NA	NA	NA	NA
Q41	NA	NA	NA	0.767	NA	NA	NA	NA	NA
Q42	NA	NA	NA	0.632	NA	NA	NA	NA	NA
Q43	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q44	NA	0.567	NA	NA	NA	NA	NA	NA	NA
Q54	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q55	0.678	NA	NA	NA	NA	NA	NA	NA	NA
Q56	0.570	NA	NA	NA	NA	NA	NA	NA	NA
Q57	0.622	NA	NA	NA	NA	NA	NA	NA	NA
Q58	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q59	0.711	NA	NA	NA	NA	NA	NA	NA	NA
Q60	0.729	NA	NA	NA	NA	NA	NA	NA	NA
Q61	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q62	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q63	NA	0.669	NA	NA	NA	NA	NA	NA	NA
Q65	0.557	NA	NA	NA	NA	NA	NA	NA	NA
Q68	NA	NA	0.506	NA	NA	NA	NA	NA	NA
Q69	NA	NA	NA	NA	0.606	NA	NA	NA	NA
Q70	NA	NA	NA	NA	0.618	NA	NA	NA	NA
Q73	NA	NA	NA	NA	NA	NA	NA	0.579	NA
Q74	NA	NA	NA	NA	NA	NA	NA	NA	NA
Q75	NA	NA	NA	NA	NA	NA	NA	NA	NA

Componente alla colonna 1

	domanda	loading
Q60	Per cosa usi il Tablet Per imparare	0.7288459
Q59	Per cosa usi il Tablet Per condividere informazioni e contenuti	0.7106770
Q55	Per cosa usi il Computer Portatile o fisso Per fare i compiti	0.6776587
Q6	Quanto usi i seguenti dispositivi a casa Smartphone	0.6527560
Q57	Per cosa usi il Tablet Per cercare informazioni	0.6223387
Q19	Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Smartphone	0.5703252
Q56	Per cosa usi il Tablet Per giocare	0.5698042
Q25	Quando hai visitato la tua o altre cittÃ quanto spesso hai usato i seguenti dispositivi mentre eri all aperto per recuperare informazioni o imparare cose Smartphone	0.5674744
Q65	Per cosa usi il Tablet Per fare i compiti	0.5572215

Componente alla colonna 2

	domanda	loading
Q40	Per cosa usi il Computer Portatile o fisso Per comunicare con gli altri	0.7795075
Q37	Quanto pensi di essere capace ad usare i seguenti dispositivi Smartglasses Visore realtÃ virtuale	0.6848783
Q63	Per cosa usi il Tablet Per creare contenuti testi foto immagini video	0.6691984
Q44	Per cosa usi il Computer Portatile o fisso Per ascoltare musica	0.5665572

Componente alla colonna 3

	domanda	loading
Q21	Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Console portatile	0.7156084
Q9	Quanto usi i seguenti dispositivi a casa Console portatile	0.6414852
Q20	Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Tablet	0.5672160
Q8	Quanto usi i seguenti dispositivi a casa Console fisse	0.5337343
Q68	Per cosa usi lo Smartphone Per giocare	0.5062355

Componente alla colonna 4

	domanda	loading
Q41	Per cosa usi il Computer Portatile o fisso Per condividere informazioni e contenuti	0.7674793
Q42	Per cosa usi il Computer Portatile o fisso Per imparare	0.6319741
Q36	Quanto pensi di essere capace ad usare i seguenti dispositivi Console sia fissa che portatile	0.6106663

Componente alla colonna 5

	domanda	loading

Q70	Per cosa usi lo Smartphone Per comunicare con gli altri	0.6179128
Q69	Per cosa usi lo Smartphone Per cercare informazioni	0.6063503
Q24	Quanto spesso ti capita di andare a visitare la tua o altre cittÃ per conoscerne meglio la storia i monumenti o l arte	-0.5568123
Q23	Quante spesso vai al museo o alle mostre qualsiasi tipo di museo o mostra	-0.6961987

Componente alla colonna 6

	domanda	loading
Q17	Quanto usi i seguenti dispositivi a scuola Tu usi la LIM Lavagna Interattiva Multimediale	0.6929200
Q16	Quanto usi i seguenti dispositivi a scuola Insegnante usa la LIM Lavagna Interattiva Multimediale	0.5461258

Componente alla colonna 7

	domanda	loading
Q22	Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Smart glasses o visore realtÃ virtuale	0.8143223
Q18	Quanto usi i seguenti dispositivi durante gli spostamenti quotidiani e all aperto quando non sei nÃ a casa nÃ a scuola ma in giro al parco ecc Computer portatile	0.7264894
Q28	Quando hai visitato la tua o altre cittÃ quanto spesso hai usato i seguenti dispositivi mentre eri all aperto per recuperare informazioni o imparare cose Smart glasses o visore realtÃ virtuale	0.7241010
Q10	Quanto usi i seguenti dispositivi a casa Smart glasses o visore realtÃ virtuale	0.5812305

Componente alla colonna 8

	domanda	loading
Q32	Quanto pensi di essere capace ad usare i seguenti dispositivi Tablet	0.6018710
Q73	Per cosa usi lo Smartphone Per condividere informazioni e contenuti	0.5794630
Q7	Quanto usi i seguenti dispositivi a casa Tablet	0.5133077

Componente alla colonna 9

	domanda	loading
Q14	Quanto usi i seguenti dispositivi a scuola Tablet	0.6914454
Q13	Quanto usi i seguenti dispositivi a scuola Smartphone	0.5563827

Questionario post-visita

```
 [27] "I.dispositivi.sono.stati.utili.durante.l.uscita...solo.per.chi.li.ha.usa
ti."
[28] "I.libretti.sono.stati.utili.durante.l.uscita...solo.per.chi.li.ha.usati."
[29] "I.dispositivi.sono.stati.facili.da.usare.durante.l.uscita...solo.per.chi.
li.ha.usati."
[30] "I.libretti.sono.stati.facili.da.usare.durante.l.uscita...solo.per.chi.li.
ha.usati."
```

```
[31]                  "Cosa.ti.e..piaciuto.dell.ultilizzo.di.app.e.dispositivo"
[32]              "Cosa.non.ti.e..piaciuto.dell.ultilizzo.di.app.e.dispositivo"
[33]  "Avrei.preferito.usare.i.libretti.e.non.il.dispositivo...solo.per.chi.ha.u
sato.il.dispositivo."
[34]  "Avrei.preferito.usare.il.dispositivo.e.non.il.libretto.durante.l.uscita..
.solo.per.chi.ha.usato.il.libretto."
[35]  "Quanto.sai.usare.gli.smartphone.Android..cioÃ¨.i.dispositivi.che.hai.usat
o.in.uscita...solo.per.chi.li.ha.usati."
```

Informazioni cronologiche

ID

Nome

Cognome

Sesso

Anno di nascita

Classe

Sezione

Tipo

Hanno spiegato tutto quello che avevano promesso all inizio

Hanno spiegato tutto quello che avrei voluto sapere

Ho imparato cose che mi saranno utili in futuro

Sono stato molto coinvolto dall esperienza Ho partecipato attivamente con interesse con emozione

I miei compagni sono stati molto coinvolti dall esperienza

Gli insegnanti sono stati molto coinvolti dall esperienza

Il materiale fornito Ã stato facile da usare

I dispositivi sono stati utili durante l uscita solo per chi li ha usati

I libretti sono stati utili durante l uscita solo per chi li ha usati

I dispositivi sono stati facili da usare durante l uscita solo per chi li ha usati

I libretti sono stati facili da usare durante l uscita solo per chi li ha usati

Cosa non ti e piaciuto dell ultilizzo di app e dispositivo

Avrei preferito usare i libretti e non il dispositivo solo per chi ha usato il dispositivo

Avrei preferito usare il dispositivo e non il libretto durante l uscita solo per chi ha usato il libretto

Quanto sai usare gli smartphone Android cioÃ i dispositivi che hai usato in uscita solo per chi li ha usati

Vorrei ripetere un esperienza come questa

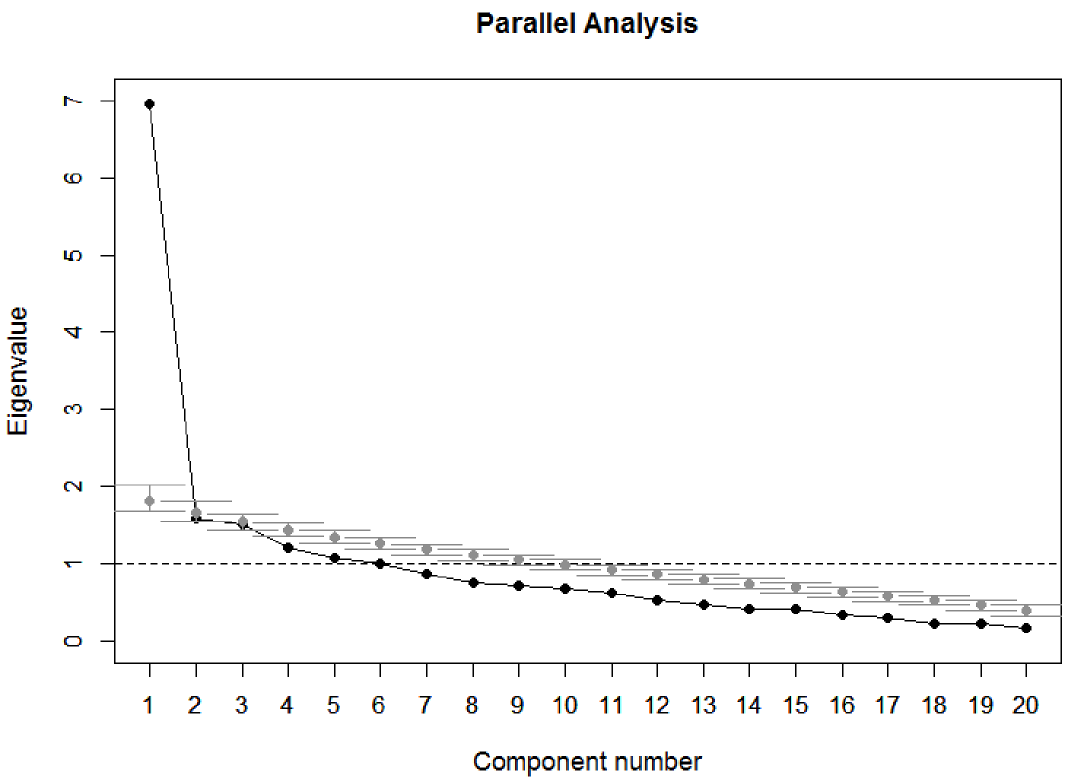
Quanto ti Ã piaciuta l esperienza di Verona Romana da 1 a 5

Quanto utile

Quanto facile

Avrei preferito altro

Conoscenza Android



Loadings table with cut off at 0.5

	PC1
Q1	0.600
Q2	0.642
Q3	0.535
Q4	0.591
Q5	NA
Q6	0.586
Q8	0.789
Q9	0.712
Q10	0.590
Q11	0.731
Q12	0.604
Q13	0.604
Q14	0.637
Q15	0.720
Q16	NA
Q17	0.582
Q18	0.692
Q19	0.547
Q20	0.515

Q21	NA

Componente alla colonna 1

	domanda	loading
Q8	Gli insegnanti sono stati molto coinvolti dall esperienza 1	0.7888142
Q11	Hanno risposto alle domande e agli interventi	0.7307657
Q15	Hanno utilizzato del buon materiale didattico presentazioni power point schede libretti dispositivi applicazioni ecc	0.7197192
Q9	L educatore lo storico hanno condotto bene l esperienza	0.7118615
Q18	I dispositivi sono stati utili durante l uscita solo per chi li ha usati	0.6918051
Q2	Hanno spiegato tutto quello che avrei voluto sapere	0.6415927
Q14	Hanno utilizzato abbastanza materiale didattico presentazioni power point schede libretti dispositivi applicazioni ecc	0.6374131
Q12	Sono stati chiari e comprensibili nelle spiegazioni	0.6043380
Q13	Hanno dato delle informazioni corrette	0.6041311
Q1	Hanno spiegato tutto quello che avevano promesso all inizio	0.5997878
Q4	Sono stato molto coinvolto dall esperienza Ho partecipato attivamente con interesse con emozione	0.5906750
Q10	Hanno gestito bene il tempo della spiegazione	0.5902512
Q6	Gli insegnanti sono stati molto coinvolti dall esperienza	0.5861090
Q17	Il materiale fornito Ã stato facile da usare	0.5816880
Q19	I libretti sono stati utili durante l uscita solo per chi li ha usati	0.5474459
Q3	Ho imparato cose che mi saranno utili in futuro	0.5353020
Q20	I dispositivi sono stati facili da usare durante l uscita solo per chi li ha usati	0.5151314

Analisi sulle componenti ottenute

Qui faccio delle analisi sulle componenti ottenute.

Prima di tutto valuto se correlano fra di loro (non dovrebbero visto che ho usato l'algoritmo VARIMAX, ma dipende dalle risposte).

L'indice ρ Ã¨ la correlazione di Pearson, che varia in un range da -1 a 1, indicando con 1 correlazione perfetta (ossia ogni volta che varia una misura cambia anche l'altra nello stesso senso), -1 correlazione perfetta inversa (ossia le due variabili vanno in senso opposto), e 0 non c'Ã¨ correlazione.

Chiaramente i valori sono difficilmente cosÃ¬ netti, quindi si dice che fra 0.3 e -0.3 non c'Ã¨ correlazione, mentre i valori piÃ¹ estremi rappresentano una correlazione.

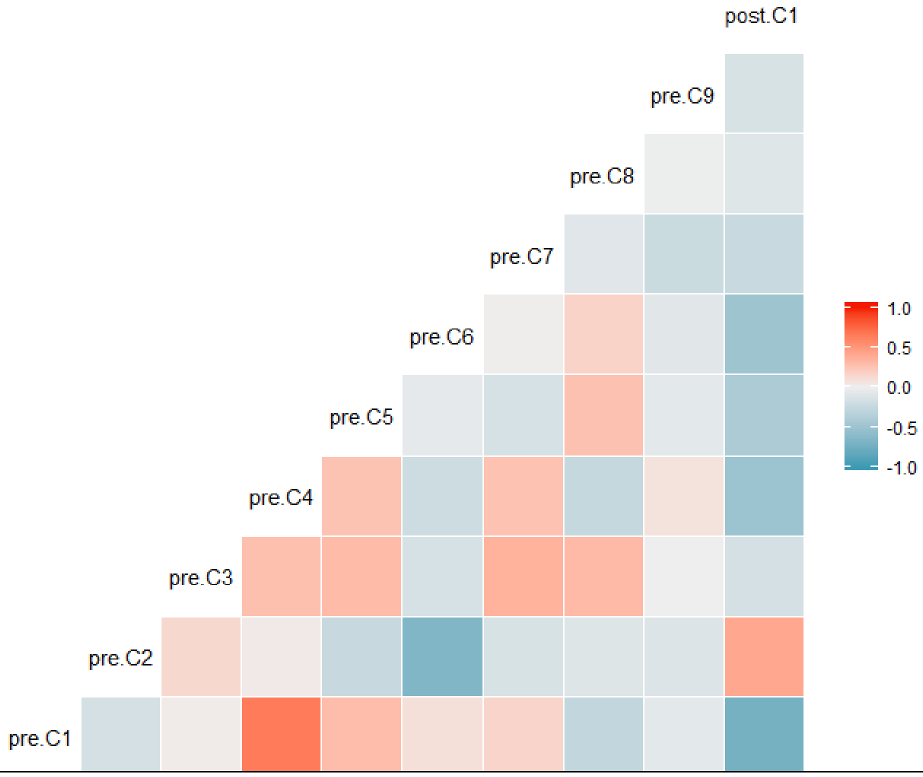
Valori di correlazione fra le componenti ottenute. La tabella si legge a "battaglia navale", ossia si incrociano le righe e le colonne per capire di che correlazione parliamo. CosÃ¬ facendo il triangolo superiore alla diagonale di 1 e quello inferiore sono identici.

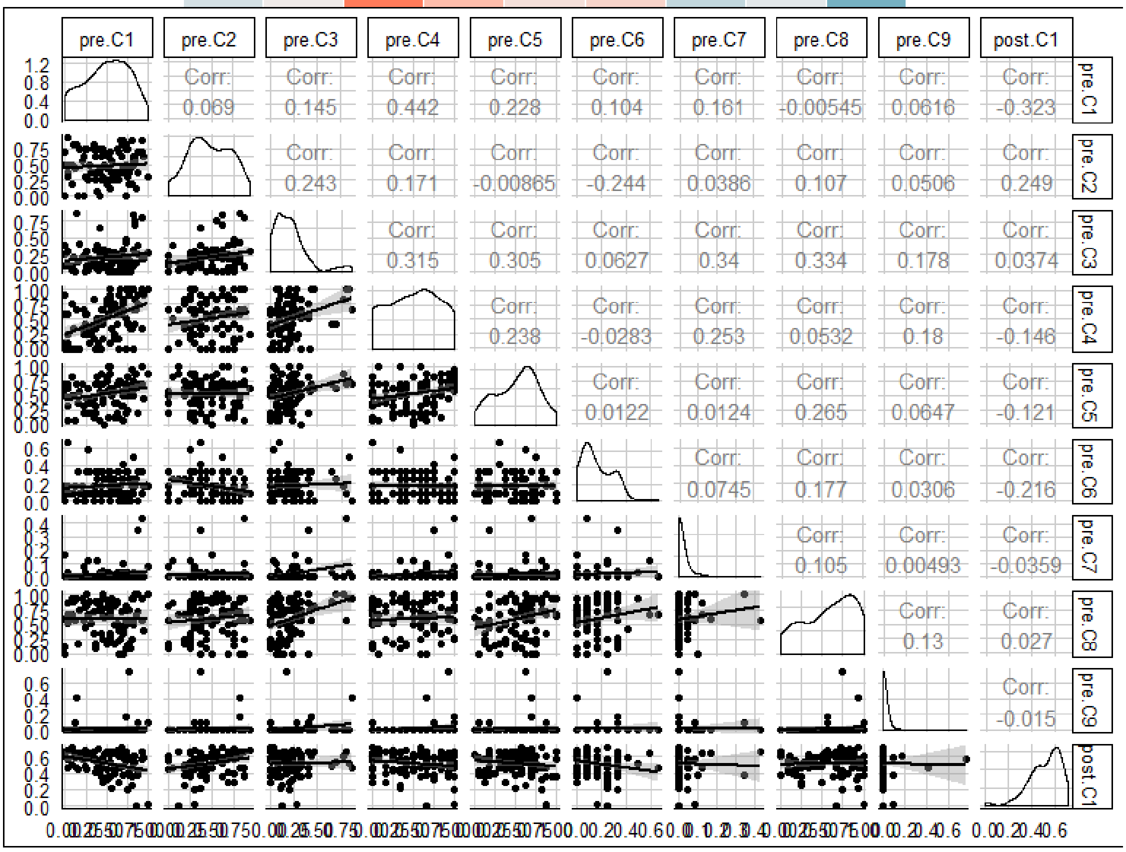
	pre.C 1	pre.C 2	pre.C 3	pre.C 4	pre.C 5	pre.C 6	pre.C 7	pre.C 8	pre.C 9	post.C 1

pre.C1	1.00	0.07	0.14	0.44	0.23	0.10	0.16	-0.01	0.06	-0.32
pre.C2	0.07	1.00	0.24	0.17	-0.01	-0.24	0.04	0.11	0.05	0.25
pre.C3	0.14	0.24	1.00	0.31	0.31	0.06	0.34	0.33	0.18	0.04
pre.C4	0.44	0.17	0.31	1.00	0.24	-0.03	0.25	0.05	0.18	-0.15
pre.C5	0.23	-0.01	0.31	0.24	1.00	0.01	0.01	0.27	0.06	-0.12
pre.C6	0.10	-0.24	0.06	-0.03	0.01	1.00	0.07	0.18	0.03	-0.22
pre.C7	0.16	0.04	0.34	0.25	0.01	0.07	1.00	0.11	0.00	-0.04
pre.C8	-0.01	0.11	0.33	0.05	0.27	0.18	0.11	1.00	0.13	0.03
pre.C9	0.06	0.05	0.18	0.18	0.06	0.03	0.00	0.13	1.00	-0.01
post.C1	-0.32	0.25	0.04	-0.15	-0.12	-0.22	-0.04	0.03	-0.01	1.00

Valori di significiativitÃ delle correlazioni. Un ffetto Ã¨ significativo se < 0.05. Anche questa tabella si legge a "battaglia navale". In questo caso perÃ² considera solo il triangolo sopra la diagopnale di zeri, che Ã¨ corretta per confronti multipli.

	pre.C1	pre.C2	pre.C3	pre.C4	pre.C5	pre.C6	pre.C7	pre.C8	pre.C9	post.C1
pre.C1	0.000	1.000	1.000	0.000	0.320	1.000	1.000	1.000	1.000	0.008
pre.C2	0.439	0.000	0.201	1.000	1.000	0.198	1.000	1.000	1.000	0.171
pre.C3	0.103	0.006	0.000	0.012	0.019	1.000	0.004	0.005	1.000	1.000
pre.C4	0.000	0.053	0.000	0.000	0.233	1.000	0.152	1.000	1.000	1.000
pre.C5	0.010	0.923	0.000	0.007	0.000	1.000	1.000	0.096	1.000	1.000
pre.C6	0.242	0.006	0.482	0.751	0.892	0.000	1.000	1.000	1.000	0.465
pre.C7	0.069	0.665	0.000	0.004	0.890	0.403	0.000	1.000	1.000	1.000
pre.C8	0.951	0.229	0.000	0.551	0.002	0.045	0.236	0.000	1.000	1.000
pre.C9	0.489	0.570	0.044	0.042	0.468	0.732	0.956	0.142	0.000	1.000
post.C1	0.000	0.005	0.675	0.101	0.174	0.015	0.688	0.762	0.867	0.000



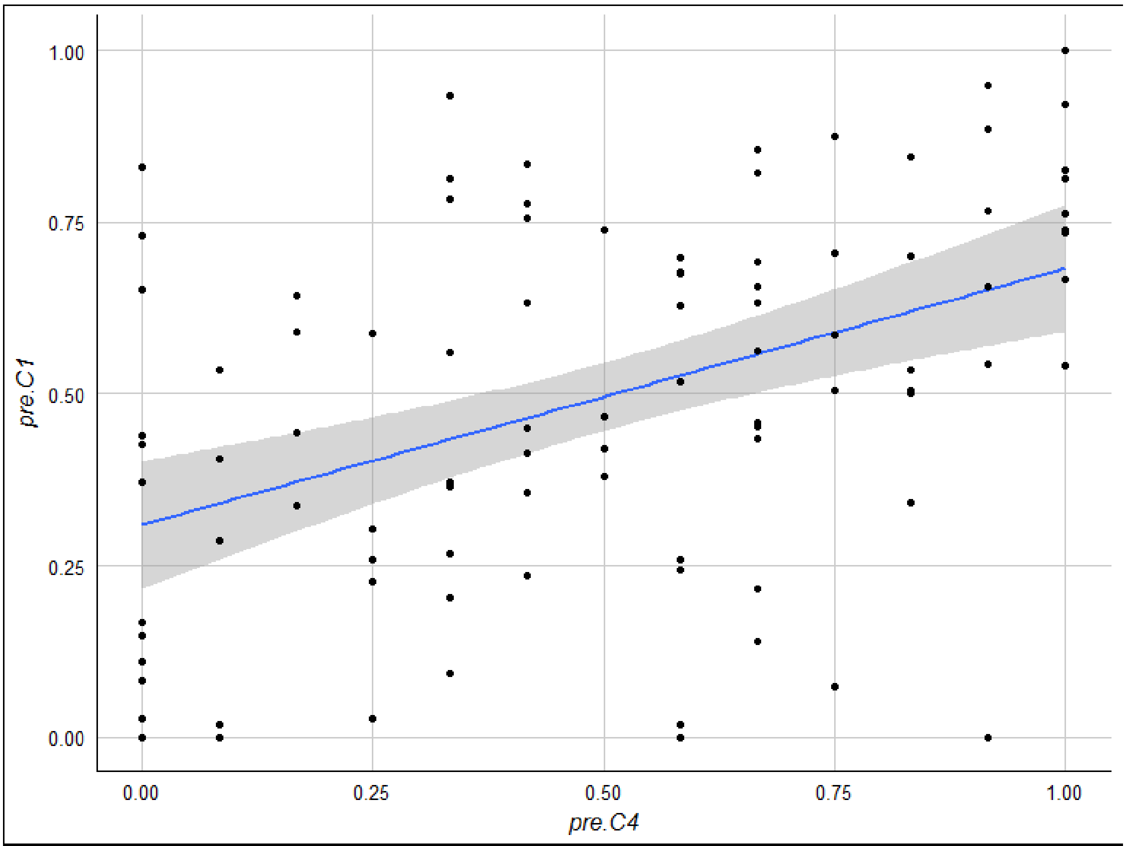


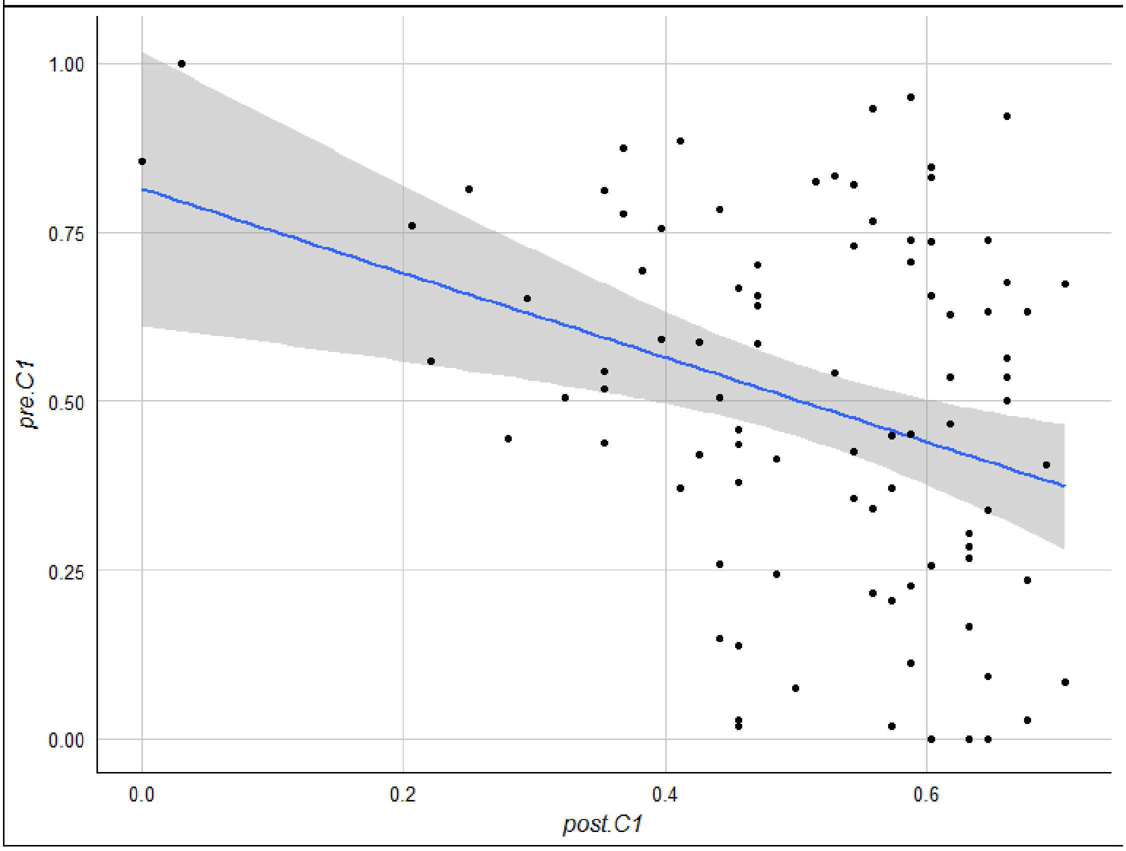
Da queste tabelle Ã¨ interessante vedede come la prima componente correli con la quarta e quella di post.

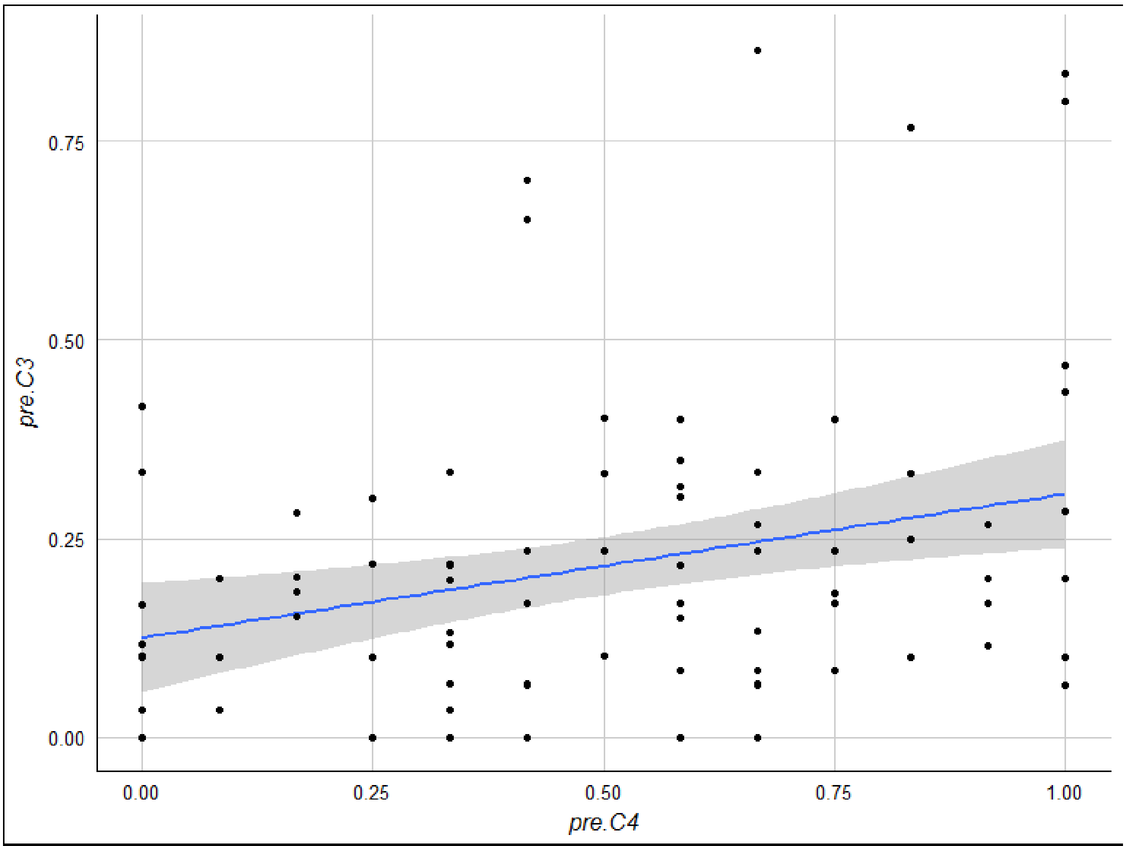
La terza con la quarta, la quinta, la settima e l'ottava.

Le altre non correlano fra di loro.

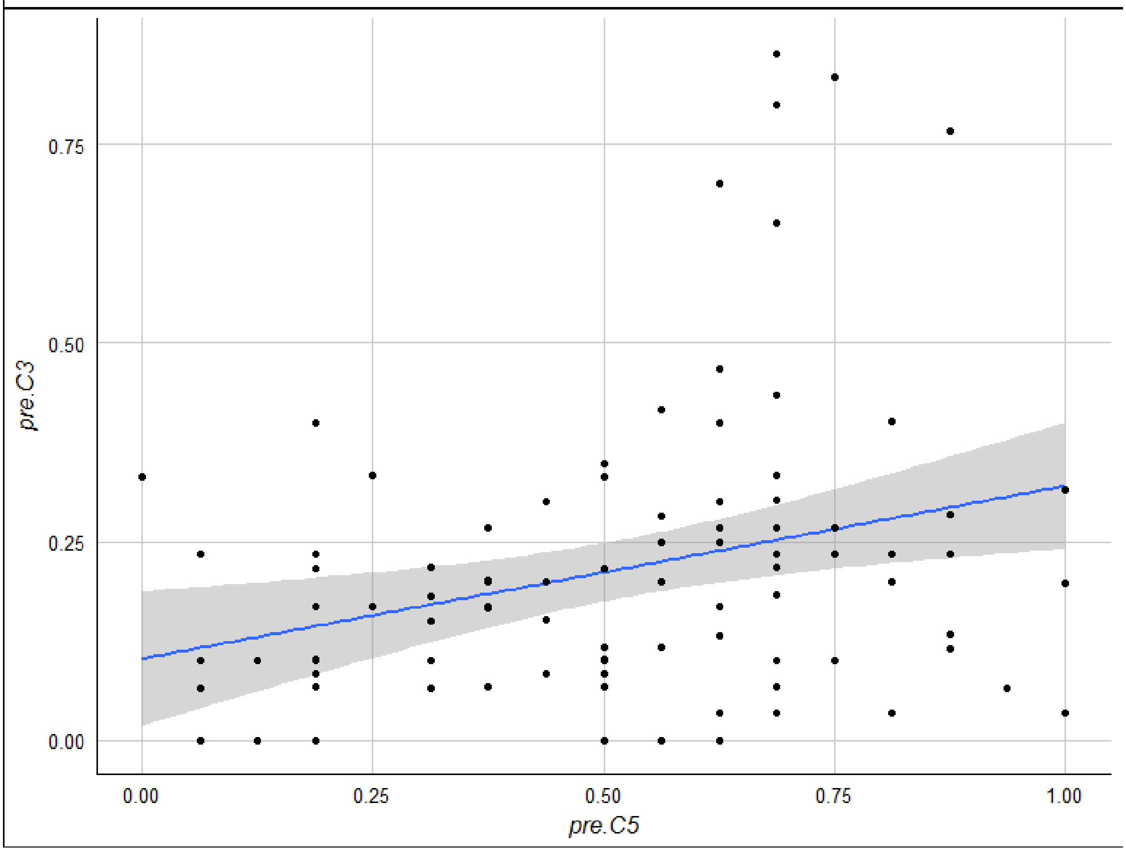
Faccio ora dei grafici solo delle cose che correlano fra loro.



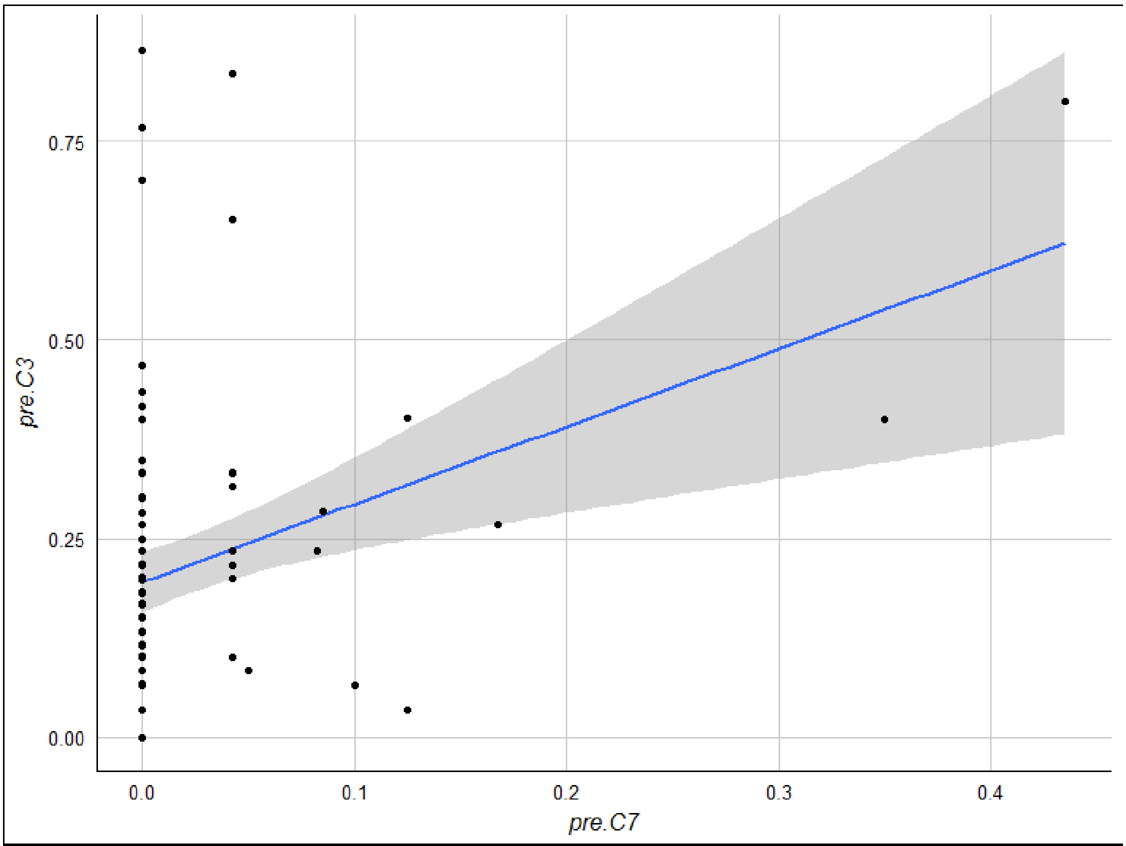


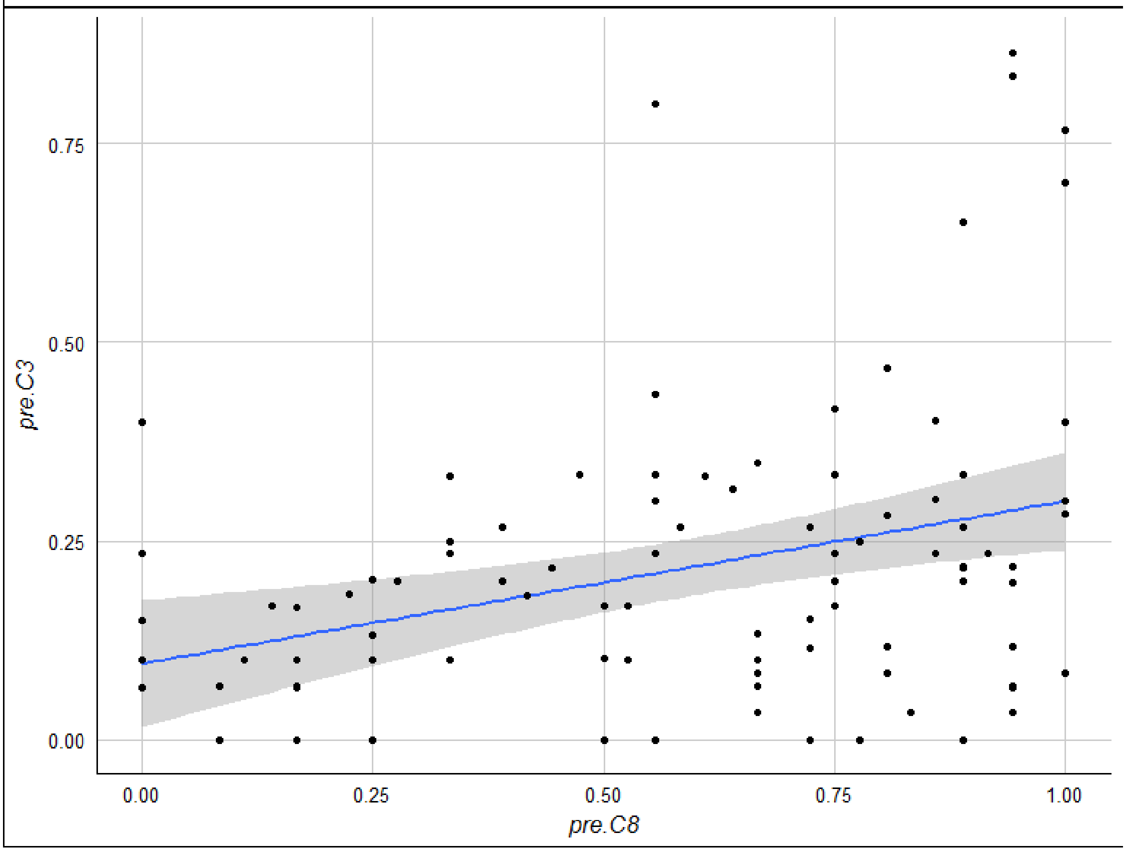


0.75
0.50
0.25
0.00
pre.C3
0.00
0.25
0.50
0.75
1.00
pre.C4



0.75
0.50
0.25
0.00
pre.C3
0.00
0.25
0.50
0.75
1.00
pre.C5





Adesso faccio delle analisi con gli MLM sulle varie componenti.

Le analisi che riporto sotto sono tutte dello stesso tipo: analisi MLM, cone variabile dipendente la componente citata.

Il fattore fisso considerato Ã¨: Tipo (sperimentale/controllo), proprio per vedere se ci sono diversitÃ fra i due campioni.

Il fattore random Ã¨ la scuola, in quanto non possiamo controllare la qualitÃ degli insegnanti in ogni scuola.

Analisi su prima componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.566	0.360	0.550
Sesso	1	88.586	0.097	0.756
Tipo:Sesso	1	88.743	1.570	0.213

Il risultato non Ã¨ significativo.

Analisi su seconda componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.953	0.715	0.400
Sesso	1	88.982	1.025	0.314
Tipo:Sesso	1	89.174	0.004	0.947

Il risultato non Ã¨ significativo.

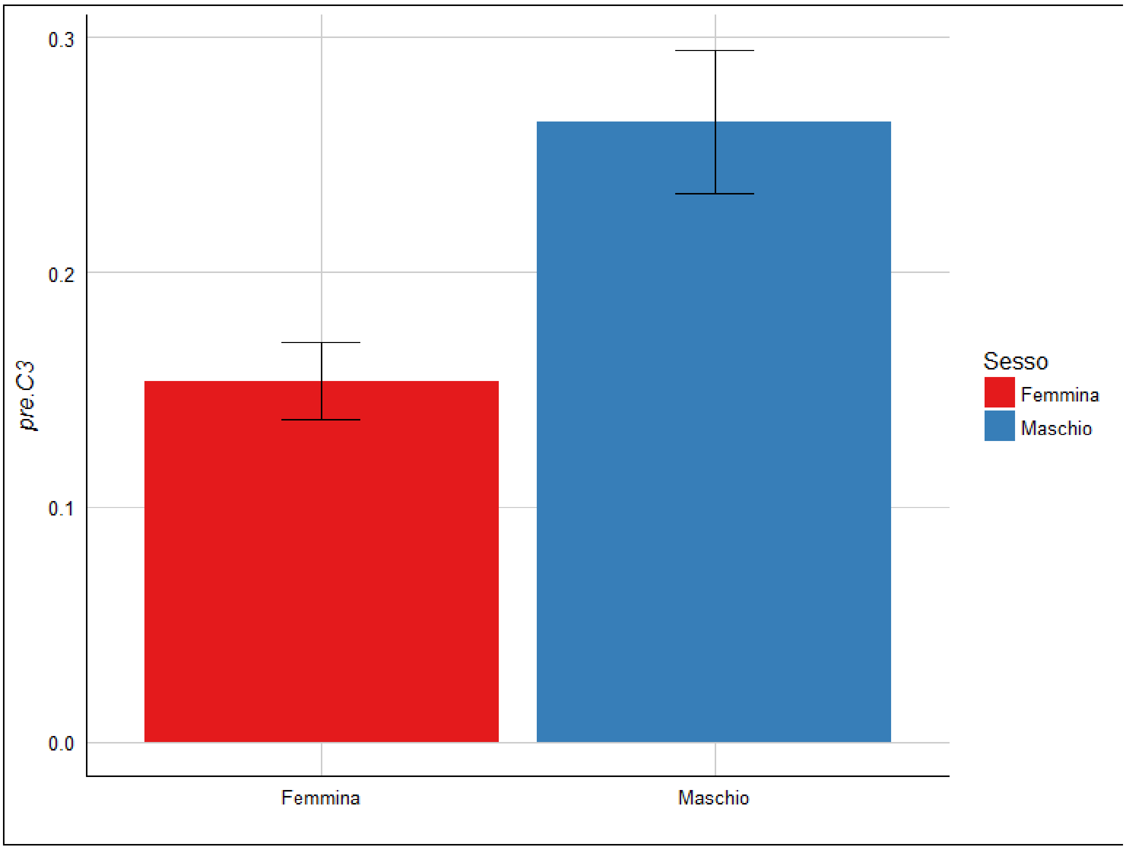
Analisi su terza componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.457	1.745	0.190
Sesso	1	88.477	9.200	0.003
Tipo:Sesso	1	88.646	0.509	0.477

C'Ã¨ una differenza significativa riguardante il sesso. Andiamo a vedere le medie di questa componente

Sesso	pre.C3
Femmina	0.15 (0.11)
Maschio	0.26 (0.22)



Le ragazze in media hanno un minore utilizzo dei dispositivi per scopi ludici.

Questa componente perÃ² non Ã¨ in interazione con "tipo", quindi non pregiudica la validitÃ della divisione sperimentale/controllo (ci sono ragazze e ragazzi in una misura confrontabile in ambo i gruppi).

Analisi su quarta componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.517	0.658	0.419
Sesso	1	88.540	0.014	0.906
Tipo:Sesso	1	88.723	2.835	0.096

Il risultato non Ã¨ significativo.

Analisi su quinta componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	89.001	1.117	0.293
Sesso	1	89.038	0.047	0.829
Tipo:Sesso	1	89.258	0.046	0.830

Il risultato non Ã¨ significativo.

Analisi su sesta componente pre visita

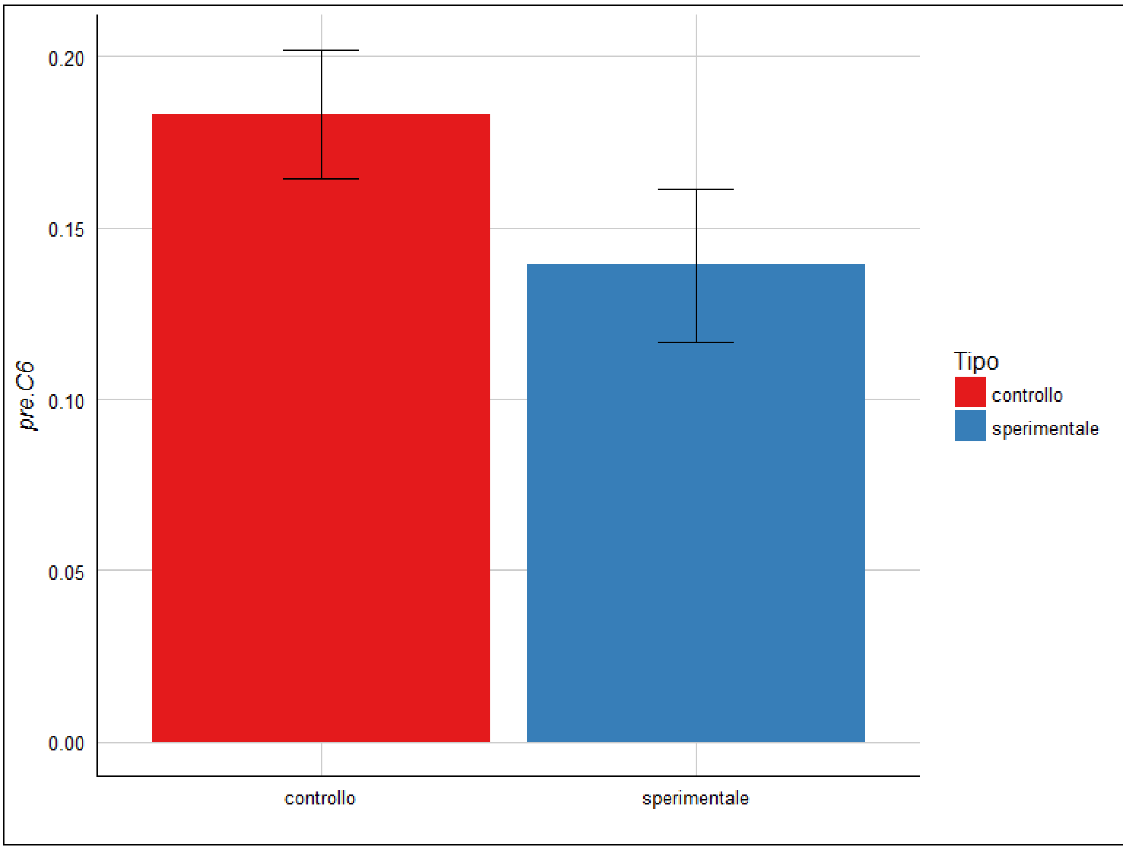
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.189	4.558	0.036
Sesso	1	88.193	0.596	0.442
Tipo:Sesso	1	88.241	0.019	0.891

Il risultato "Tipo" Ã¨ significativo.

Quindi vediamo quali sono i punteggi medi fra i due gruppi:

Tipo	pre.C6
controllo	0.18 (0.14)
sperimentale	0.14 (0.14)



Medie ed errori standard

C'Ã¨ diversitÃ nella dimensione riguardante la LIM fra le due tipologie di classi. Questo andrÃ tenuto in considerazione nelle analisi successive.

Analisi su settima componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	88.414	0.166	0.685
Sesso	1	88.429	2.724	0.102
Tipo:Sesso	1	88.567	0.047	0.829

Non Ã¨ significativo.

Analisi su ottava componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	90	1.466	0.229
Sesso	1	90	0.326	0.570
Tipo:Sesso	1	90	4.481	0.037

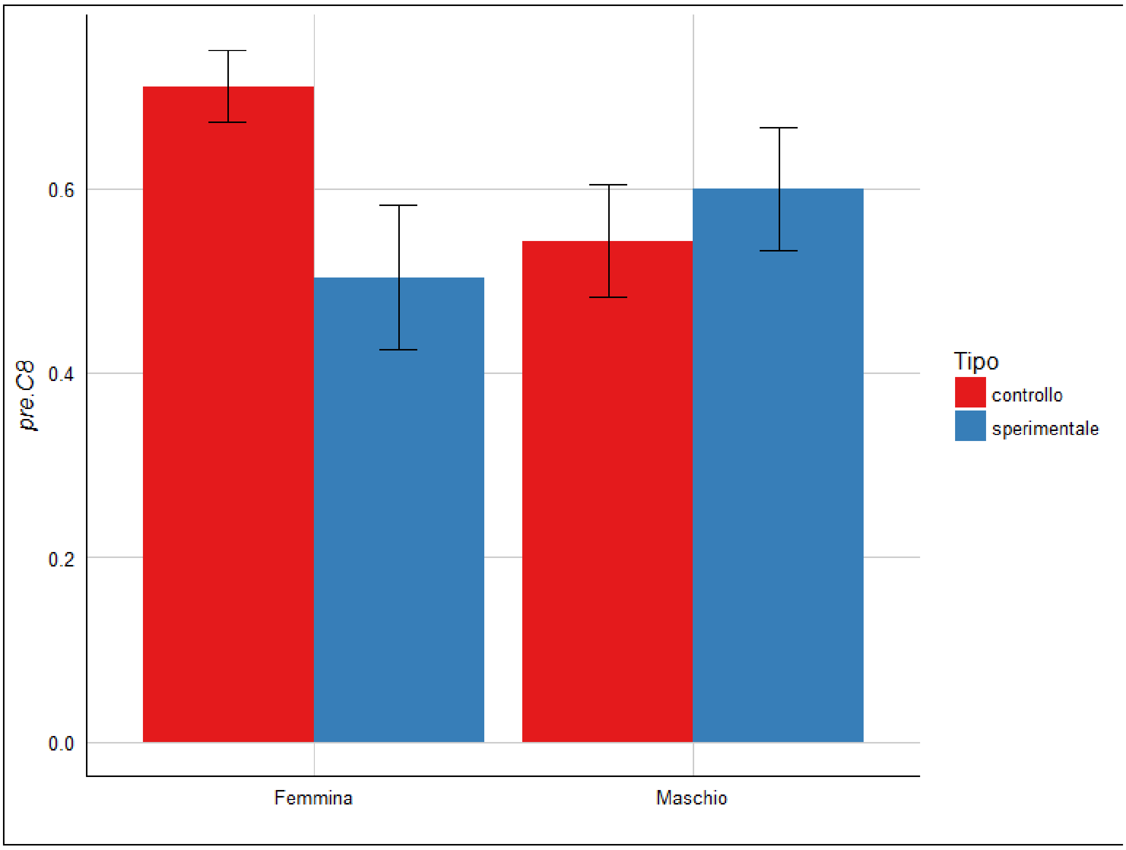
L'interazione Ã¨ significativa.

Per questo faccio delle analisi a posteriori.

Confronti appaiati fra i campioni, corretti Bonferroni. E' una matrice a doppia entrata, i risultati si leggono come se fossimo a battaglia navale, incroci la riga con la colonna e sai se il confronto fra questi 2 gruppi Ã¨ significativo oppure no.

	Femmina.controllo	Maschio.controllo	Femmina.sperimentale
Maschio.controllo	0.092	NA	NA
Femmina.sperimentale	0.057	1.000	NA
Maschio.sperimentale	0.437	0.995	0.607

Sesso	Tipo	pre.C8
Femmina	controllo	0.71 (0.18)
Maschio	controllo	0.54 (0.34)
Femmina	sperimentale	0.5 (0.33)
Maschio	sperimentale	0.6 (0.3)



Il confronto fra il gruppo di femmine sperimentali e di controllo tende alla significativitÃ . In particolare possiamo vedere che le ragazze del gruppo di controllo hanno un pre.C8 maggiore rispetto a quelle del gruppo sperimentale. Ossia riguardo l'uso del tablet. Per questo terrÃ² conto di questo fattore come variabile random di pre.C8 in interazione col Sesso nelle tappe in cui hanno usato il tablet.

Analisi su nona componente pre visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	89.515	0.873	0.353
Sesso	1	89.598	0.043	0.836
Tipo:Sesso	1	89.854	1.086	0.300

Non Ã¨ significativo.

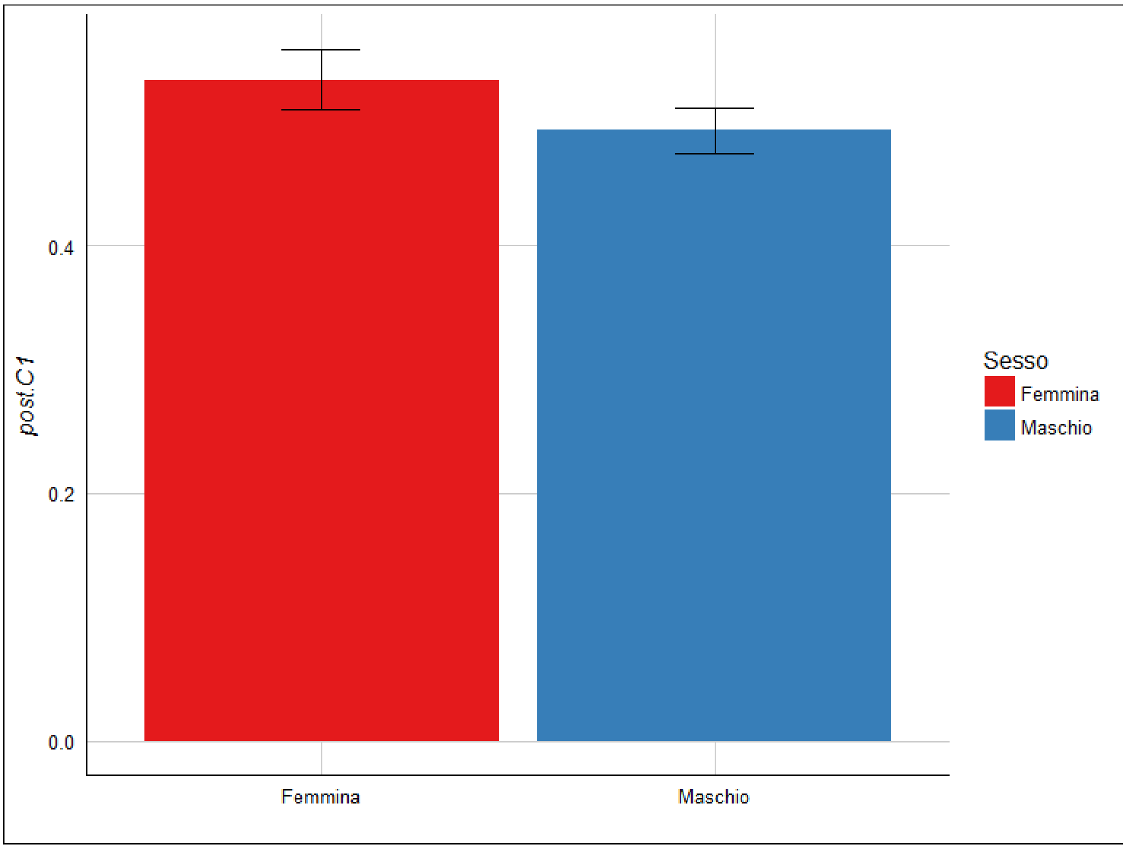
Analisi su componente post visita

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Tipo	1	86.337	0.003	0.956
Sesso	1	86.275	4.174	0.044
Tipo:Sesso	1	86.349	0.032	0.859

Il sesso del partecipante Ã¨ significativo.

Sesso	post.C1
Femmina	0.53 (0.15)
Maschio	0.49 (0.13)



Medie ed errori standard

La differenza non Ã¨ molta, ma l'esperienza Ã¨ piaciuta di piÃ¹ a femmine che a maschi (o hanno uno stile attributivo tendenzialmente piÃ¹ positivo).

Anche questo non verrÃ tenuto conto nella parte random del modello in qunto maschi e femmine sono ugualmente distribuiti fra i due gruppi.

Analisi sui punteggi al test finale

Dopo la revisione dei dati qui si andrÃ a valutare la performance su piÃ¹ ambiti.

Dapprima collego le componenti ottenute nelle varie fasi in un unico database, che salvo a parte con l'identificativo che hai dato al partecipante ed altre infomarzioni utili. Il file si chiama *"database-per-analisi.csv"*.

Il modello Ã¨ un MLM, con variabile dipendente esplicata nei titoli.

I fattori fissi sono: Tipo (sperimentale/controllo) e tutte le componenti ottenute tranne la sesta e l'ottava. Come effetti random abbiamo la sesta componente e la scuola.

aggiunta Ho inserito anche delle analisi MLM su singolo predittore e punteggio (es: tenendo conto solo di pre.C1, o pre.C2 ecc...). Poi, per motivi statistici (mantenere il livello α dell'errore di I tipo sotto il 0.05), ho applicato la correzione Holm-Bonferroni.

Questo da origine a tabelle molto grandi, nella prima colonna si vede la componente considerata (avvertenza: pre.C1.1, pre.C1.2 e pre.C1.3 si riferiscono sempre allo stesso valore di pre.C1, Ã¨ che i nomi delle righe messi cosÃ¬ devono essere univoci e non mi sembrava molto utile intervenire). Nella seconda colonna si distinguono i 3 effetti per ogni analisi (Tipo: sperimentale/controllo; c: Ã¨ sempre la componente, quindi se nella prima colonna c'Ã¨ scritto "pre.C1", questo sarÃ "pre.C1"; Tipo:x = l'interazione fra i due, ossia se il gruppo sperimentale o quello di controllo in relazione alla componente si comportano in modo *molto* diverso). Nella terza e quarta ci sono elementi statistici utili per riportare il dato, nella quinta c'Ã¨ il valore p non corretto, e su p.adj quello corretto. Infine, nell'ultima colonna, se l'effetto Ã¨ significativo, nonostante la correzione, dovrebbe esserci almeno un asterisco.

aggiunta Come fattore fisso ho aggiunto il sesso dello studente, e come fattori random ho aggiunto l'ordine delle tappe per considerarlo come effetto stanchezza e fra pre.C8 ed il Sesso.

Ho tolto la parte delle analisi singole inserita precedentemente in quanto confondente.

Punteggio finale

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	58.340	0.539	0.466
Tipo	1	56.324	0.322	0.573
pre.C1	1	56.512	0.269	0.606
pre.C2	1	57.022	0.011	0.915
pre.C3	1	56.973	3.427	0.069
pre.C4	1	53.604	0.070	0.792
pre.C5	1	56.396	1.777	0.188
pre.C7	1	55.521	0.042	0.839
post.C1	1	52.830	0.010	0.920
Sesso:Tipo	1	54.471	1.622	0.208
Sesso:pre.C1	1	55.381	0.265	0.609
Sesso:pre.C2	1	54.945	0.028	0.869
Sesso:pre.C3	1	56.554	0.791	0.378
Sesso:pre.C4	1	56.088	0.052	0.821
Sesso:pre.C5	1	55.199	0.120	0.731
Sesso:pre.C7	1	56.234	0.327	0.570
Sesso:post.C1	1	56.045	0.652	0.423
Tipo:pre.C1	1	55.007	0.000	0.991
Tipo:pre.C2	1	55.944	2.133	0.150
Tipo:pre.C3	1	58.532	0.282	0.598

Tipo:pre.C4	1	57.128	0.200	0.657
Tipo:pre.C5	1	57.400	1.131	0.292
Tipo:pre.C7	1	56.519	2.039	0.159
Tipo:post.C1	1	54.584	0.000	0.997
Sesso:Tipo:pre.C1	1	55.406	0.929	0.339
Sesso:Tipo:pre.C2	1	57.023	3.119	0.083
Sesso:Tipo:pre.C3	1	55.950	2.410	0.126
Sesso:Tipo:pre.C4	1	57.297	0.624	0.433
Sesso:Tipo:pre.C5	1	57.029	0.010	0.919
Sesso:Tipo:pre.C7	1	55.041	1.729	0.194
Sesso:Tipo:post.C1	1	55.129	0.595	0.444

Punteggio Arena

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	53.713	1.359	0.249
Tipo	1	55.288	0.367	0.547
pre.C1	1	56.579	1.071	0.305
pre.C2	1	56.828	0.001	0.974
pre.C3	1	55.009	4.223	0.045
pre.C4	1	55.784	0.219	0.641
pre.C5	1	54.938	1.128	0.293
pre.C7	1	56.043	1.371	0.247
post.C1	1	51.298	0.194	0.661
Sesso:Tipo	1	54.519	6.298	0.015
Sesso:pre.C1	1	55.836	1.344	0.251
Sesso:pre.C2	1	56.389	0.064	0.802
Sesso:pre.C3	1	52.919	6.327	0.015
Sesso:pre.C4	1	53.794	0.511	0.478
Sesso:pre.C5	1	54.790	0.171	0.681
Sesso:pre.C7	1	55.817	3.078	0.085
Sesso:post.C1	1	53.032	0.003	0.954
Tipo:pre.C1	1	54.393	0.806	0.373
Tipo:pre.C2	1	56.204	1.307	0.258
Tipo:pre.C3	1	57.738	0.000	0.988
Tipo:pre.C4	1	55.566	0.997	0.322
Tipo:pre.C5	1	55.629	0.271	0.605
Tipo:pre.C7	1	55.704	0.410	0.525
Tipo:post.C1	1	55.406	0.466	0.498

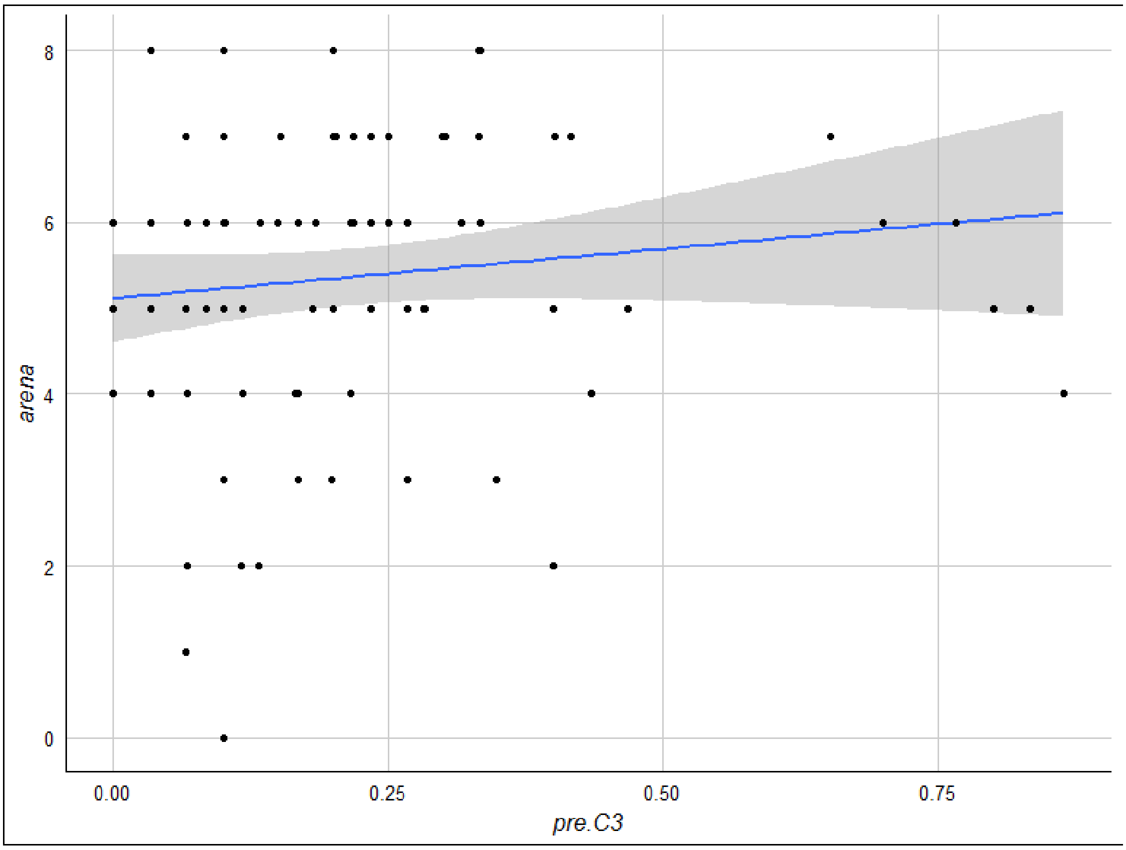
Sesso:Tipo:pre.C1	1	53.205	2.130	0.150
Sesso:Tipo:pre.C2	1	56.505	4.674	0.035
Sesso:Tipo:pre.C3	1	54.241	0.618	0.435
Sesso:Tipo:pre.C4	1	56.590	0.993	0.323
Sesso:Tipo:pre.C5	1	54.180	1.259	0.267
Sesso:Tipo:pre.C7	1	55.511	1.380	0.245
Sesso:Tipo:post.C1	1	55.734	1.201	0.278

Abbiamo diversi risultati significativi:

- pre.C3
- Sesso:Tipo
- Sesso:pre.C3
- Sesso:Tipo:pre.C2

pre.C3

Inizio con un grafico sulla significativitÃ della componente pre.C3.

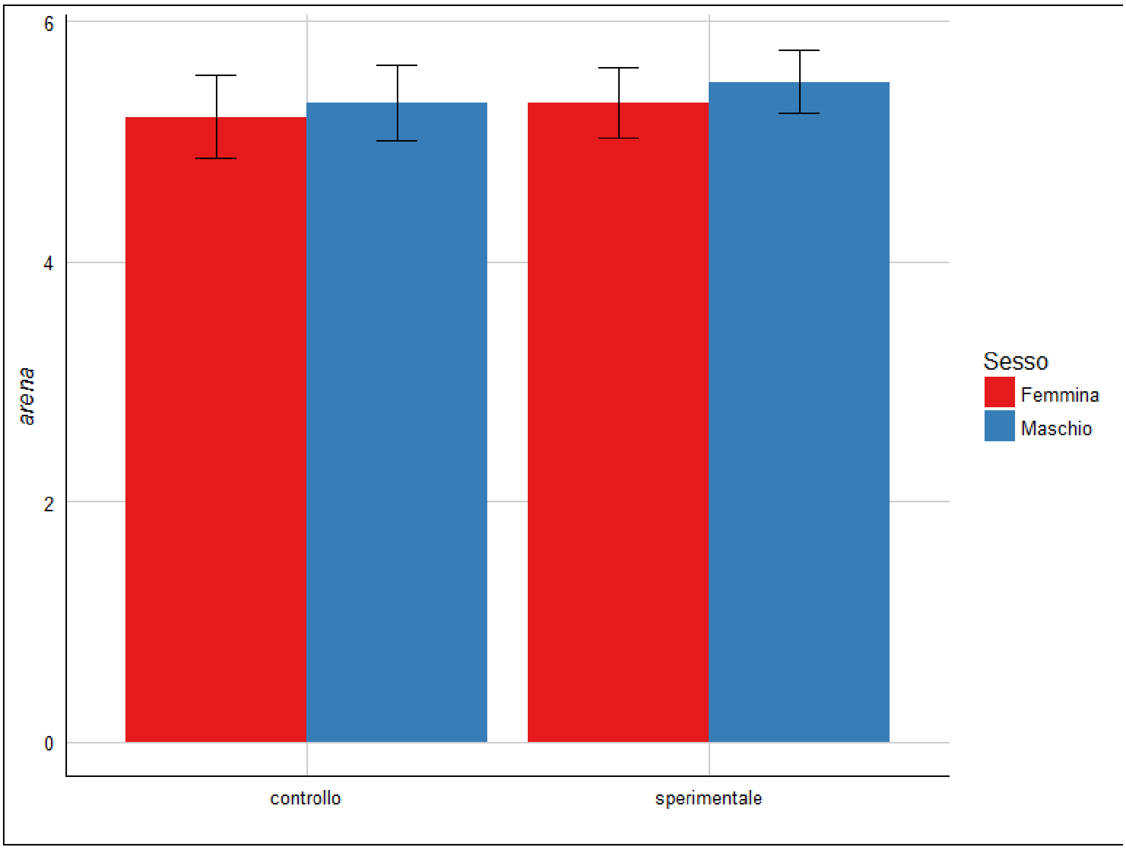


Il suo coefficente angolare Ã¨ di 3.652.

Notiamo come gli studenti che avevano un maggior pre.C3 abbiano anche ottenuto un miglior punteggio al test finale.

Sesso:Tipo

Sesso	Tipo	arena
Femmina	controllo	5.21 (1.64)
Maschio	controllo	5.32 (1.79)
Femmina	sperimentale	5.32 (1.65)
Maschio	sperimentale	5.5 (1.54)



Contronti controllo vs. sperimentale divisi epr sesso

contrast	Sesso	estimate	SE	df	t.ratio	p.value
controllo - sperimentale	Femmina	-0.463	0.742	48.354	-0.624	0.536
controllo - sperimentale	Maschio	0.423	0.452	55.399	0.936	0.353

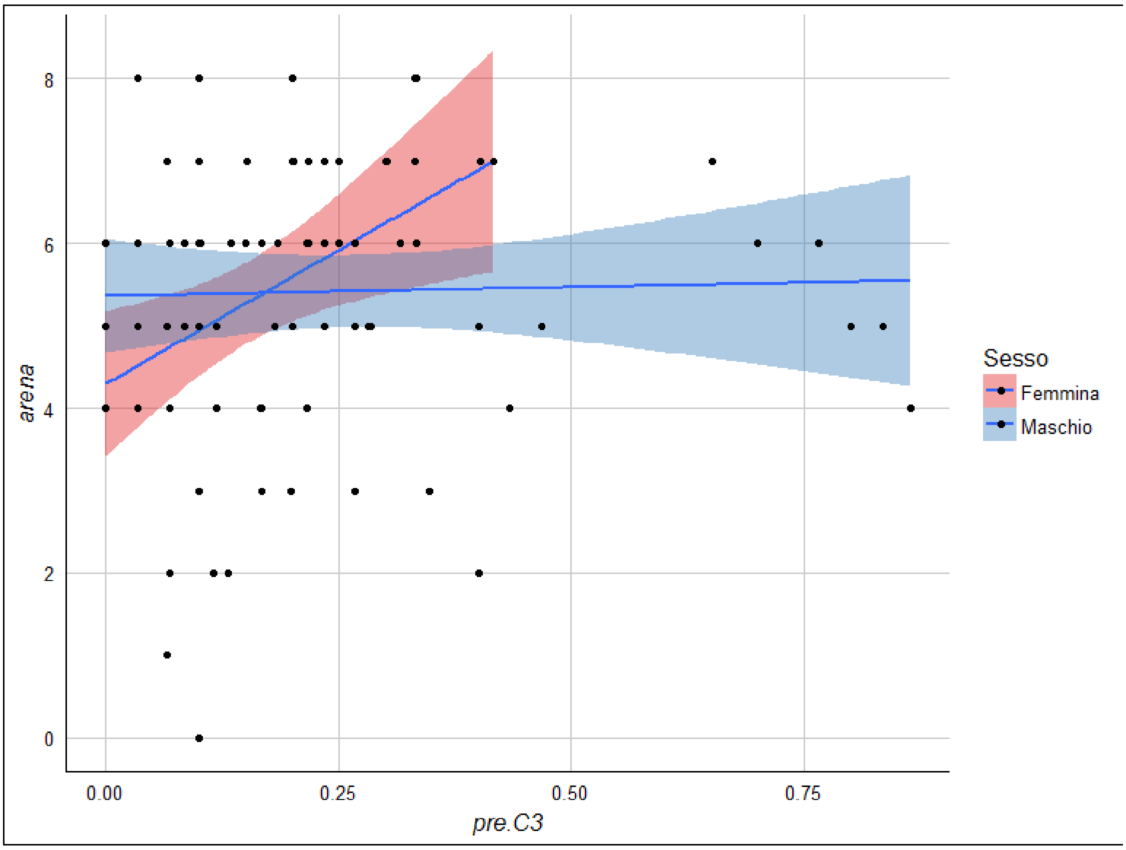
Confronti maschio vs. femmina divisi per gruppo

contrast	Tipo	estimate	SE	df	t.ratio	p.value
Femmina - Maschio	controllo	0.339	0.522	6.104	0.650	0.539
Femmina - Maschio	sperimentale	1.225	0.784	32.293	1.562	0.128

Nonostante l'interazione sia significativa, le analisi a posteriori non mostrano alcuna differenza.

Sesso:pre.C3

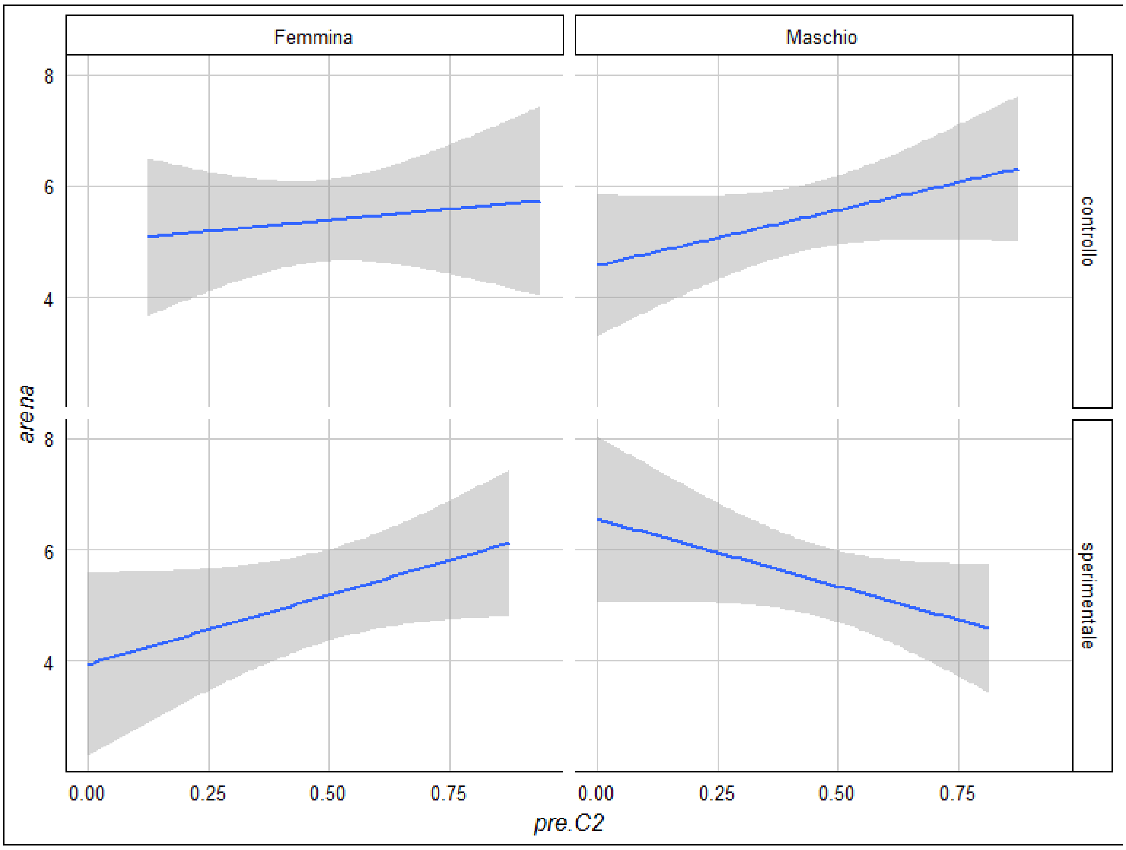
Adesso analizziamo questa interazione complessa.



Il coefficiente angolare per le ragazze Ã¨ 6.493, per i maschi Ã¨ di 0.218.

Come si puÃ² vedere, ad un piÃ¹ alto valore di pre.C3 le ragazze hanno un miglior punteggio all'esame finale.

Sesso:Tipo:pre.C2



Coefficienti angolari

Tipo	Sesso	pre.C2.trend	SE	df	lower.CL	upper.CL
controllo	Femmina	-0.618	1.694	51.219	-4.018	2.782
sperimentale	Femmina	1.090	1.606	56.628	-2.134	4.315
controllo	Maschio	2.572	1.543	55.723	-0.524	5.669
sperimentale	Maschio	-2.935	1.830	54.823	-6.608	0.738

Contrasti pairwise corretti Tukey

contrast	estimate	SE	df	t.ratio	p.value
controllo,Femmina - sperimentale,Femmina	-1.708	2.295	56.426	-0.744	0.879
controllo,Femmina - controllo,Maschio	-3.190	2.299	56.408	-1.387	0.512
controllo,Femmina - sperimentale,Maschio	2.317	2.448	55.924	0.947	0.780
sperimentale,Femmina - controllo,Maschio	-1.482	2.238	56.726	-0.662	0.911
sperimentale,Femmina - sperimentale,Maschio	4.026	2.400	55.430	1.677	0.345
controllo,Maschio - sperimentale,Maschio	5.507	2.414	55.303	2.282	0.115

Nonostante l'interazione sia significativa, le analisi a posteriori non mostrano alcuna differenza, am olo una tendenza fra sperimentale e congtrollo maschio.

Punteggio Gallieno

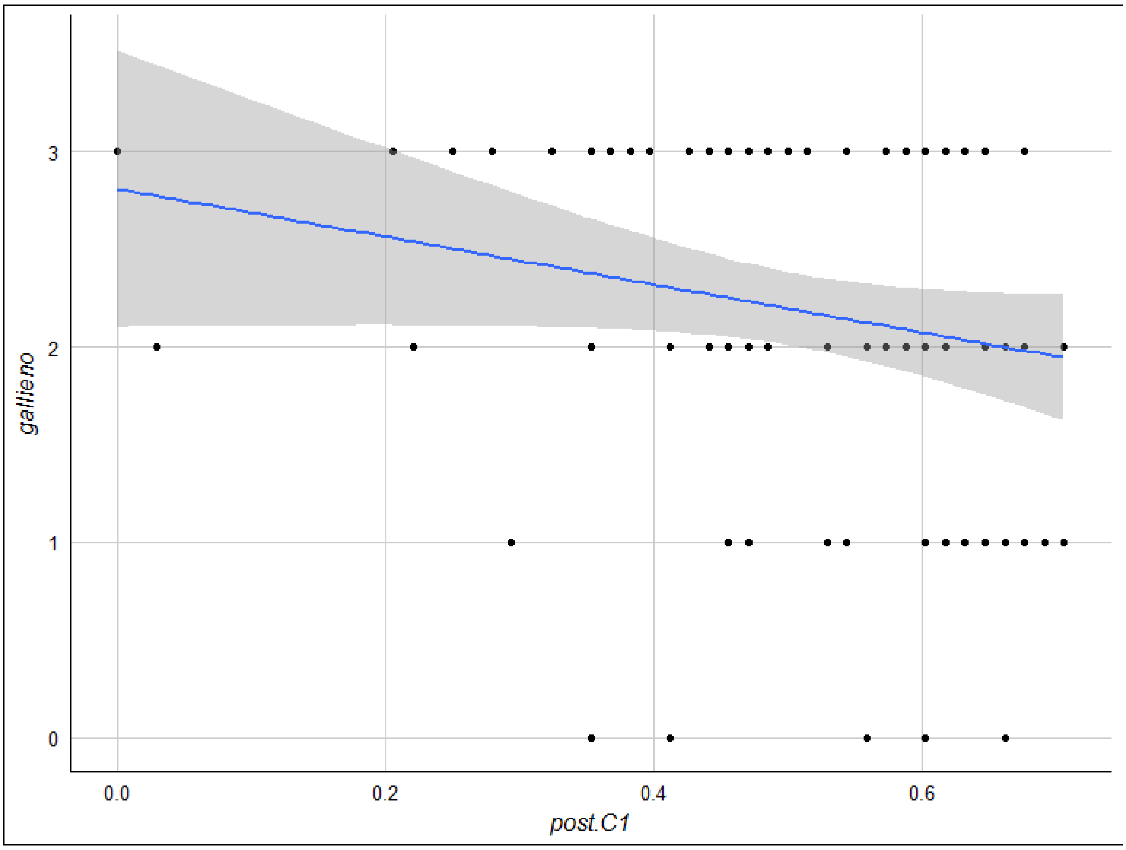
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	56.686	1.933	0.170
Tipo	1	56.816	2.975	0.090
pre.C1	1	54.842	3.370	0.072
pre.C2	1	56.514	1.897	0.174
pre.C3	1	55.748	0.128	0.722
pre.C4	1	51.444	0.674	0.416
pre.C5	1	57.159	0.094	0.760
pre.C7	1	56.688	1.016	0.318
post.C1	1	52.690	4.082	0.048
Sesso:Tipo	1	55.848	0.542	0.465
Sesso:pre.C1	1	55.754	1.131	0.292
Sesso:pre.C2	1	56.197	0.446	0.507
Sesso:pre.C3	1	55.639	0.348	0.557
Sesso:pre.C4	1	55.737	0.200	0.657
Sesso:pre.C5	1	56.070	0.140	0.710
Sesso:pre.C7	1	56.787	0.002	0.963
Sesso:post.C1	1	56.351	0.502	0.481
Tipo:pre.C1	1	54.535	0.297	0.588
Tipo:pre.C2	1	56.806	5.388	0.024
Tipo:pre.C3	1	56.672	1.608	0.210
Tipo:pre.C4	1	56.777	0.331	0.567
Tipo:pre.C5	1	57.459	5.104	0.028
Tipo:pre.C7	1	56.404	2.698	0.106
Tipo:post.C1	1	55.639	0.167	0.684
Sesso:Tipo:pre.C1	1	53.915	1.456	0.233
Sesso:Tipo:pre.C2	1	56.710	0.036	0.849
Sesso:Tipo:pre.C3	1	56.773	0.131	0.719
Sesso:Tipo:pre.C4	1	56.579	1.803	0.185
Sesso:Tipo:pre.C5	1	56.102	0.651	0.423
Sesso:Tipo:pre.C7	1	56.469	0.360	0.551
Sesso:Tipo:post.C1	1	57.013	0.808	0.372

Risulta significativo:

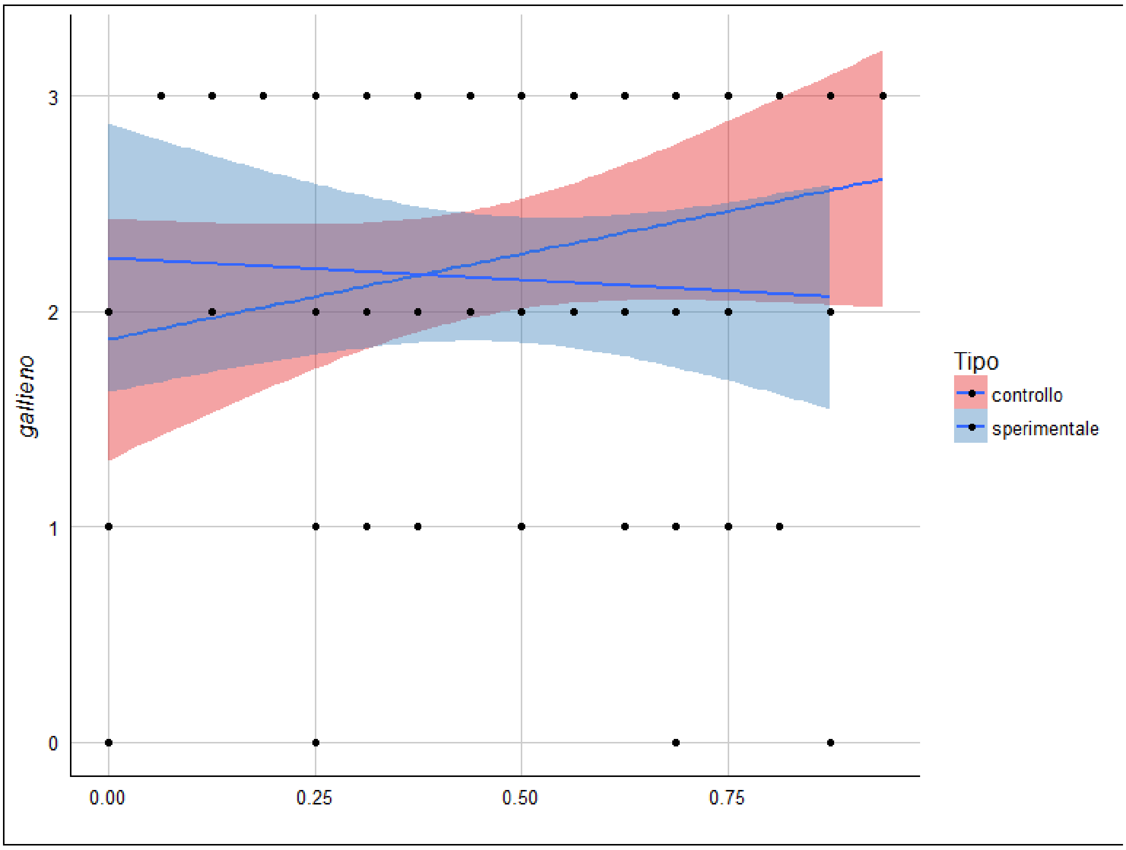
- post.C1
- Tipo:pre.C2
- Tipo:pre.C5

post.C1



Il coefficiente angolare di questo risultato Ã¨ di -1.71.

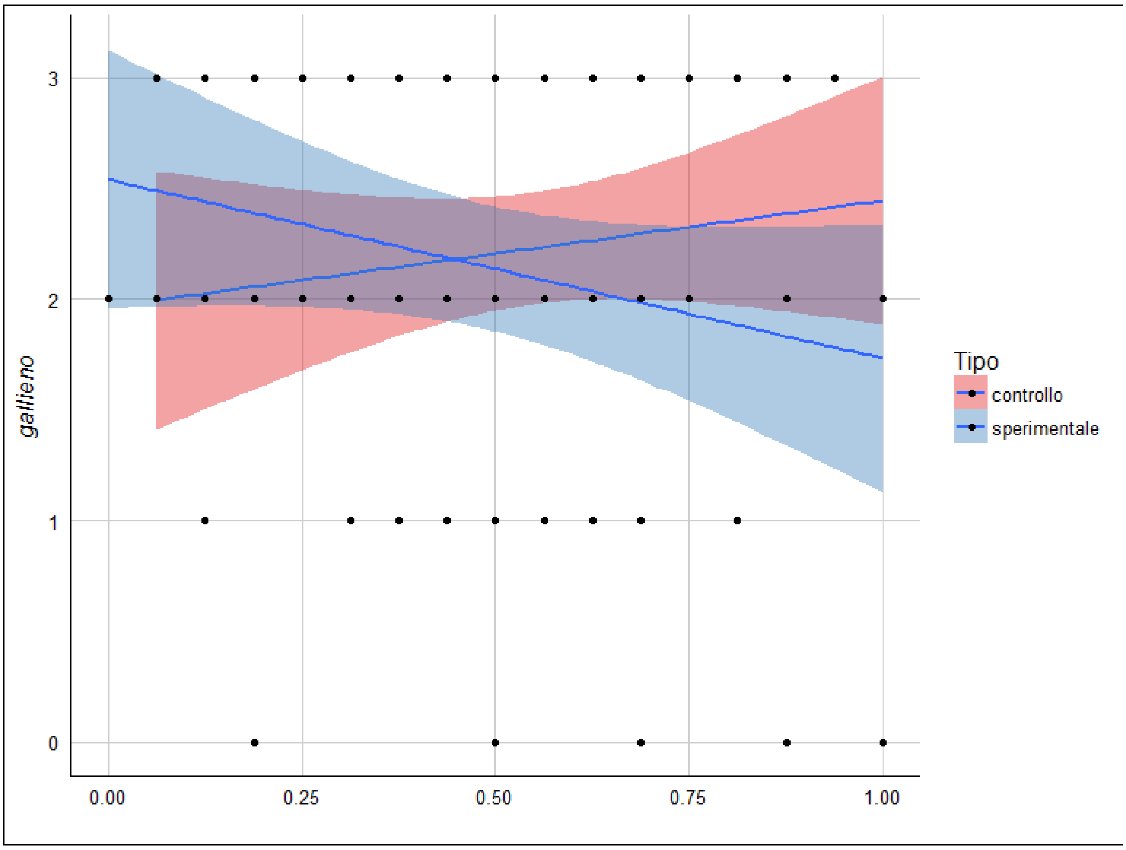
Tipo:pre.C2



Coefficienti Angolari

Tipo	pre.C2.trend	SE	df	lower.CL	upper.CL
controllo	1.693	0.635	56.763	0.420	2.965
sperimentale	-0.417	0.662	55.140	-1.743	0.908

Tipo:pre.C5



Coefficienti Angolari

Tipo	pre.C5.trend	SE	df	lower.CL	upper.CL
controllo	0.802	0.544	55.393	-0.289	1.892
sperimentale	-1.053	0.615	56.718	-2.287	0.180

Punteggio Porta Leoni

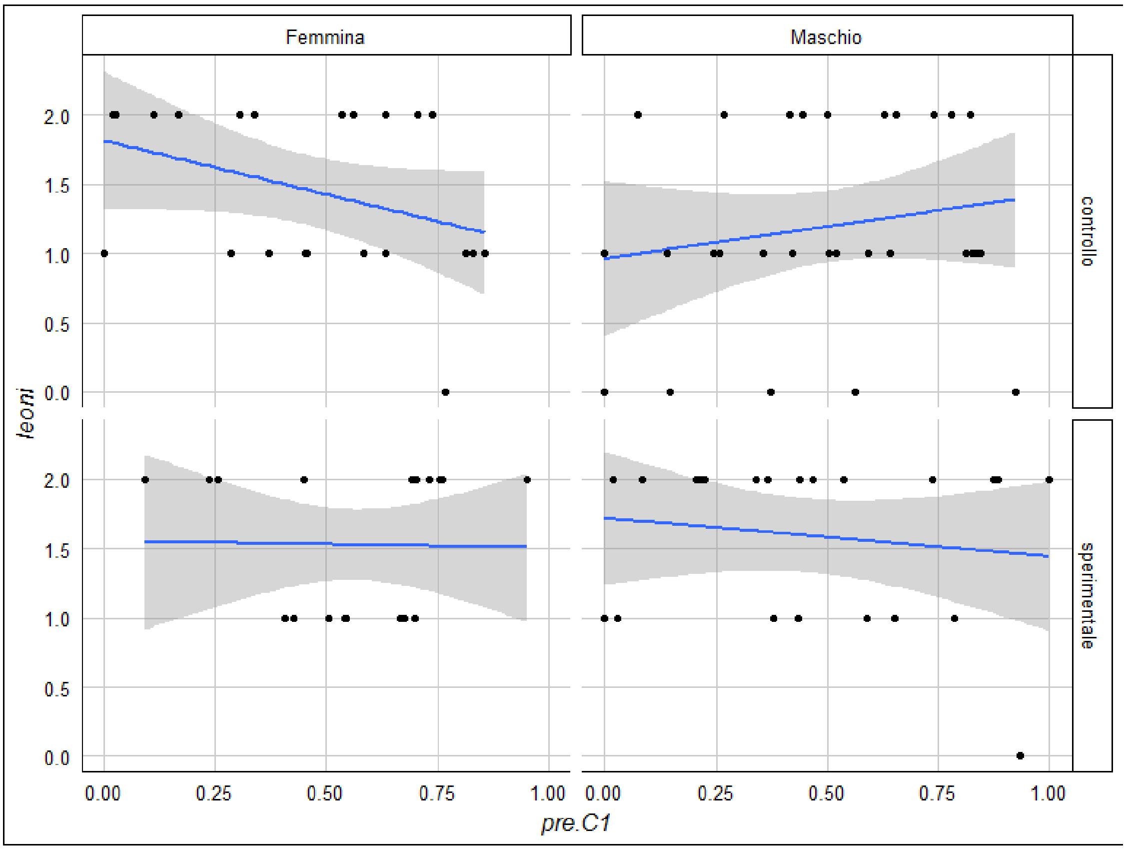
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	55.561	2.811	0.099
Tipo	1	57.007	0.806	0.373
pre.C1	1	56.137	0.709	0.403
pre.C2	1	57.701	0.074	0.786
pre.C3	1	55.923	0.436	0.512
pre.C4	1	54.660	0.661	0.420
pre.C5	1	56.790	3.505	0.066
pre.C7	1	57.046	0.895	0.348
post.C1	1	55.950	1.979	0.165
Sesso:Tipo	1	56.673	0.257	0.614
Sesso:pre.C1	1	56.049	0.009	0.923

Sesso:pre.C2	1	56.877	1.275	0.264
Sesso:pre.C3	1	56.835	0.944	0.335
Sesso:pre.C4	1	57.141	3.566	0.064
Sesso:pre.C5	1	56.658	2.377	0.129
Sesso:pre.C7	1	57.062	0.378	0.541
Sesso:post.C1	1	57.122	0.134	0.716
Tipo:pre.C1	1	56.792	0.020	0.888
Tipo:pre.C2	1	57.167	0.223	0.638
Tipo:pre.C3	1	57.945	0.266	0.608
Tipo:pre.C4	1	56.901	0.001	0.971
Tipo:pre.C5	1	57.259	1.064	0.307
Tipo:pre.C7	1	57.416	1.056	0.308
Tipo:post.C1	1	57.017	0.573	0.452
Sesso:Tipo:pre.C1	1	55.957	4.578	0.037
Sesso:Tipo:pre.C2	1	57.181	0.017	0.898
Sesso:Tipo:pre.C3	1	57.485	0.308	0.581
Sesso:Tipo:pre.C4	1	56.899	0.111	0.740
Sesso:Tipo:pre.C5	1	56.999	0.176	0.676
Sesso:Tipo:pre.C7	1	57.087	0.016	0.901
Sesso:Tipo:post.C1	1	56.810	0.077	0.782

Sesso:Tipo:pre.C1 Ã¨ significativo.

Sesso:Tipo:pre.C1



Coefficienti angolari

Tipo	Sesso	pre.C1.trend	SE	df	lower.CL	upper.CL
controllo	Femmina	-0.906	0.654	56.884	-2.216	0.405
sperimentale	Femmina	0.414	0.764	52.969	-1.115	1.944
controllo	Maschio	0.443	0.499	57.137	-0.557	1.442
sperimentale	Maschio	-1.061	0.681	54.210	-2.425	0.302

Contrasti pairwise corretti Tukey

contrast	estimate	SE	df	t.ratio	p.value
controllo,Femmina - sperimentale,Femmina	-1.320	0.999	56.340	-1.321	0.554
controllo,Femmina - controllo,Maschio	-1.348	0.821	56.789	-1.643	0.363
controllo,Femmina - sperimentale,Maschio	0.156	0.947	56.132	0.164	0.998
sperimentale,Femmina - controllo,Maschio	-0.028	0.901	55.850	-0.031	1.000
sperimentale,Femmina - sperimentale,Maschio	1.475	1.032	54.754	1.430	0.486
controllo,Maschio - sperimentale,Maschio	1.504	0.845	55.280	1.780	0.294

Nonostante l'interazione sia significativa, le analisi a posteriori non mostrano alcuna differenza, am olo una tendenza fra sperimentale e congtrollo maschio e fra maschio e femmina nel gruppo di controllo.

Punteggio Piazza Erbe

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	58.393	0.026	0.873
Tipo	1	57.891	1.080	0.303
pre.C1	1	58.754	0.060	0.807
pre.C2	1	58.894	0.160	0.691
pre.C3	1	57.483	3.620	0.062
pre.C4	1	57.456	0.011	0.915
pre.C5	1	58.474	0.479	0.491
pre.C7	1	57.470	0.015	0.902
post.C1	1	56.271	0.032	0.859
Sesso:Tipo	1	57.728	0.205	0.652
Sesso:pre.C1	1	57.723	0.546	0.463
Sesso:pre.C2	1	57.519	0.575	0.451
Sesso:pre.C3	1	57.224	2.114	0.151
Sesso:pre.C4	1	57.119	0.494	0.485
Sesso:pre.C5	1	57.079	0.055	0.816
Sesso:pre.C7	1	57.644	0.563	0.456
Sesso:post.C1	1	57.035	0.211	0.648
Tipo:pre.C1	1	57.528	0.273	0.603
Tipo:pre.C2	1	57.730	0.221	0.640
Tipo:pre.C3	1	58.100	0.001	0.972
Tipo:pre.C4	1	58.537	0.997	0.322
Tipo:pre.C5	1	57.395	0.161	0.689
Tipo:pre.C7	1	57.799	2.290	0.136
Tipo:post.C1	1	57.428	0.563	0.456
Sesso:Tipo:pre.C1	1	57.311	0.532	0.469
Sesso:Tipo:pre.C2	1	57.919	3.361	0.072
Sesso:Tipo:pre.C3	1	56.737	2.314	0.134
Sesso:Tipo:pre.C4	1	59.102	0.413	0.523
Sesso:Tipo:pre.C5	1	57.487	0.256	0.615
Sesso:Tipo:pre.C7	1	58.486	1.444	0.234
Sesso:Tipo:post.C1	1	58.066	0.023	0.881

Nulla di significativo.

Punteggio Piazza dei Signori

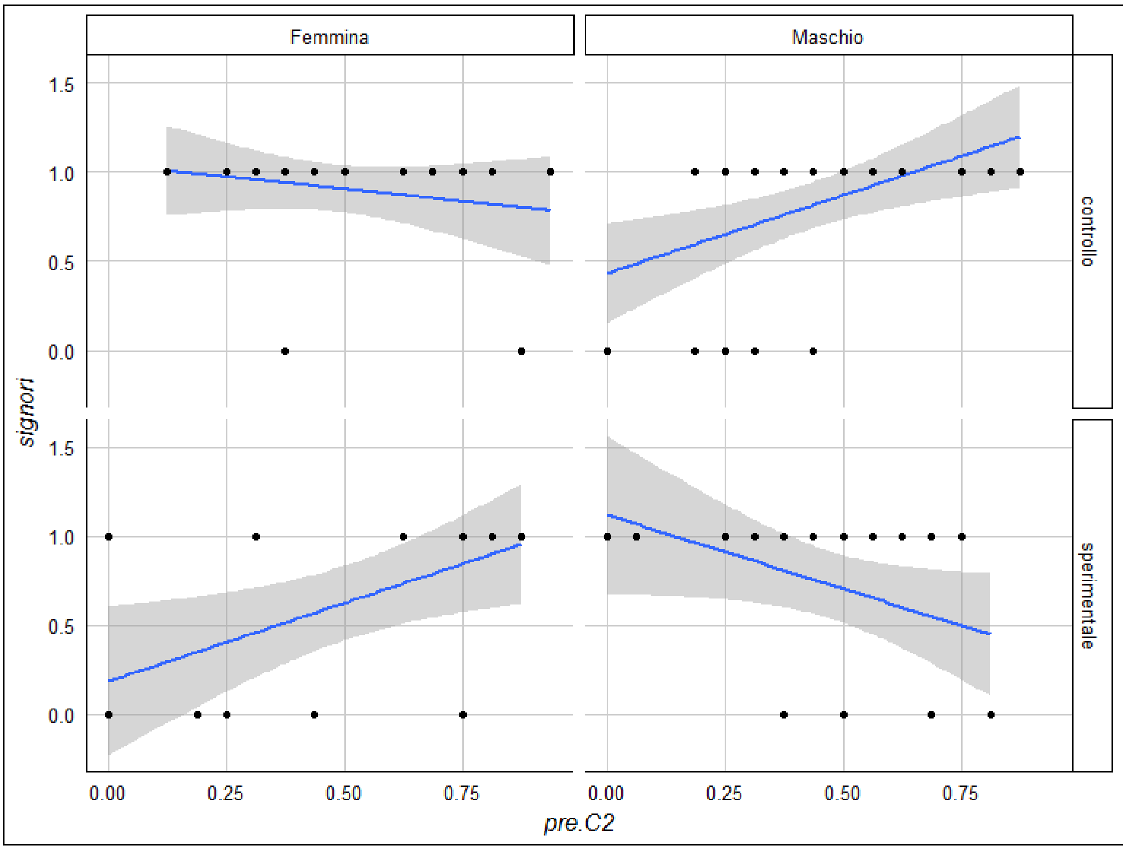
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	55.667	0.631	0.430
Tipo	1	56.558	0.756	0.388
pre.C1	1	55.818	0.569	0.454
pre.C2	1	55.348	0.540	0.466
pre.C3	1	53.962	0.047	0.829
pre.C4	1	52.144	0.661	0.420
pre.C5	1	55.966	0.130	0.719
pre.C7	1	55.791	1.964	0.167
post.C1	1	53.771	1.091	0.301
Sesso:Tipo	1	56.456	2.797	0.100
Sesso:pre.C1	1	55.184	2.088	0.154
Sesso:pre.C2	1	54.828	0.137	0.713
Sesso:pre.C3	1	54.345	0.022	0.883
Sesso:pre.C4	1	54.360	0.145	0.705
Sesso:pre.C5	1	56.362	0.061	0.806
Sesso:pre.C7	1	54.958	2.379	0.129
Sesso:post.C1	1	54.023	0.211	0.648
Tipo:pre.C1	1	56.714	0.460	0.501
Tipo:pre.C2	1	56.144	1.677	0.201
Tipo:pre.C3	1	55.423	0.285	0.596
Tipo:pre.C4	1	56.262	0.116	0.735
Tipo:pre.C5	1	57.008	0.161	0.689
Tipo:pre.C7	1	54.882	1.059	0.308
Tipo:post.C1	1	55.010	0.855	0.359
Sesso:Tipo:pre.C1	1	53.660	0.435	0.512
Sesso:Tipo:pre.C2	1	55.376	13.214	0.001
Sesso:Tipo:pre.C3	1	54.199	1.050	0.310
Sesso:Tipo:pre.C4	1	56.541	0.221	0.640
Sesso:Tipo:pre.C5	1	56.277	0.269	0.606
Sesso:Tipo:pre.C7	1	56.154	1.714	0.196
Sesso:Tipo:post.C1	1	56.489	0.371	0.545

Risulta significativa l'interazione a tre vie: Sesso:Tipo:pre.C2

Sesso:Tipo:pre.C2

Questa interazione appare significativa.



Coefficienti ANgolari

Tipo	Sesso	pre.C2.trend	SE	df	lower.CL	upper.CL
controllo	Femmina	-0.593	0.434	53.879	-1.463	0.277
sperimentale	Femmina	0.428	0.417	54.666	-0.408	1.265
controllo	Maschio	0.836	0.403	54.757	0.028	1.644
sperimentale	Maschio	-1.319	0.487	57.134	-2.295	-0.343

Contrasti pairwise corretti Tukey

contrast	estimate	SE	df	t.ratio	p.value
controllo,Femmina - sperimentale,Femmina	-1.021	0.596	54.082	-1.713	0.327
controllo,Femmina - controllo,Maschio	-1.429	0.593	54.654	-2.408	0.087
controllo,Femmina - sperimentale,Maschio	0.726	0.644	55.701	1.127	0.675
sperimentale,Femmina - controllo,Maschio	-0.407	0.582	54.885	-0.700	0.897
sperimentale,Femmina - sperimentale,Maschio	1.747	0.632	55.285	2.763	0.038
controllo,Maschio - sperimentale,Maschio	2.155	0.640	57.513	3.367	0.007

La differenza fra maschi del gruppo sperimentale e del gruppo di controllo maschio Ã¨ significativa, come quello fra i due gruppi di controllo maschiio e femmina ed i due gruppi sperimentali maschio e femmina.

Punteggio Teatro

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	58.362	0.086	0.771
Tipo	1	58.181	0.442	0.509
pre.C1	1	57.408	2.406	0.126
pre.C2	1	57.921	0.171	0.680
pre.C3	1	54.662	0.243	0.624
pre.C4	1	56.728	0.201	0.656
pre.C5	1	57.637	0.363	0.549
pre.C7	1	57.424	0.000	0.996
post.C1	1	54.311	0.102	0.750
Sesso:Tipo	1	56.293	0.190	0.664
Sesso:pre.C1	1	57.965	0.050	0.823
Sesso:pre.C2	1	57.603	0.972	0.328
Sesso:pre.C3	1	56.401	0.499	0.483
Sesso:pre.C4	1	56.920	0.006	0.940
Sesso:pre.C5	1	57.633	0.611	0.438
Sesso:pre.C7	1	56.658	0.003	0.955
Sesso:post.C1	1	56.699	0.073	0.788
Tipo:pre.C1	1	57.306	0.628	0.431
Tipo:pre.C2	1	59.049	0.585	0.447
Tipo:pre.C3	1	57.095	0.411	0.524
Tipo:pre.C4	1	57.844	0.001	0.981
Tipo:pre.C5	1	58.251	0.566	0.455
Tipo:pre.C7	1	57.173	2.927	0.093
Tipo:post.C1	1	57.070	0.077	0.783
Sesso:Tipo:pre.C1	1	57.550	0.682	0.412
Sesso:Tipo:pre.C2	1	57.589	1.621	0.208
Sesso:Tipo:pre.C3	1	58.067	1.058	0.308
Sesso:Tipo:pre.C4	1	56.795	0.219	0.642
Sesso:Tipo:pre.C5	1	57.260	0.031	0.861
Sesso:Tipo:pre.C7	1	57.289	1.272	0.264
Sesso:Tipo:post.C1	1	56.678	0.814	0.371

Nessun confronto risulta significativo.

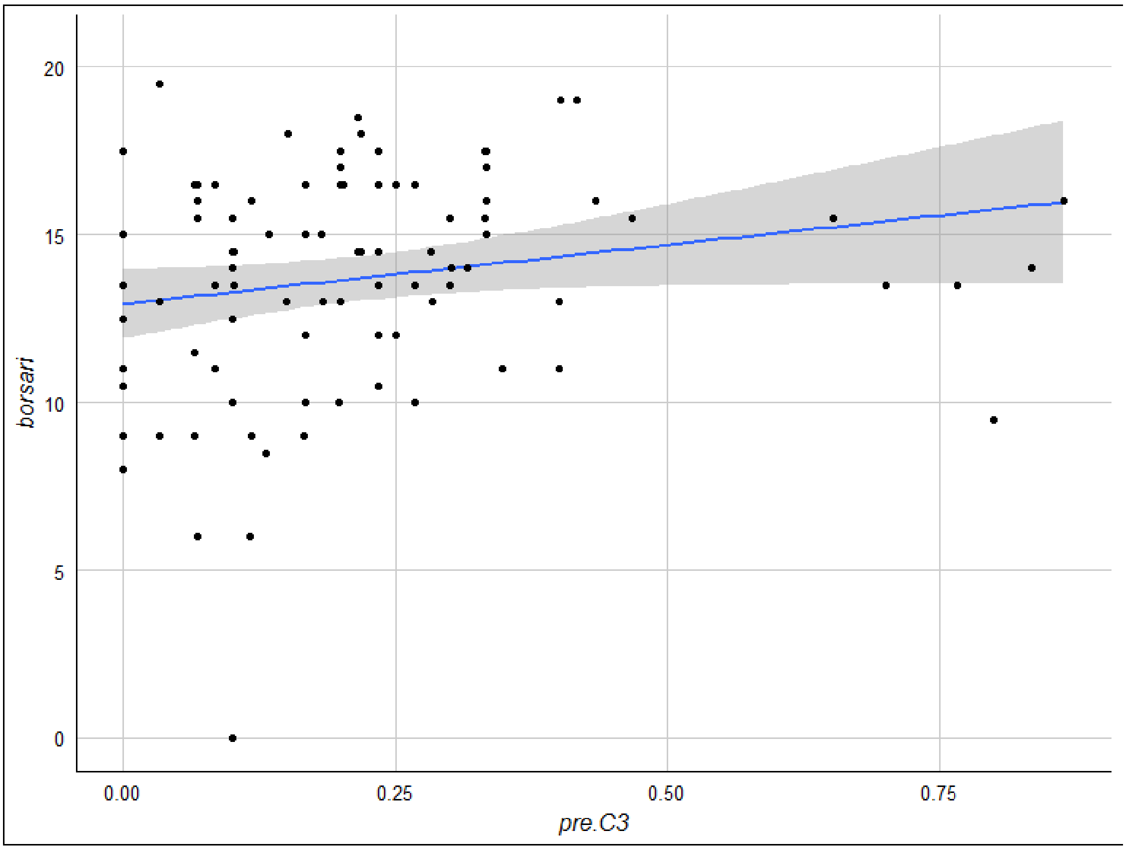
Punteggio Borsari

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	57.050	0.015	0.902

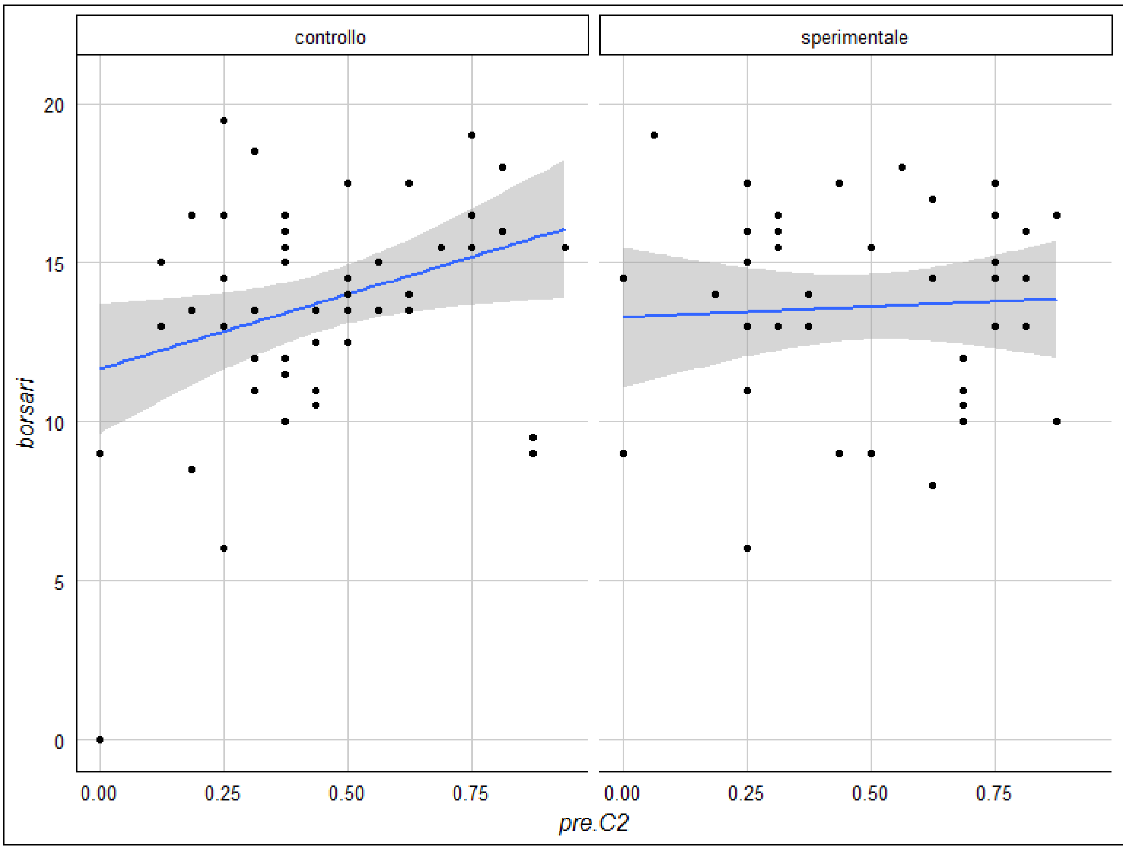
Tipo	1	56.342	1.478	0.229
pre.C1	1	56.051	0.066	0.798
pre.C2	1	57.131	0.000	0.995
pre.C3	1	57.093	5.858	0.019
pre.C4	1	52.776	0.007	0.935
pre.C5	1	55.650	3.770	0.057
pre.C7	1	55.609	0.895	0.348
post.C1	1	52.099	0.108	0.744
Sesso:Tipo	1	54.278	0.658	0.421
Sesso:pre.C1	1	54.826	0.003	0.955
Sesso:pre.C2	1	55.484	0.076	0.784
Sesso:pre.C3	1	56.135	0.520	0.474
Sesso:pre.C4	1	56.572	0.018	0.895
Sesso:pre.C5	1	55.345	0.808	0.372
Sesso:pre.C7	1	56.048	0.167	0.684
Sesso:post.C1	1	54.592	0.019	0.890
Tipo:pre.C1	1	55.838	0.001	0.980
Tipo:pre.C2	1	56.434	5.213	0.026
Tipo:pre.C3	1	58.201	0.601	0.441
Tipo:pre.C4	1	56.354	0.007	0.932
Tipo:pre.C5	1	56.653	2.376	0.129
Tipo:pre.C7	1	56.267	0.133	0.717
Tipo:post.C1	1	55.309	0.015	0.901
Sesso:Tipo:pre.C1	1	54.641	0.038	0.847
Sesso:Tipo:pre.C2	1	56.666	3.605	0.063
Sesso:Tipo:pre.C3	1	55.709	1.961	0.167
Sesso:Tipo:pre.C4	1	56.587	1.966	0.166
Sesso:Tipo:pre.C5	1	56.519	1.038	0.313
Sesso:Tipo:pre.C7	1	55.674	0.396	0.532
Sesso:Tipo:post.C1	1	55.591	0.407	0.526

Effetti significativi: - pre.C3 - Tipo:pre.C2 pre.C3



Il coefficiente angolare Ã¨ di 8.838.

Tipo:pre.C2



Coefficienti angolari

Tipo	pre.C2.trend	SE	df	lower.CL	upper.CL
controllo	3.945	2.386	56.367	-0.833	8.724
sperimentale	-3.924	2.537	55.977	-9.007	1.158

Punteggio Gavi

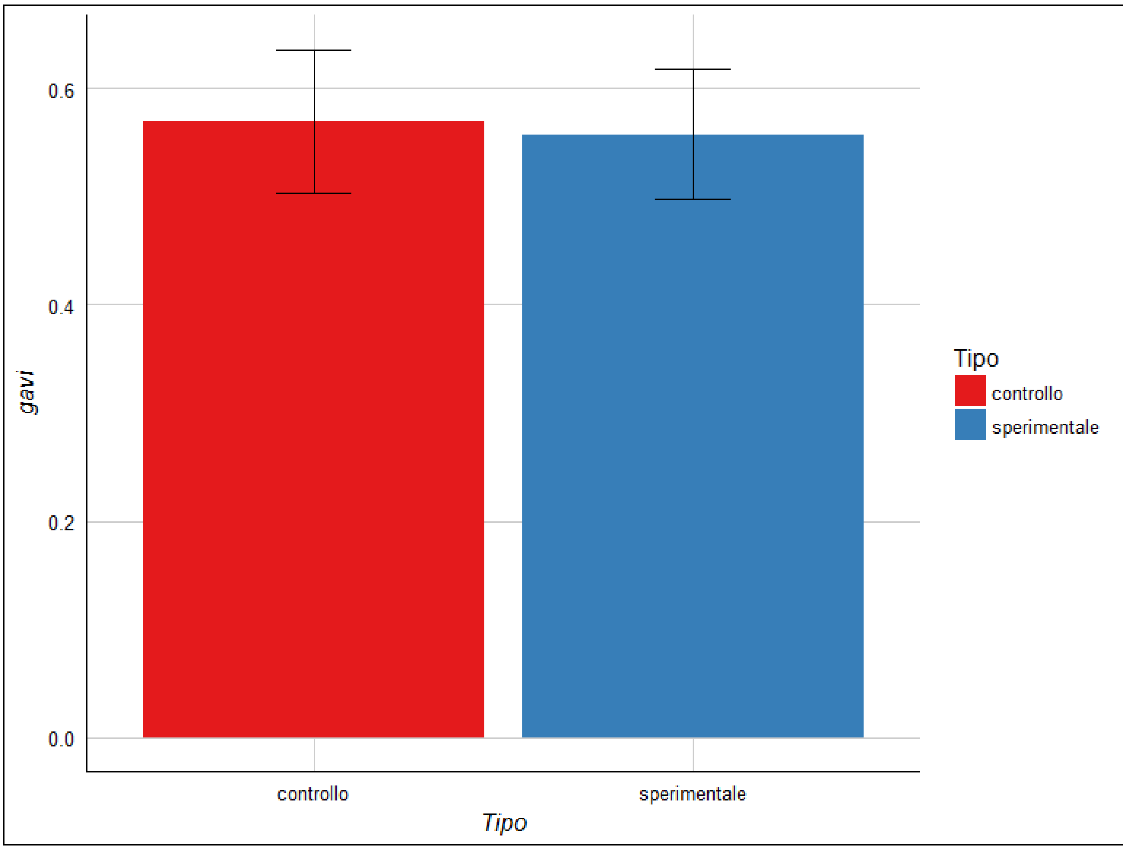
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	59.469	0.050	0.824
Tipo	1	58.080	4.191	0.045
pre.C1	1	57.995	0.019	0.890
pre.C2	1	59.403	0.590	0.445
pre.C3	1	58.584	0.020	0.888
pre.C4	1	57.426	0.015	0.904
pre.C5	1	58.144	0.416	0.522
pre.C7	1	58.284	0.053	0.818
post.C1	1	55.340	2.703	0.106
Sesso:Tipo	1	57.925	2.535	0.117
Sesso:pre.C1	1	56.086	0.206	0.652

Sesso:pre.C2	1	58.978	0.308	0.581
Sesso:pre.C3	1	58.338	1.378	0.245
Sesso:pre.C4	1	57.610	1.547	0.219
Sesso:pre.C5	1	58.279	2.046	0.158
Sesso:pre.C7	1	58.292	0.064	0.802
Sesso:post.C1	1	56.572	0.029	0.865
Tipo:pre.C1	1	58.239	1.578	0.214
Tipo:pre.C2	1	58.331	0.064	0.801
Tipo:pre.C3	1	59.523	1.221	0.274
Tipo:pre.C4	1	58.061	1.383	0.244
Tipo:pre.C5	1	57.898	0.919	0.342
Tipo:pre.C7	1	58.411	0.539	0.466
Tipo:post.C1	1	58.086	1.967	0.166
Sesso:Tipo:pre.C1	1	57.334	0.001	0.978
Sesso:Tipo:pre.C2	1	58.456	0.354	0.554
Sesso:Tipo:pre.C3	1	58.315	0.678	0.414
Sesso:Tipo:pre.C4	1	58.910	8.051	0.006
Sesso:Tipo:pre.C5	1	58.254	0.040	0.843
Sesso:Tipo:pre.C7	1	58.347	0.250	0.619
Sesso:Tipo:post.C1	1	58.324	0.800	0.375

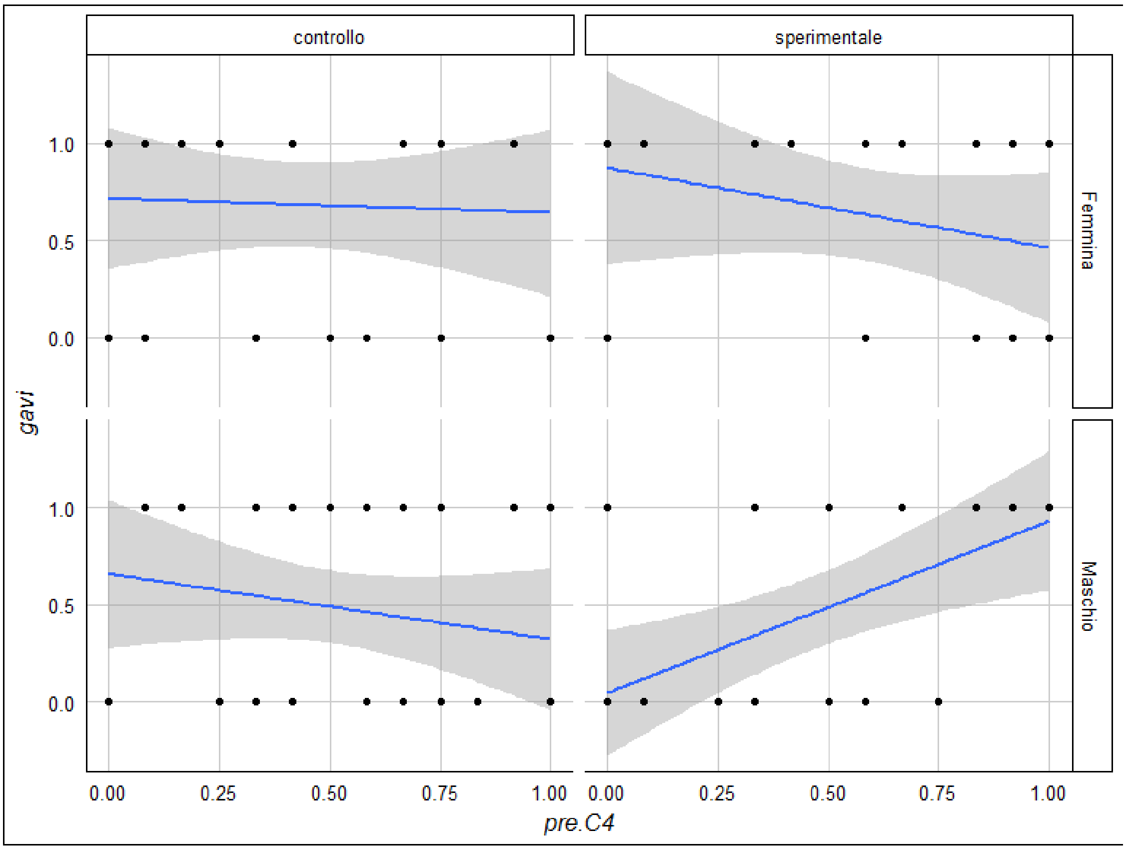
Tipo e Sesso:Tipo:pre.C4 risulta significativo.

Tipo



Tipo	gavi
controllo	0.57 (0.5)
sperimentale	0.56 (0.5)

Sesso:Tipo:pre.C4



Coefficienti angolari

Tipo	Sesso	pre.C4.trend	SE	df	lower.CL	upper.CL
controllo	Femmina	0.053	0.419	57.912	-0.786	0.892
sperimentale	Femmina	-0.664	0.474	58.616	-1.613	0.284
controllo	Maschio	-0.608	0.404	55.694	-1.418	0.202
sperimentale	Maschio	1.115	0.434	57.688	0.247	1.983

Analisi a posteriori

contrast	estimate	SE	df	t.ratio	p.value
controllo,Femmina - sperimentale,Femmina	0.718	0.620	58.731	1.158	0.655
controllo,Femmina - controllo,Maschio	0.661	0.597	55.138	1.109	0.686
controllo,Femmina - sperimentale,Maschio	-1.062	0.613	58.261	-1.732	0.317
sperimentale,Femmina - controllo,Maschio	-0.056	0.627	57.671	-0.090	1.000
sperimentale,Femmina - sperimentale,Maschio	-1.780	0.647	58.511	-2.752	0.038
controllo,Maschio - sperimentale,Maschio	-1.723	0.592	56.846	-2.908	0.026

Anche qui la differenza Ã¨ fra maschi sperimentale vs. controllo, ed inoltre fra i due gruppi sperimentali maschio vs. femmina.

Punteggio Giove

Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.
Sesso	1	56.106	0.359	0.552
Tipo	1	57.420	0.129	0.720
pre.C1	1	56.376	0.217	0.643
pre.C2	1	56.803	0.027	0.870
pre.C3	1	56.414	0.040	0.841
pre.C4	1	53.541	0.452	0.504
pre.C5	1	56.424	0.279	0.599
pre.C7	1	56.112	0.487	0.488
post.C1	1	52.792	0.981	0.326
Sesso:Tipo	1	56.064	0.302	0.585
Sesso:pre.C1	1	56.392	0.048	0.828
Sesso:pre.C2	1	55.947	1.250	0.268
Sesso:pre.C3	1	55.370	0.028	0.868
Sesso:pre.C4	1	56.708	1.552	0.218
Sesso:pre.C5	1	56.443	0.035	0.853
Sesso:pre.C7	1	56.214	0.697	0.407
Sesso:post.C1	1	53.428	0.233	0.631
Tipo:pre.C1	1	55.560	0.186	0.668
Tipo:pre.C2	1	57.148	0.681	0.413
Tipo:pre.C3	1	55.242	0.236	0.629
Tipo:pre.C4	1	56.604	1.557	0.217
Tipo:pre.C5	1	57.206	0.554	0.460
Tipo:pre.C7	1	57.043	0.004	0.952
Tipo:post.C1	1	55.720	0.314	0.578
Sesso:Tipo:pre.C1	1	56.456	0.359	0.552
Sesso:Tipo:pre.C2	1	56.253	0.037	0.848
Sesso:Tipo:pre.C3	1	57.525	0.040	0.843
Sesso:Tipo:pre.C4	1	56.112	0.247	0.621
Sesso:Tipo:pre.C5	1	56.106	0.031	0.861
Sesso:Tipo:pre.C7	1	57.353	0.005	0.944
Sesso:Tipo:post.C1	1	55.332	0.485	0.489

Punteggio Organizzazione Romana

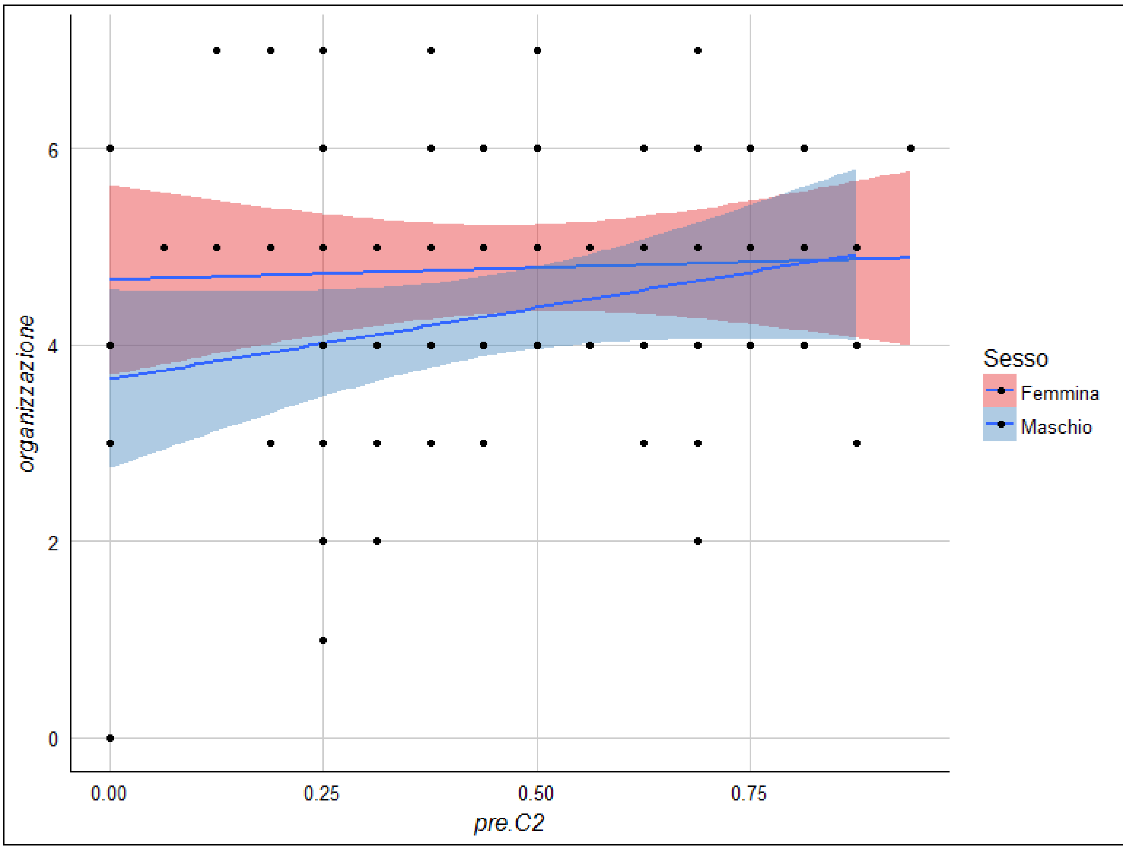
Fitting one lmer() model. [DONE] Calculating p-values. [DONE]

	num.Df	den.Df	F	Pr..F.

Sesso	1	57.741	0.059	0.810
Tipo	1	55.931	0.332	0.567
pre.C1	1	55.563	0.438	0.511
pre.C2	1	56.032	0.041	0.840
pre.C3	1	55.560	0.542	0.465
pre.C4	1	55.256	0.620	0.434
pre.C5	1	55.805	0.015	0.903
pre.C7	1	54.955	0.010	0.919
post.C1	1	51.458	0.240	0.626
Sesso:Tipo	1	54.328	0.026	0.873
Sesso:pre.C1	1	53.847	0.000	0.983
Sesso:pre.C2	1	55.959	4.351	0.042
Sesso:pre.C3	1	56.362	0.287	0.594
Sesso:pre.C4	1	53.540	0.019	0.891
Sesso:pre.C5	1	54.705	0.266	0.608
Sesso:pre.C7	1	55.716	0.322	0.573
Sesso:post.C1	1	55.630	1.192	0.280
Tipo:pre.C1	1	54.355	0.791	0.378
Tipo:pre.C2	1	56.030	0.028	0.868
Tipo:pre.C3	1	58.549	0.057	0.812
Tipo:pre.C4	1	56.903	1.160	0.286
Tipo:pre.C5	1	56.425	1.120	0.294
Tipo:pre.C7	1	55.631	4.003	0.050
Tipo:post.C1	1	54.555	0.205	0.653
Sesso:Tipo:pre.C1	1	54.048	0.673	0.415
Sesso:Tipo:pre.C2	1	56.479	0.284	0.596
Sesso:Tipo:pre.C3	1	53.671	1.014	0.318
Sesso:Tipo:pre.C4	1	56.460	0.315	0.577
Sesso:Tipo:pre.C5	1	56.281	1.070	0.305
Sesso:Tipo:pre.C7	1	54.995	0.757	0.388
Sesso:Tipo:post.C1	1	55.781	0.171	0.681

Sesso:pre.C2 e Tipo:pre.C7 risultano significativi.

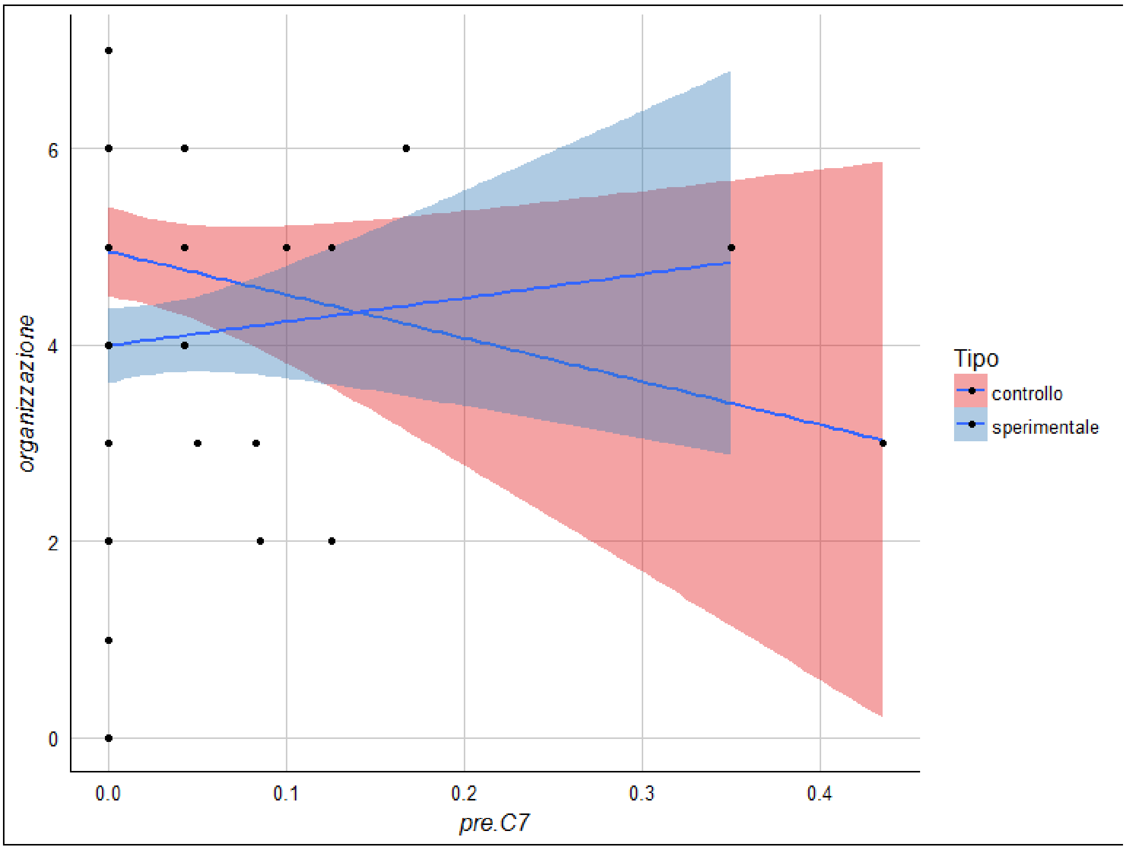
Sesso:pre.C2



Coefficienti Angolari

Sesso	pre.C2.trend	SE	df	lower.CL	upper.CL
Femmina	-1.405	1.081	56.370	-3.570	0.759
Maschio	1.715	1.057	55.743	-0.401	3.831

Tipo:pre.C7



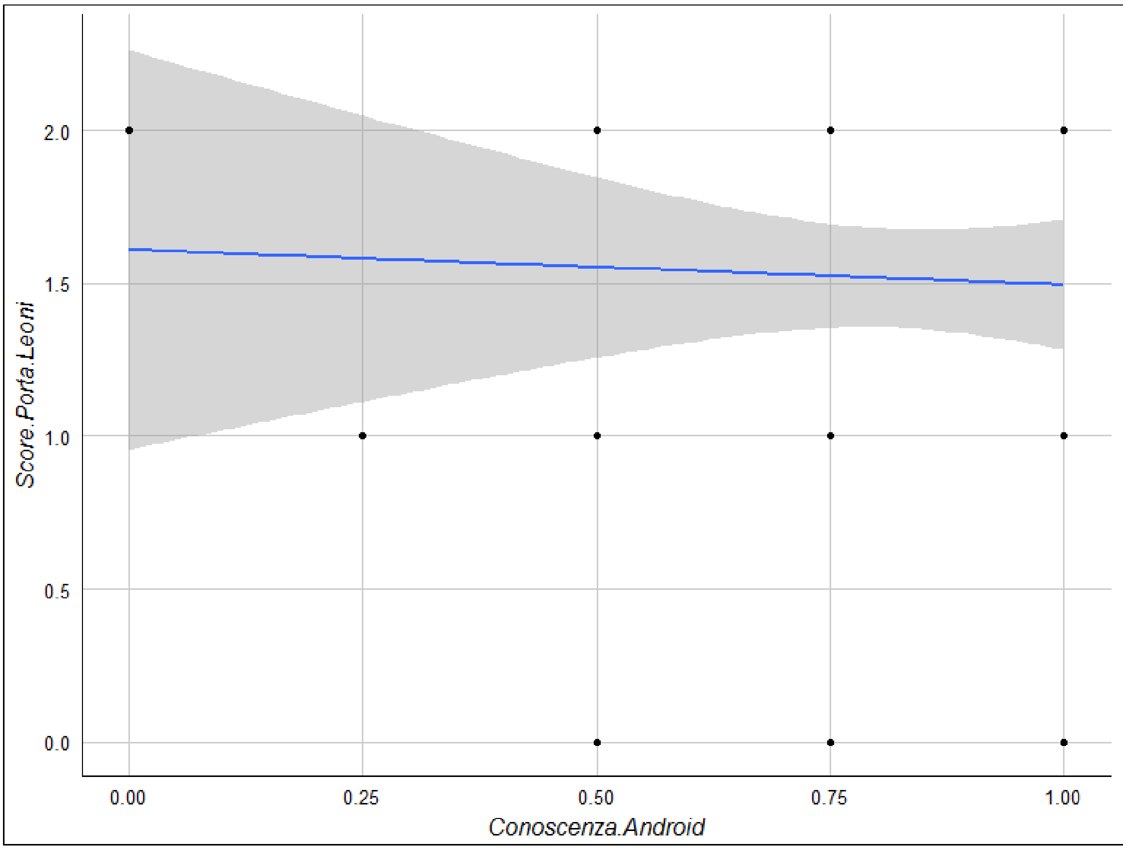
Coefficienti Angolari

Tipo	pre.C7.trend	SE	df	lower.CL	upper.CL
controllo	-9.707	5.275	56.144	-20.273	0.859
sperimentale	10.747	8.746	54.917	-6.772	28.266

Correlazioni solo nel gruppo sperimentale fra score e capacitÃ uso android

	rho	p
score	-0.057	0.654
arena	-0.025	0.846
gallieno	0.030	0.816
leoni	-0.037	0.769
erbe	-0.012	0.923
signori	0.014	0.912
teatro	-0.075	0.555
borsari	-0.128	0.315
gavi	-0.010	0.934
giove	-0.066	0.606
organizzazione	0.036	0.776

Abbiamo un trend su porta leoni con coefficiente positivo. Stampiamolo a schermo.



Medie e deviazioni standard varie

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso e scuola

Sesso	Scuola	Tipo	score	arena	gallieno	leoni	erbe	signori	teatro	borsari	gavi	giove	organizzazione
Femmina	camozzini	controllo	26.21 (3.92)	5.5 (1.45)	2.33 (0.78)	1.67 (0.49)	15.12 (2.23)	1 (0)	2.42 (0.9)	14.71 (2.71)	0.67 (0.49)	0.33 (0.49)	6.25 (0.62)
Maschio	camozzini	controllo	24.66 (3.88)	5.56 (0.96)	2.44 (0.73)	1.44 (0.63)	13.28 (2.86)	0.94 (0.25)	2.56 (0.81)	14.66 (2.6)	0.38 (0.5)	0.06 (0.25)	5.19 (1.11)
Femmina	dall'oca bianca	controllo	19.62 (6.57)	3.75 (2.5)	2 (1.15)	1.25 (0.5)	12.38 (4.27)	0.75 (0.5)	1.75 (0.96)	11.88 (2.78)	0.25 (0.5)	0.75 (0.5)	4.25 (1.5)
Maschio	dall'oca bianca	controllo	18.35 (7.97)	4.6 (2.5)	1.9 (1.1)	0.8 (0.63)	10.45 (4.47)	0.5 (0.53)	2 (1.25)	10.35 (4.87)	0.5 (0.53)	0.1 (0.32)	3.7 (1.95)

Femmina	rita rosani	controllo	23.75 (3)	5.5 (1.2)	1.88 (0.83)	1.25 (0.71)	13.25 (2.1)	0.88 (0.35)	2.38 (0.74)	14.38 (2.4)	0.88 (0.35)	0.25 (0.46)	5.12 (1.36)
Maschio	rita rosani	controllo	23.69 (6.47)	5.75 (1.98)	2.5 (1.07)	1.25 (0.71)	12.06 (4.03)	0.75 (0.46)	1.62 (1.19)	14.06 (4.44)	0.75 (0.46)	0.25 (0.46)	4 (1.69)
Femmina	camozzini	sperimentale	22.29 (4.24)	4.57 (1.13)	2.14 (1.07)	1.29 (0.76)	13 (3.28)	0.71 (0.49)	2.86 (0.38)	13.14 (2.95)	0.86 (0.38)	0.43 (0.53)	4.14 (1.07)
Maschio	camozzini	sperimentale	22.82 (4.22)	5.82 (1.54)	2 (0.77)	1.82 (0.4)	12.09 (1.93)	0.73 (0.47)	2 (1.1)	13.64 (2.59)	0.36 (0.5)	0 (0)	4.27 (0.9)
Femmina	dall'oca bianca	sperimentale	18.31 (5.65)	4.5 (2)	1.38 (0.74)	1.25 (0.71)	10.44 (3.4)	0.62 (0.52)	1.75 (0.71)	10.56 (4.29)	0.5 (0.53)	0.38 (0.52)	3.25 (1.16)
Maschio	dall'oca bianca	sperimentale	19.12 (5.72)	4.5 (1.41)	1.88 (1.13)	1 (0.76)	9.88 (3.31)	0.75 (0.46)	1.5 (0.76)	12 (3.63)	0.38 (0.52)	0.5 (0.53)	3.5 (1.2)
Femmina	rita rosani	sperimentale	24.66 (3.16)	5.95 (1.43)	2.84 (0.37)	1.68 (0.58)	13.03 (1.94)	0.58 (0.51)	2.68 (0.82)	14.66 (1.77)	0.47 (0.51)	0.11 (0.32)	4.32 (1)
Maschio	rita rosani	sperimentale	24.65 (3.9)	5.76 (1.48)	2.59 (0.71)	1.71 (0.47)	12.94 (2.02)	0.76 (0.44)	2.59 (1)	14.65 (2.63)	0.76 (0.44)	0 (0)	4.24 (1.15)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso e scuola

Sesso	Scuola	Tipo	pre. C1	pre. C2	pre. C3	pre. C4	pre. C5	pre. C6	pre. C7	pre. C8	pre. C9	post. C1
Femmina	camozzini	controllo	0.34 (0.27)	0.56 (0.23)	0.16 (0.13)	0.27 (0.3)	0.48 (0.27)	0.09 (0.09)	0.02 (0.05)	0.63 (0.12)	0.01 (0.03)	0.63 (0.03)
Maschio	camozzini	controllo	0.58 (0.26)	0.49 (0.21)	0.35 (0.3)	0.69 (0.2)	0.57 (0.21)	0.11 (0.12)	0.01 (0.02)	0.62 (0.33)	0.03 (0.11)	0.55 (0.09)
Femmina	dall'oca bianca	controllo	0.47 (0.41)	0.58 (0.26)	0.18 (0.12)	0.78 (0.21)	0.67 (0.28)	0.17 (0)	0 (0)	0.77 (0.24)	0 (0)	0.43 (0.06)

Maschio	dall'oca bianca	controllo	0.31 (0.23)	0.33 (0.24)	0.15 (0.09)	0.23 (0.21)	0.38 (0.23)	0.26 (0.1)	0 (0)	0.31 (0.33)	0 (0)	0.45 (0.1)
Femmina	rita rosani	controllo	0.62 (0.16)	0.34 (0.14)	0.19 (0.08)	0.55 (0.29)	0.56 (0.19)	0.29 (0.08)	0.01 (0.02)	0.8 (0.19)	0.09 (0.27)	0.47 (0.24)
Maschio	rita rosani	controllo	0.58 (0.23)	0.43 (0.25)	0.35 (0.28)	0.51 (0.29)	0.71 (0.15)	0.26 (0.17)	0.09 (0.16)	0.68 (0.23)	0 (0)	0.44 (0.16)
Femmina	camozzini	sperimentale	0.38 (0.22)	0.69 (0.21)	0.11 (0.07)	0.4 (0.21)	0.41 (0.19)	0.08 (0)	0 (0)	0.69 (0.39)	0 (0)	0.64 (0.05)
Maschio	camozzini	sperimentale	0.3 (0.23)	0.54 (0.23)	0.2 (0.14)	0.38 (0.35)	0.36 (0.3)	0.05 (0.06)	0.02 (0.03)	0.54 (0.28)	0 (0)	0.55 (0.13)
Femmina	dall'oca bianca	sperimentale	0.6 (0.23)	0.45 (0.36)	0.08 (0.08)	0.55 (0.43)	0.55 (0.22)	0.17 (0.11)	0.01 (0.02)	0.54 (0.29)	0 (0)	0.55 (0.12)
Maschio	dall'oca bianca	sperimentale	0.6 (0.35)	0.42 (0.25)	0.16 (0.16)	0.39 (0.31)	0.58 (0.32)	0.22 (0.26)	0.02 (0.05)	0.57 (0.36)	0 (0)	0.46 (0.05)
Femmina	rita rosani	sperimentale	0.66 (0.11)	0.47 (0.28)	0.18 (0.09)	0.79 (0.22)	0.49 (0.29)	0.18 (0.14)	0.03 (0.04)	0.28 (0.26)	0 (0)	0.4 (0.11)
Maschio	rita rosani	sperimentale	0.65 (0.33)	0.46 (0.23)	0.31 (0.1)	0.75 (0.28)	0.66 (0.28)	0.24 (0.09)	0.09 (0.15)	0.77 (0.3)	0.07 (0.07)	0.41 (0.23)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso

Sesso	score	arena	gallieno	leoni	erbe	signori	teatro	borsari	gavi	giove	organizzazione
Femmina	23.34 (4.72)	5.28 (1.63)	2.26 (0.87)	1.48 (0.63)	13.09 (2.85)	0.74 (0.44)	2.41 (0.84)	13.69 (2.99)	0.6 (0.49)	0.29 (0.46)	4.66 (1.4)
Maschio	22.72 (5.6)	5.41 (1.65)	2.27 (0.9)	1.4 (0.67)	12.08 (3.18)	0.76 (0.43)	2.17 (1.06)	13.51 (3.58)	0.53 (0.5)	0.11 (0.32)	4.27 (1.39)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso

Sesso	pre.C1	pre.C2	pre.C3	pre.C4	pre.C5	pre.C6	pre.C7	pre.C8	pre.C9	post.C1
Femmina	0.51 (0.25)	0.5 (0.26)	0.15 (0.1)	0.51 (0.34)	0.52 (0.24)	0.16 (0.12)	0.01 (0.03)	0.61 (0.28)	0.02 (0.12)	0.53 (0.15)

Maschio	0.49 (0.29)	0.45 (0.23)	0.26 (0.22)	0.5 (0.31)	0.53 (0.27)	0.17 (0.15)	0.03 (0.08)	0.57 (0.32)	0.01 (0.06)	0.49 (0.13)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per scuola

Scuola	score	arena	gallieno	leoni	erbe	signori	teatro	borsari	gavi	giove	organizzazione
camozzini	24.26 (4.16)	5.46 (1.29)	2.26 (0.8)	1.57 (0.58)	13.43 (2.73)	0.87 (0.34)	2.43 (0.89)	14.2 (2.66)	0.52 (0.51)	0.17 (0.38)	5.09 (1.23)
dall'oca bianca	18.72 (6.33)	4.43 (2.03)	1.77 (1.01)	1.03 (0.67)	10.55 (3.76)	0.63 (0.49)	1.77 (0.94)	11.05 (4.04)	0.43 (0.5)	0.37 (0.49)	3.6 (1.48)
rita rosani	24.37 (3.93)	5.79 (1.47)	2.56 (0.75)	1.56 (0.61)	12.88 (2.36)	0.71 (0.46)	2.44 (0.98)	14.52 (2.61)	0.67 (0.47)	0.12 (0.32)	4.37 (1.24)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per scuola

Scuola	pre.C1	pre.C2	pre.C3	pre.C4	pre.C5	pre.C6	pre.C7	pre.C8	pre.C9	post.C1
camozzini	0.42 (0.27)	0.54 (0.22)	0.23 (0.22)	0.47 (0.32)	0.48 (0.25)	0.09 (0.09)	0.01 (0.03)	0.61 (0.28)	0.01 (0.07)	0.58 (0.09)
dall'oca bianca	0.48 (0.3)	0.41 (0.28)	0.14 (0.11)	0.42 (0.34)	0.51 (0.26)	0.21 (0.15)	0.01 (0.03)	0.49 (0.34)	0 (0)	0.48 (0.1)
rita rosani	0.62 (0.2)	0.42 (0.22)	0.25 (0.17)	0.63 (0.28)	0.61 (0.23)	0.25 (0.13)	0.05 (0.11)	0.64 (0.31)	0.04 (0.15)	0.43 (0.18)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per tipo

Tipo	score	arena	gallieno	leoni	erbe	signori	teatro	borsari	gavi	giove	organizzazione
controllo	23.28 (5.75)	5.28 (1.71)	2.22 (0.9)	1.31 (0.65)	12.94 (3.47)	0.83 (0.38)	2.22 (0.99)	13.61 (3.63)	0.57 (0.5)	0.22 (0.42)	4.91 (1.58)
sperimentale	22.77 (4.75)	5.41 (1.58)	2.3 (0.87)	1.54 (0.63)	12.2 (2.66)	0.69 (0.47)	2.33 (0.96)	13.57 (3.05)	0.56 (0.5)	0.17 (0.38)	4.06 (1.1)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per tipo

Tipo	pre.C1	pre.C2	pre.C3	pre.C4	pre.C5	pre.C6	pre.C7	pre.C8	pre.C9	post.C1

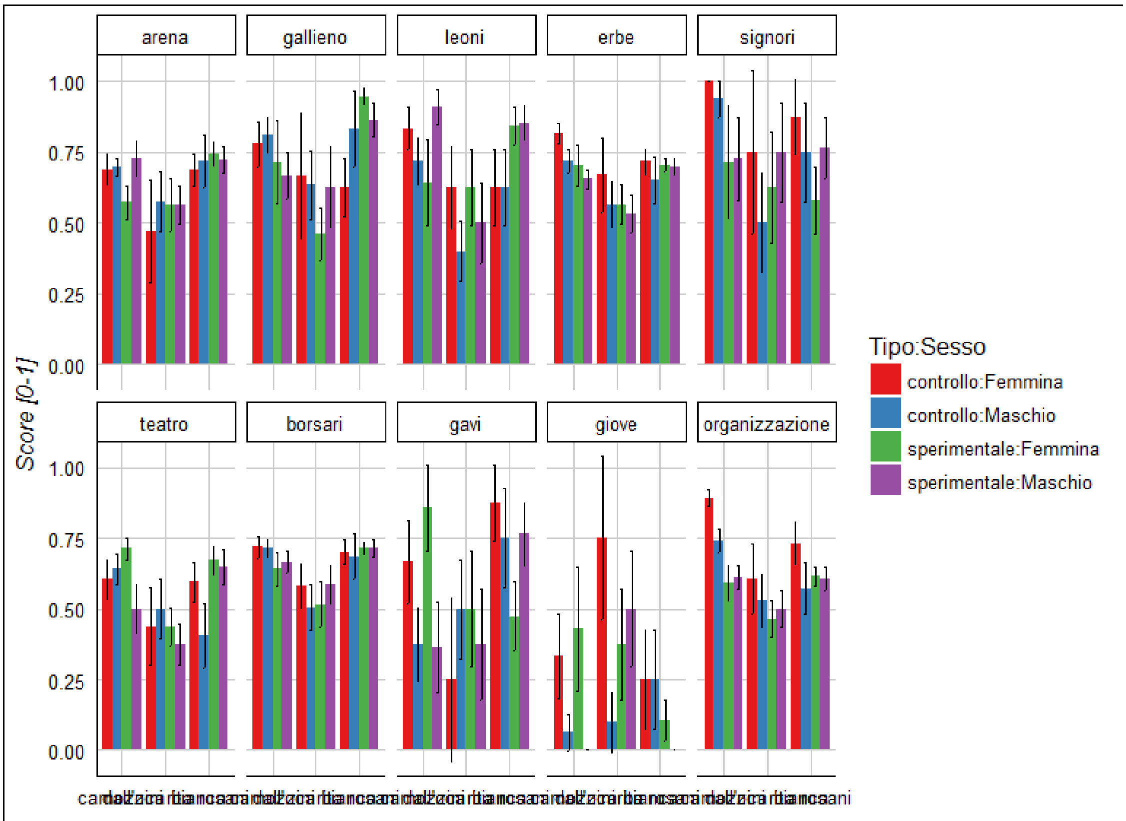
controllo	0.48 (0.27)	0.45 (0.23)	0.24 (0.22)	0.49 (0.31)	0.54 (0.23)	0.18 (0.14)	0.02 (0.07)	0.61 (0.29)	0.02 (0.12)	0.51 (0.14)
sperimentale	0.51 (0.28)	0.5 (0.26)	0.17 (0.13)	0.52 (0.34)	0.49 (0.28)	0.15 (0.14)	0.02 (0.06)	0.55 (0.32)	0.01 (0.03)	0.51 (0.14)

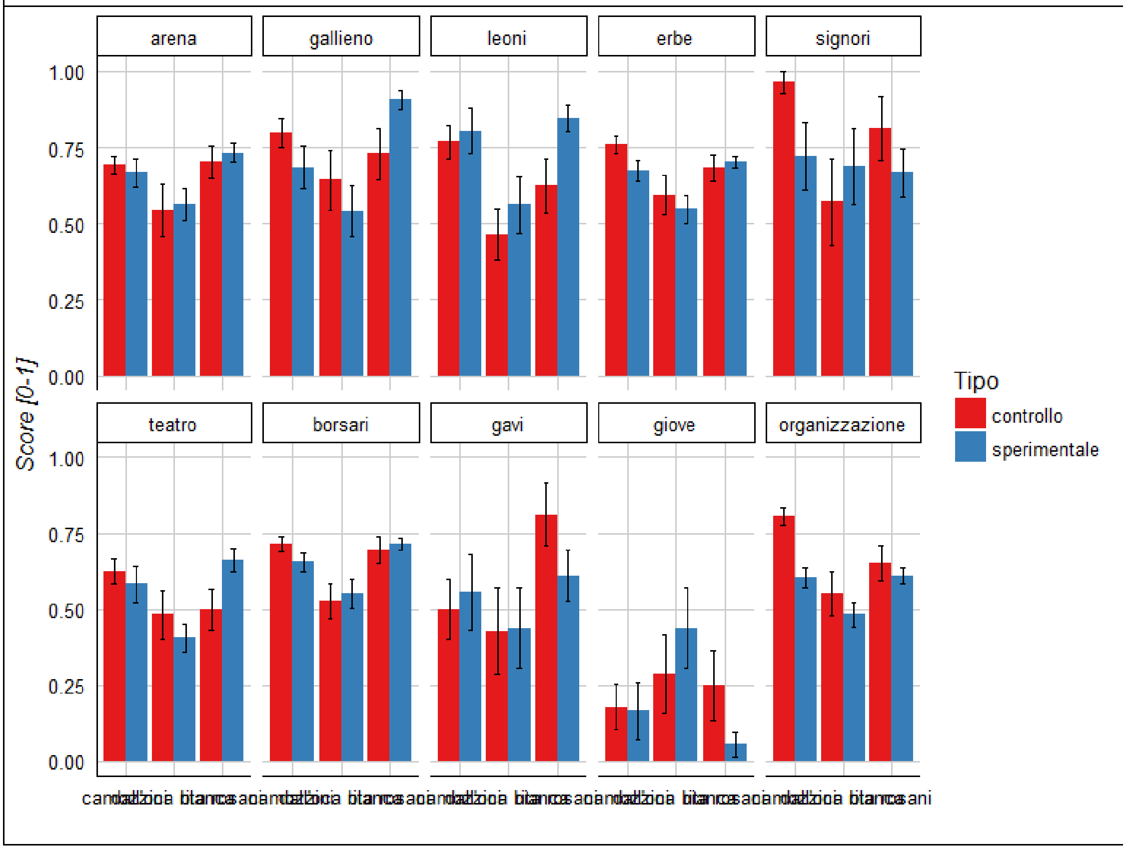
Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per tipo e sesso

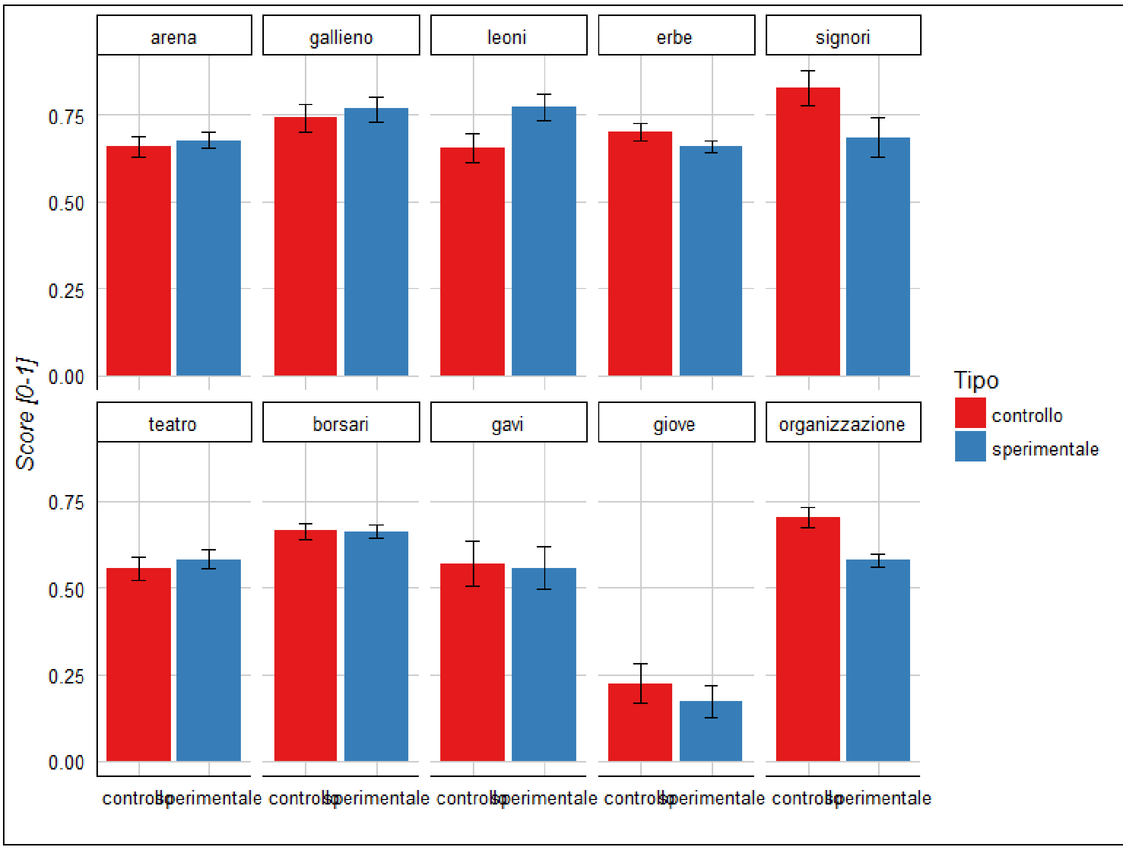
Tipo	Sesso	score	arena	gallieno	leoni	erbe	signori	teatro	borsari	gavi	giove	organizzazione
controllo	Femmina	24.29 (4.64)	5.21 (1.64)	2.12 (0.85)	1.46 (0.59)	14.04 (2.72)	0.92 (0.28)	2.29 (0.86)	14.12 (2.71)	0.67 (0.48)	0.38 (0.49)	5.54 (1.28)
sperimentale	Femmina	22.68 (4.73)	5.32 (1.65)	2.35 (0.88)	1.5 (0.66)	12.41 (2.77)	0.62 (0.49)	2.5 (0.83)	13.38 (3.17)	0.56 (0.5)	0.24 (0.43)	4.03 (1.11)
controllo	Maschio	22.57 (6.39)	5.32 (1.79)	2.29 (0.94)	1.21 (0.69)	12.16 (3.76)	0.76 (0.43)	2.18 (1.09)	13.25 (4.17)	0.5 (0.51)	0.12 (0.33)	4.47 (1.64)
sperimentale	Maschio	22.86 (4.83)	5.5 (1.54)	2.25 (0.87)	1.58 (0.6)	12 (2.57)	0.75 (0.44)	2.17 (1.06)	13.75 (2.97)	0.56 (0.5)	0.11 (0.32)	4.08 (1.11)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per tipo e sesso

Tipo	Sesso	pre.C1	pre.C2	pre.C3	pre.C4	pre.C5	pre.C6	pre.C7	pre.C8	pre.C9	post.C1
controllo	Femmina	0.46 (0.28)	0.48 (0.22)	0.17 (0.11)	0.44 (0.34)	0.53 (0.24)	0.18 (0.12)	0.01 (0.04)	0.71 (0.18)	0.04 (0.16)	0.54 (0.16)
sperimentale	Femmina	0.56 (0.22)	0.52 (0.3)	0.12 (0.09)	0.59 (0.34)	0.49 (0.23)	0.15 (0.11)	0.01 (0.03)	0.49 (0.34)	0 (0)	0.53 (0.14)
controllo	Maschio	0.5 (0.27)	0.43 (0.23)	0.29 (0.26)	0.52 (0.29)	0.55 (0.23)	0.19 (0.15)	0.02 (0.08)	0.54 (0.34)	0.01 (0.07)	0.49 (0.12)
sperimentale	Maschio	0.47 (0.32)	0.49 (0.23)	0.22 (0.14)	0.47 (0.35)	0.49 (0.32)	0.14 (0.17)	0.03 (0.08)	0.61 (0.31)	0.02 (0.04)	0.49 (0.15)


arena
gallieno
leoni
erbe
signori
teatro
borsari
gavi
giove
organizzazione
Score [0-1]
1.00
0.75
0.50
0.25
0.00
Tipo:Sesso
controllo:Femmina
controllo:Maschio
sperimentale:Femmina
sperimentale:Maschio


arena
gallieno
leoni
erbe
signori
teatro
borsari
gavi
giove
organizzazione
Score [0-1]
1.00
0.75
0.50
0.25
0.00
Tipo
controllo
sperimentale



arena
gallieno
leoni
erbe
signori
teatro
borsari
gavi
giove
organizzazione
Score [0-1]
0.00
0.25
0.50
0.75
controllo
sperimentale
Tipo
controllo
sperimentale

Hestercombe Statistical Analysis

Principal Component Analysis

Questionario pre-visita

Rimuovo tutte quelle domande in cui piÃ¹ di 10 studenti non hanno risposto o hanno un "99", per intenderci.

Stampo a schermo le domande rimaste

Informazioni cronologiche
Sex
Year of birth just the year
School Name
Do you have internet connection at home
How many smartphones are there at home
How many tablets are there at home
How often do you use the following devices at home Desktop computer
How often do you use the following devices at home Laptop
How often do you use the following devices at home Smartphone
How often do you use the following devices at home Tablet
How often do you use the following devices at home Game console
How often do you use the following devices at home Portable game console
How often do you use the following devices at home Smart glasses or VR headsets
How often do you use the following devices at school Desktop computer
How often do you use the following devices at school Laptop
How often do you use the following devices at school Smartphone
How often do you use the following devices at school Tablet
How often do you use the following devices at school Smart glasses or VR headsets
How often do you use the following devices at school Interactive WhiteBoard used by teacher
How often do you use the following devices at school Interacative Whiteboard used by you
How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Laptop
How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Smartphone
How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Tablet
How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Portable game console

How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Smart glasses or VR headset

How often do you visit historical places and gardens

When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Smartphone

When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Tablet

When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Portable game console

When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Smart glasses or VR Headset

When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Interactive screen

What do you use a tablet for To play videogames

What do you use a tablet for To look for information

What do you use a tablet for To communicate

What do you use a tablet for To share content

What do you use a tablet for To learn

What do you use a tablet for To watch videos

What do you use a tablet for To listen to music

What do you use a tablet for To create contents like photos drawings videos etc

What do you use a tablet for To do homework

What do you use a smartphone for To play videogames

What do you use a smartphone for To communicate

What do you use a smartphone for To share content

What do you use a smartphone for To listen to music

What do you use a smartphone for To create contents like photos drawings videos etc

What do you use a smartphone for To do homework

How much do you think those devices help you learn anything Computer both desktop and laptop

How much do you think those devices help you learn anything Tablet

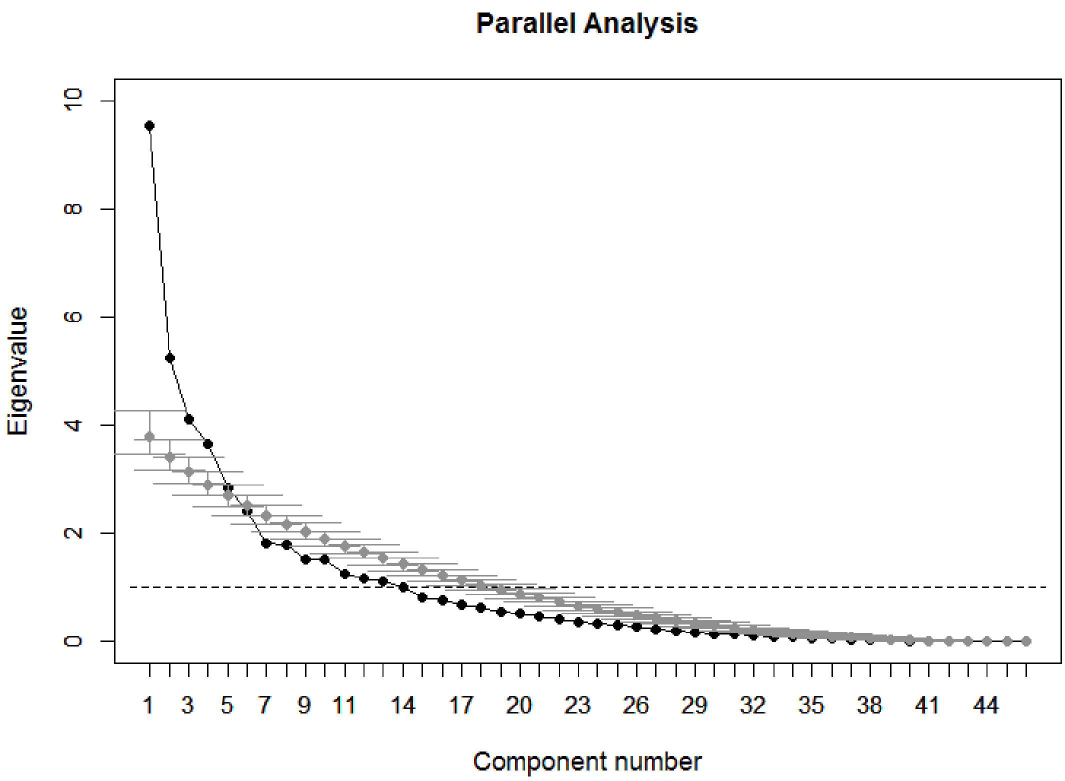
How much do you think those devices help you learn anything Smartphone

How much do you think those devices help you learn anything Game console

How much do you think those devices help you learn anything Smartglasses VR Headset

How best do you learn during a visit to an historical place Choice 1

How best do you learn during a visit to an historical place Choice 2



Dalla parallel analysis sono necessarie 5 diverse componenti.

Ho rinominato le domande da "Q1" a "Q50", sono nell'ordine in cui appaiano nel database.

Adesso applico la PCA chiedendo di avere 5 componenti che siano ortogonali fra loro, ossia che non correlino fra loro (Ã¨ una tecnica standard): ossia faccio una PCA con rotazione VARIMAX.

Setto soglia a 0.4.

Loadings table with cut off at 0.4

	RC1	RC2	RC5	RC4	RC3
Q2	0.488	NA	NA	NA	NA
Q3	NA	NA	NA	NA	NA
Q4	NA	NA	0.428	NA	NA
Q5	0.402	NA	NA	NA	NA
Q6	0.667	NA	NA	NA	NA
Q7	NA	NA	NA	NA	0.810
Q8	NA	NA	NA	NA	0.537
Q9	0.562	NA	NA	NA	NA
Q10	0.506	NA	NA	NA	NA
Q11	NA	NA	NA	NA	NA
Q12	NA	NA	0.424	NA	NA
Q13	NA	NA	NA	0.777	NA
Q14	NA	0.454	NA	NA	NA

Q15	NA	NA	0.713	NA	NA
Q16	NA	NA	NA	-0.666	NA
Q17	NA	NA	NA	0.596	NA
Q18	NA	NA	0.814	NA	NA
Q19	0.738	NA	NA	NA	NA
Q20	NA	NA	NA	NA	0.491
Q21	0.459	NA	NA	NA	NA
Q22	NA	NA	0.681	NA	NA
Q23	NA	NA	NA	NA	-0.543
Q24	NA	NA	NA	NA	NA
Q25	NA	NA	NA	NA	NA
Q27	NA	NA	NA	0.680	NA
Q28	NA	NA	NA	0.486	NA
Q29	NA	NA	NA	0.659	NA
Q30	NA	NA	0.535	NA	NA
Q31	NA	0.731	NA	NA	NA
Q32	0.439	NA	NA	NA	NA
Q33	0.491	NA	NA	NA	NA
Q34	NA	0.869	NA	NA	NA
Q35	NA	NA	NA	NA	0.610
Q36	NA	0.519	NA	NA	NA
Q38	NA	0.740	NA	NA	NA
Q39	0.567	NA	NA	NA	NA
Q40	0.454	0.436	NA	NA	NA
Q41	0.714	NA	NA	NA	NA
Q42	0.709	NA	NA	NA	NA
Q43	0.424	0.693	NA	NA	NA
Q44	0.680	NA	NA	NA	NA
Q45	0.840	NA	NA	NA	NA
Q46	0.806	NA	NA	NA	NA
Q47	NA	0.759	NA	NA	NA
Q49	NA	NA	NA	NA	NA
Q50	NA	NA	-0.457	NA	NA

Componente alla colonna 1

	domanda	loading
Q45	What do you use a smartphone for To share content	0.8399945
Q46	What do you use a smartphone for To learn	0.8061584
Q19	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Laptop	0.7380814

Q41	What do you use a tablet for To do homework	0.7137574
Q42	What do you use a smartphone for To play videogames	0.7087907
Q44	What do you use a smartphone for To communicate	0.6801806
Q6	How often do you use the following devices at home Laptop	0.6668407
Q39	What do you use a tablet for To listen to music	0.5671428
Q9	How often do you use the following devices at home Game console	0.5615780
Q10	How often do you use the following devices at home Portable game console	0.5060661
Q33	What do you use a tablet for To look for information	0.4911477
Q2	Do you have internet connection at home	0.4881890
Q21	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Tablet	0.4587976
Q40	What do you use a tablet for To create contents like photos drawings videos etc	0.4536838
Q32	What do you use a tablet for To play videogames	0.4392143
Q43	What do you use a smartphone for To look for information	0.4242534
Q5	How often do you use the following devices at home Desktop computer	0.4015422

Componente alla colonna 2

	domanda	loading
Q34	What do you use a tablet for To communicate	0.8694447
Q47	What do you use a smartphone for To watch videos	0.7592771
Q38	What do you use a tablet for To watch videos	0.7397673
Q31	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Audioguide	0.7306653
Q43	What do you use a smartphone for To look for information	0.6931030
Q36	What do you use a tablet for To learn	0.5186943
Q14	How often do you use the following devices at school Smartphone	0.4535804
Q40	What do you use a tablet for To create contents like photos drawings videos etc	0.4364641

Componente alla colonna 3

	domanda	loading
Q18	How often do you use the following devices at school Interacative Whiteboard used by you	0.8144944
Q15	How often do you use the following devices at school Tablet	0.7131971
Q22	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Portable game console	0.6812119
Q30	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Interactive screen	0.5347015

Q4	How many tablets are there at home	0.4278452
Q12	How often do you use the following devices at school Desktop computer	0.4241491
Q50	What do you use a smartphone for To create contents like photos drawings videos etc	-0.4567935

Componente alla colonna 4

	domanda	loading
Q13	How often do you use the following devices at school Laptop	0.7773559
Q27	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Tablet	0.6803480
Q29	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Smart glasses or VR Headset	0.6585481
Q17	How often do you use the following devices at school Interactive WhiteBoard used by teacher	0.5962661
Q28	When you visited historical places and gardens how often have you actually used the following devices in order to get information or guide you during your visit Portable game console	0.4864251
Q16	How often do you use the following devices at school Smart glasses or VR headsets	-0.6658486

Componente alla colonna 5

	domanda	loading
Q7	How often do you use the following devices at home Smartphone	0.8099812
Q35	What do you use a tablet for To share content	0.6096477
Q8	How often do you use the following devices at home Tablet	0.5370835
Q20	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Smartphone	0.4911185
Q23	How often do you use the following devices when you are around or on the move neither at home or at school but around in the park or going about places Smart glasses or VR headset	-0.5432001

I punteggi di queste 5 componenti le calcolo sommando tutte le domnde con leading positivo, e sottraendo quelle con loading negativo. Poi questo valore lo trasformo in proporzione 0/1.

Questionario post-visita

Informazioni cronologiche

Sex

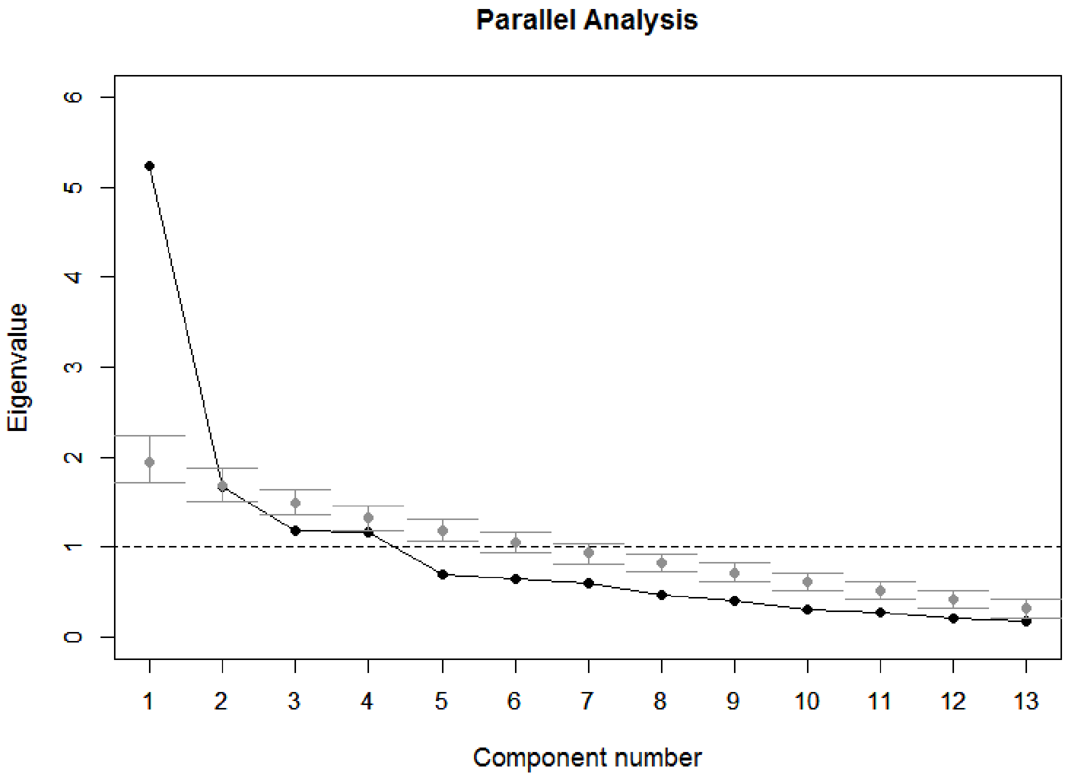
Year of birth just the year

Name of the School

They told me all that I wished to know

I learned things that will be useful in the future

It was an engaging experience
I found my school mates were engaging fully with the visit
The teachers seemed absorbed in the visit
The guide conducted the visit well
They spoke the right amount of time not too much not too little
Using the app was useful
Using the app was easy
How much did you enjoy the visit from 1 to 5
What did you like the most in the whole visit
What you didn t like of the Visit
Tell us what you would like to see or do and have not seen or done in this visit



Loadings table

	tabtab[, 1]
Q1	0.674
Q2	0.803
Q3	0.661
Q4	0.470
Q5	0.534
Q6	0.635
Q7	0.644
Q8	0.719

Q9	0.376
Q10	0.757
Q11	0.741
Q14	-0.437
Q15	0.706

Componente alla colonna 1

	domanda	loading
Q2	They gave adequate answers to our questions	0.8032623
Q10	How much did you enjoy the visit from 1 to 5	0.7571241
Q11	What did you like the most in the whole visit	0.7409560
Q8	I wish I had a traditional visit without device and app	0.7192110
Q15	Tell us what you would like to see or do and have not seen or done in this visit	0.7058770
Q1	They spoke the right amount of time not too much not too little	0.6741448
Q3	They were clear and understandable in their explanations	0.6613696
Q7	What you disliked of the App	0.6443955
Q6	What you liked of the App	0.6353151
Q5	Using the app was easy	0.5343186
Q4	Using the app was useful	0.4700098
Q9	I would like to have another visit like this one	0.3757205
Q14	What you didn t like of the Visit	- 0.4373714

Analisi sulle componenti ottenute

Utilizzo modelli lineari ANOVA per analizzare tali dati.

Analisi su prima componente pre visita

[1] bishops hull bishops hull bishops hull bishops hull bishops hull [6] bishops hull bishops hull bishops hull bishops hull bishops hull [11] bishops hull bishops hull bishops hull bishops hull bishops hull [16] bishops hull bishops hull bishops hull bishops hull bishops hull [21] bishops hull bishops hull bishops hull bishops hull bishops hull [26] bishops hull blackbrook blackbrook blackbrook blackbrook
[31] blackbrook blackbrook blackbrook blackbrook blackbrook
[36] blackbrook blackbrook blackbrook blackbrook blackbrook
[41] blackbrook blackbrook blackbrook blackbrook blackbrook
[46] blackbrook blackbrook blackbrook blackbrook blackbrook
[51] blackbrook blackbrook blackbrook blackbrook blackbrook
[56] blackbrook blackbrook
Levels: bishops hull blackbrook

	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.

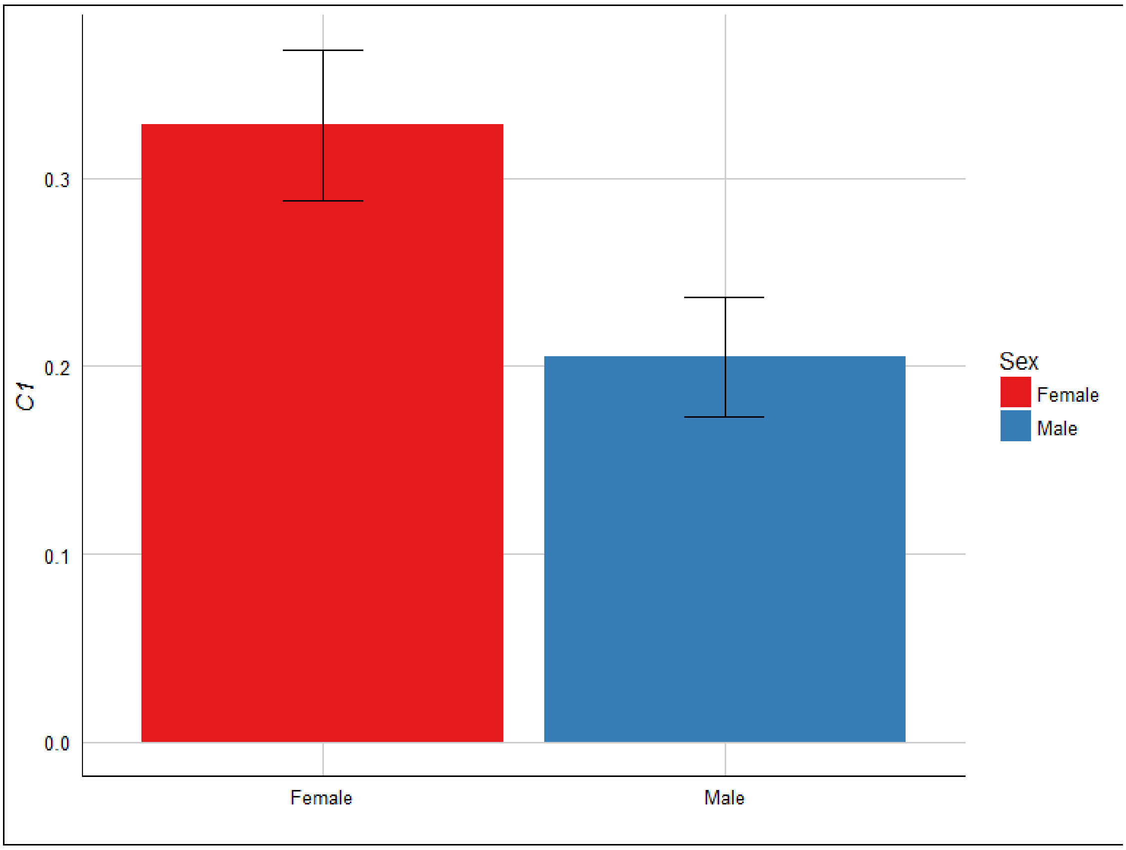
School.Name	1	0.025	0.025	0.771	0.384
Sex	1	0.197	0.197	5.979	0.018
School.Name:Sex	1	0.203	0.203	6.155	0.016
Residuals	52	1.713	0.033	NA	NA

Di significativo c'è il sesso e l'interazione fra scuola e sesso.

Vediamo il sesso:

Medie e deviazioni standard divise per sesso

Sex	C1
Female	0.33 (0.21)
Male	0.2 (0.16)



Vediamo l'interazione:

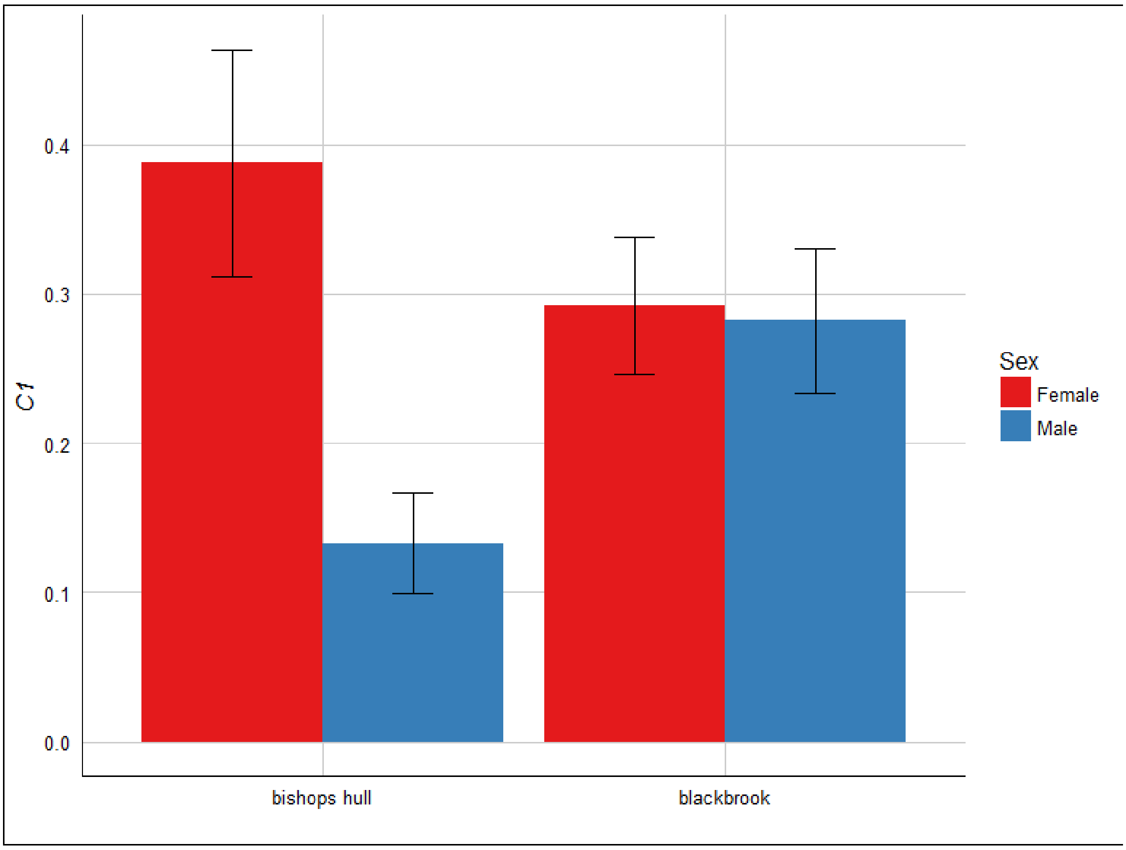
Medie e deviazioni standard divise per sesso e scuola

Sex	School.Name	C1
Female	bishops hull	0.39 (0.24)
Male	bishops hull	0.13 (0.12)
Female	blackbrook	0.29 (0.19)
Male	blackbrook	0.28 (0.17)

Tabella dei post-hoc.

	Female.bishops hull	Male.bishops hull	Female.blackbrook

Male.bishops hull	0.006	NA	NA
Female.blackbrook	0.486	0.087	NA
Male.blackbrook	0.486	0.151	0.88



Analisi sulla seconda componente pre visita

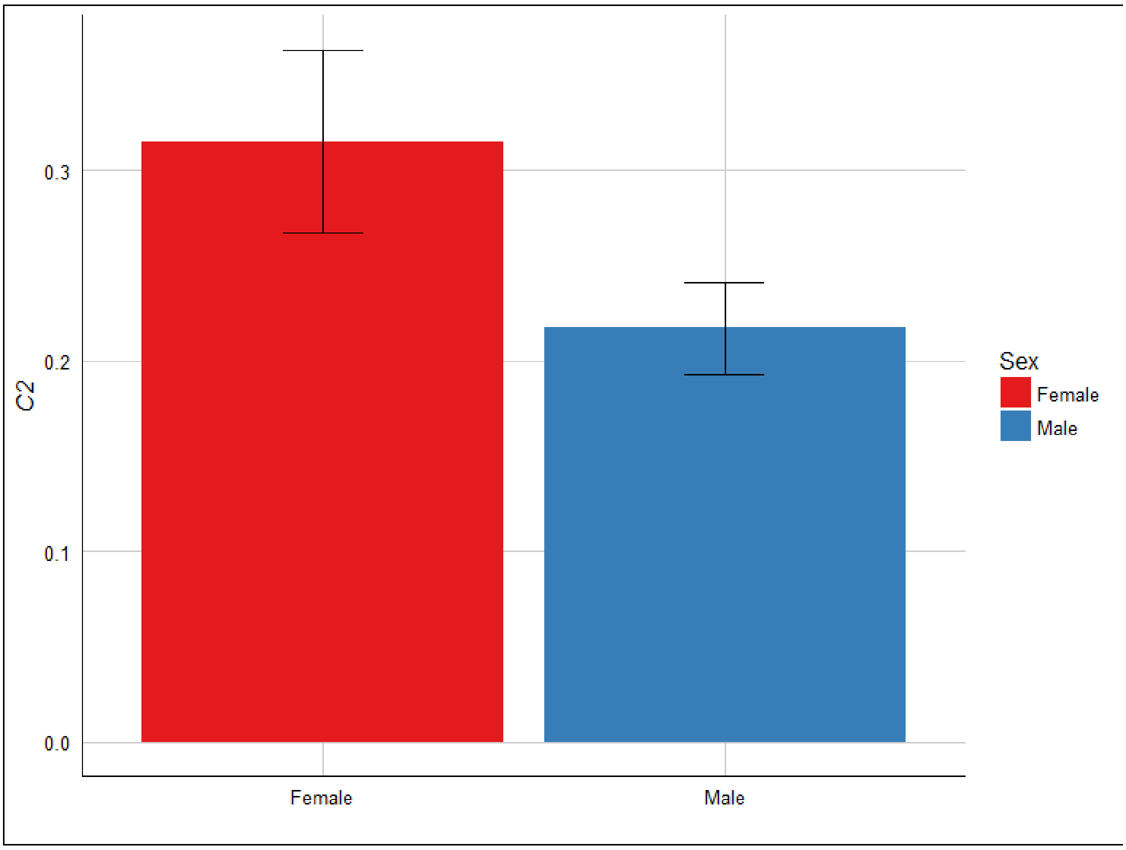
	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.
School.Name	1	0.422	0.422	16.694	0.000
Sex	1	0.213	0.213	8.407	0.005
School.Name:Sex	1	0.365	0.365	14.436	0.000
Residuals	52	1.316	0.025	NA	NA

Qui è tutto significativo!

Cominciamo dagli effetti principali.

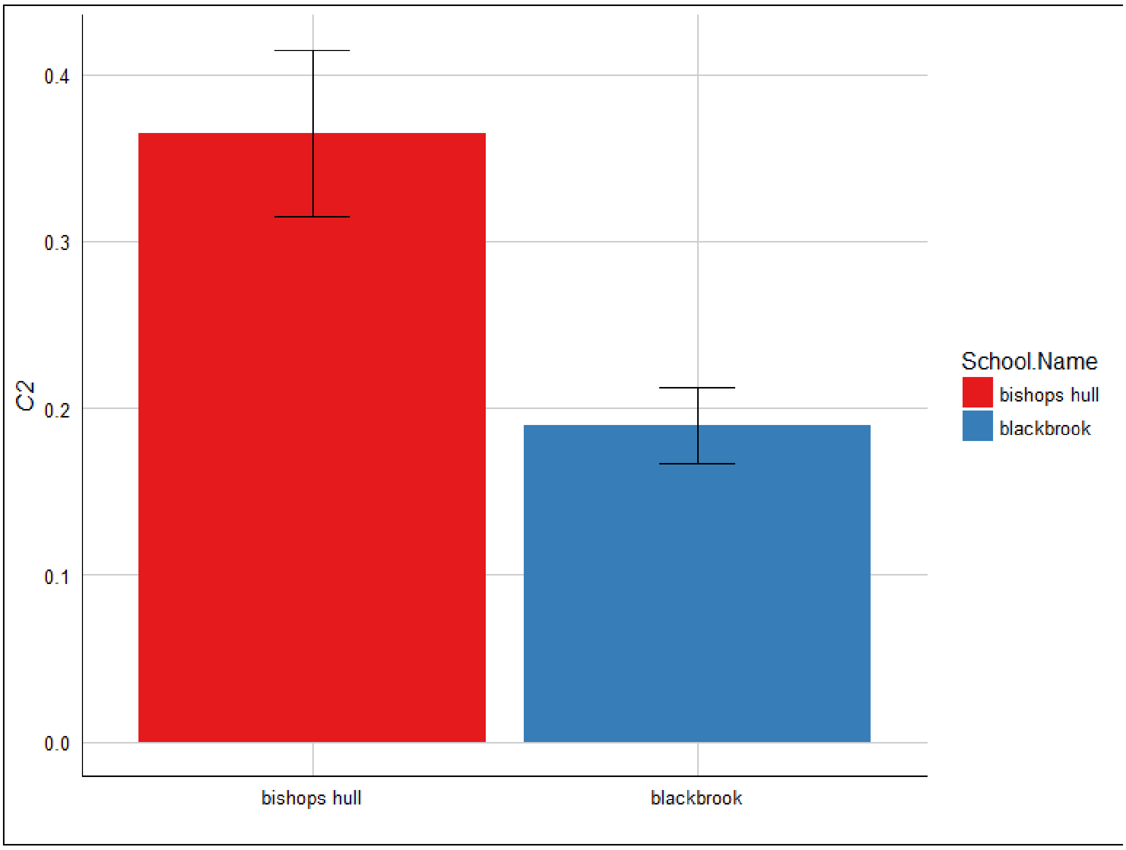
Medie e deviazioni standard divise per sesso

Sex	C2
Female	0.32 (0.25)
Male	0.22 (0.12)



Medie e deviazioni standard divise per sesso

School.Name	C2
bishops hull	0.36 (0.24)
blackbrook	0.19 (0.12)



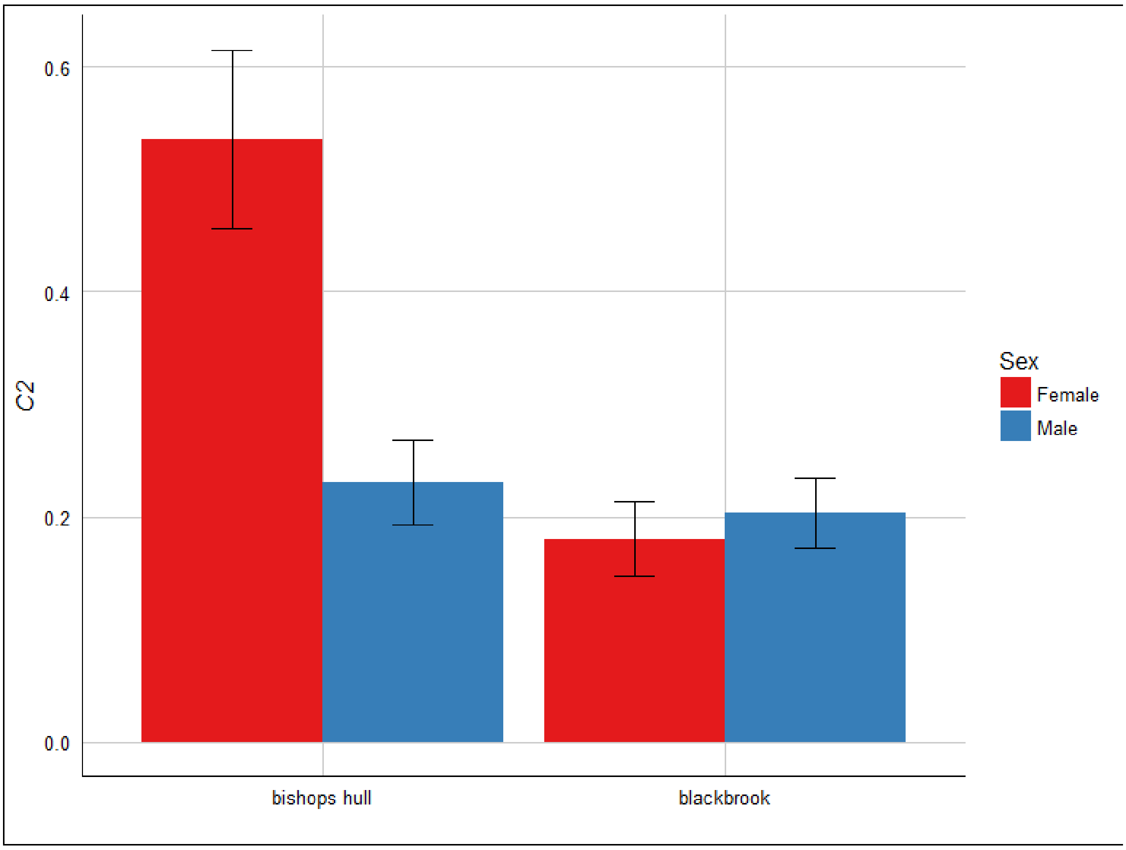
Vediamo l'interazione.

Medie e deviazioni standard divise per sesso e scuola

Sex	School.Name	C2
Female	bishops hull	0.54 (0.25)
Male	bishops hull	0.23 (0.14)
Female	blackbrook	0.18 (0.14)
Male	blackbrook	0.2 (0.11)

Tabella dei post-hoc.

	Female.bishops hull	Male.bishops hull	Female.blackbrook
Male.bishops hull	0	NA	NA
Female.blackbrook	0	1	NA
Male.blackbrook	0	1	1



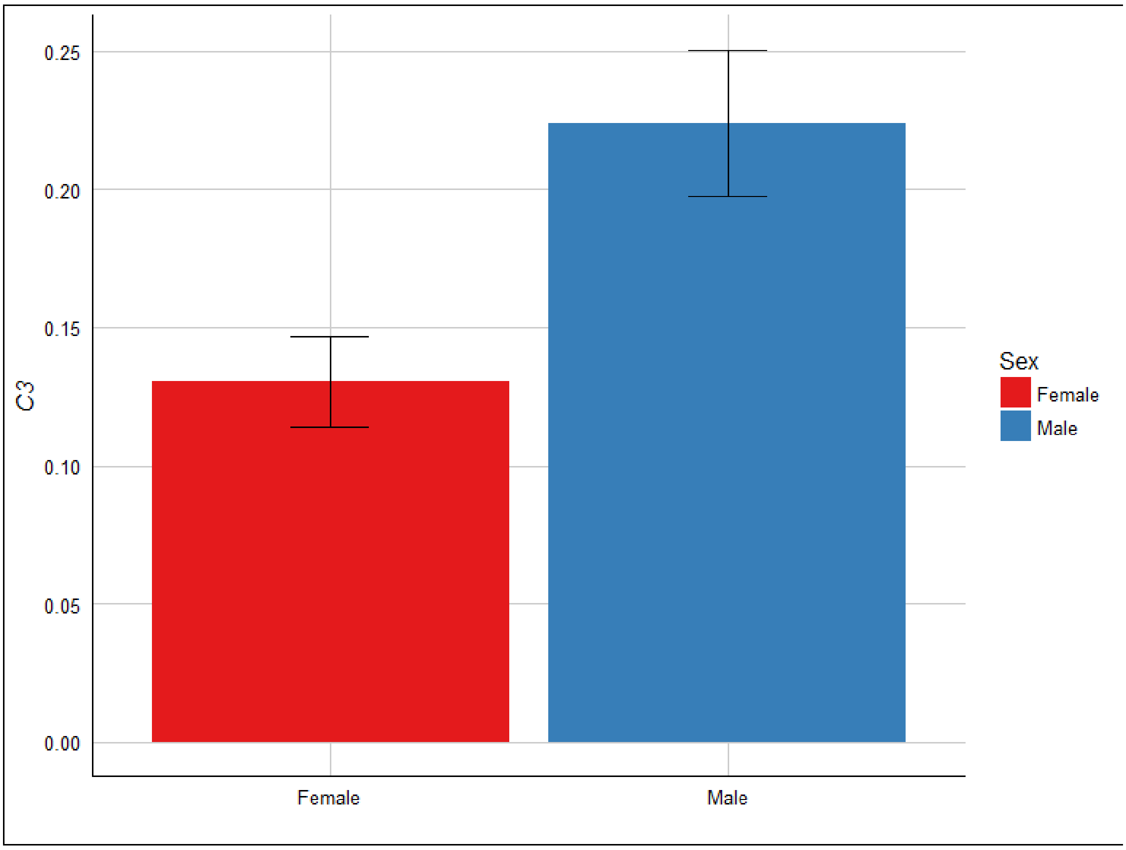
Analisi sulla terza componente pre visita

	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.
School.Name	1	0.000	0.000	0.006	0.937
Sex	1	0.124	0.124	9.486	0.003
School.Name:Sex	1	0.006	0.006	0.435	0.512
Residuals	52	0.679	0.013	NA	NA

Qui abbiamo solo il sesso di significativo.

Medie e deviazioni standard divise per sesso

Sex	C3
Female	0.13 (0.09)
Male	0.22 (0.14)



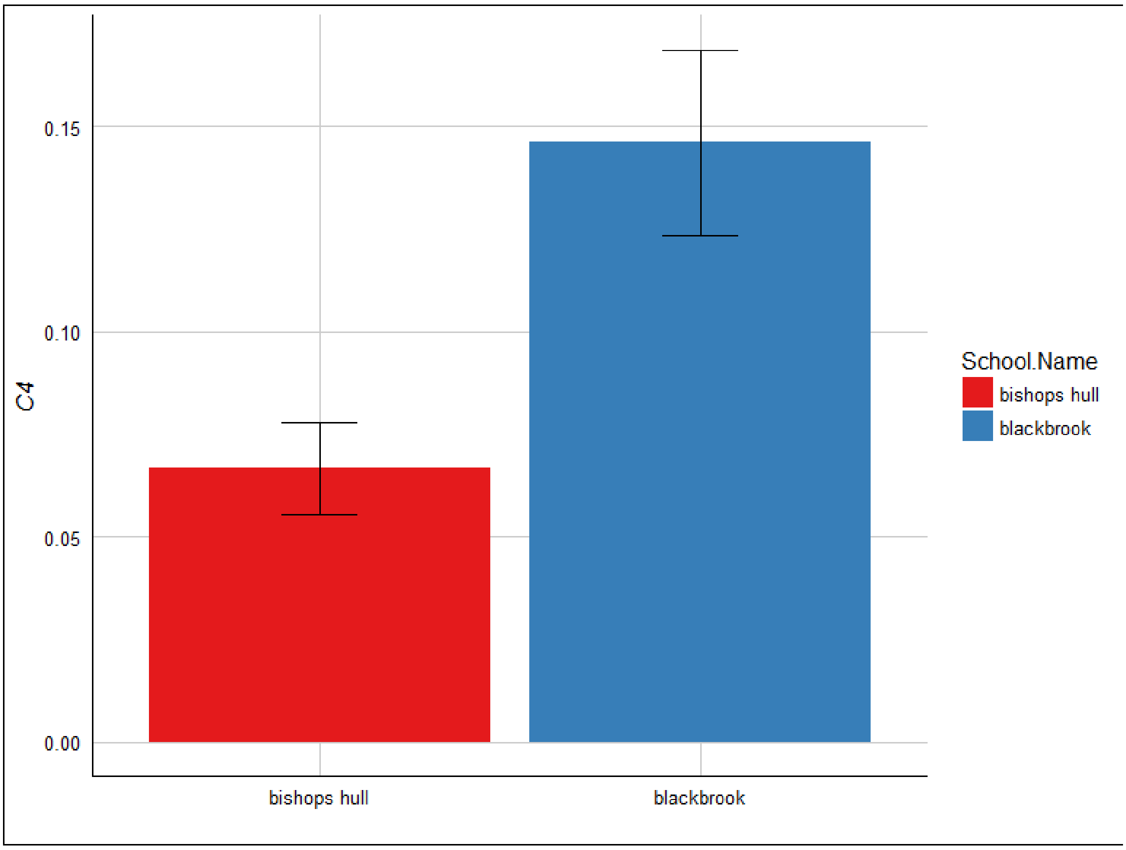
Analisi sulla quarta componente pre visita

	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.
School.Name	1	0.087	0.087	9.203	0.004
Sex	1	0.026	0.026	2.755	0.103
School.Name:Sex	1	0.011	0.011	1.128	0.293
Residuals	52	0.492	0.009	NA	NA

Solo la scuola è significativa.

Medie e deviazioni standard divise per scuola

School.Name	C4
bishops hull	0.07 (0.05)
blackbrook	0.15 (0.12)



Analisi sulla quinta componente pre visita

	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.
School.Name	1	0.019	0.019	0.422	0.519
Sex	1	0.151	0.151	3.287	0.076
School.Name:Sex	1	0.008	0.008	0.181	0.672
Residuals	52	2.390	0.046	NA	NA

Qui nulla di significativo.

Analisi sulla componente post-visita

	Df	Sum.Sq	Mean.Sq	F.value	Pr..F.
Name.of.the.School	1	0.024	0.024	0.919	0.342
Sex	1	0.000	0.000	0.014	0.907
Name.of.the.School:Sex	1	0.019	0.019	0.724	0.399
Residuals	52	1.372	0.026	NA	NA

Nulla di significativo nemmeno qui.

Analisi sui punteggi al test

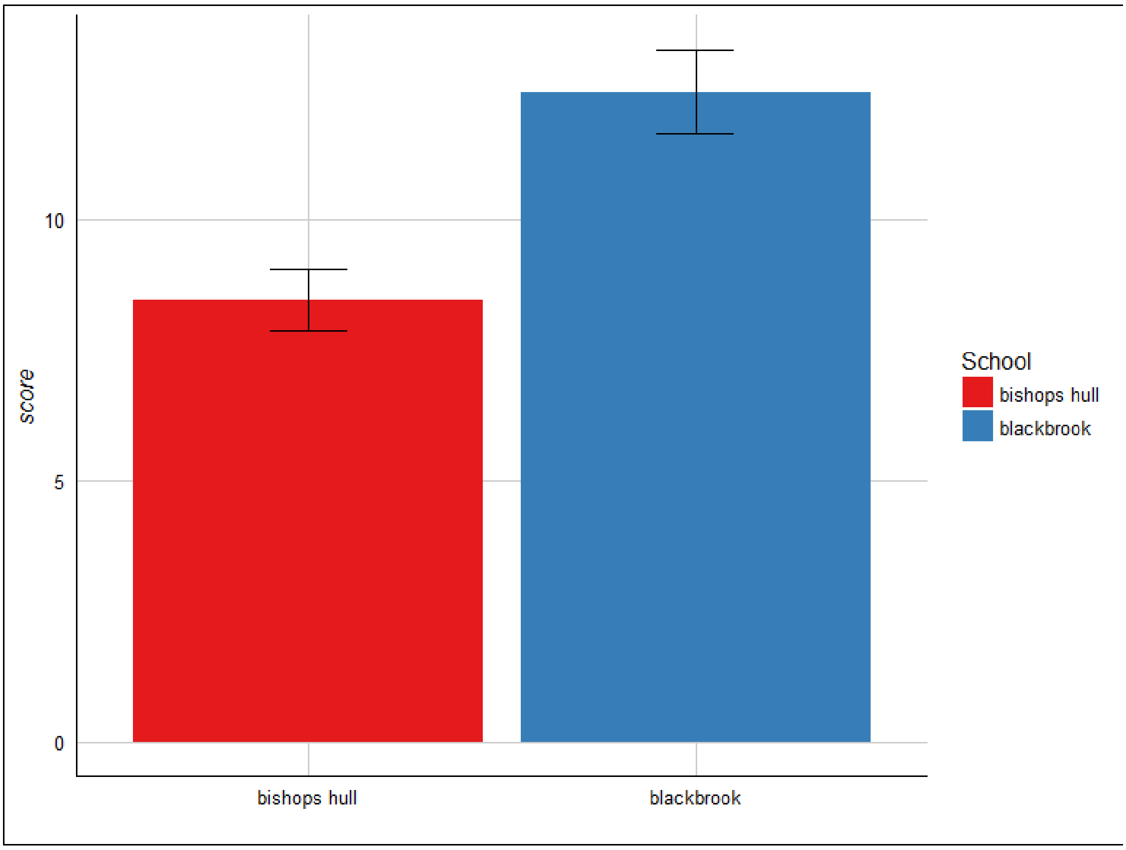
Punteggio totale

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	1.247	1.247	0.114	0.738
School	1	182.050	182.050	16.571	0.000
Sex:School	1	0.012	0.012	0.001	0.974
Residuals	41	450.435	10.986	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	score
bishops hull	8.45 (2.67)
blackbrook	12.43 (3.73)



Punteggio octagon

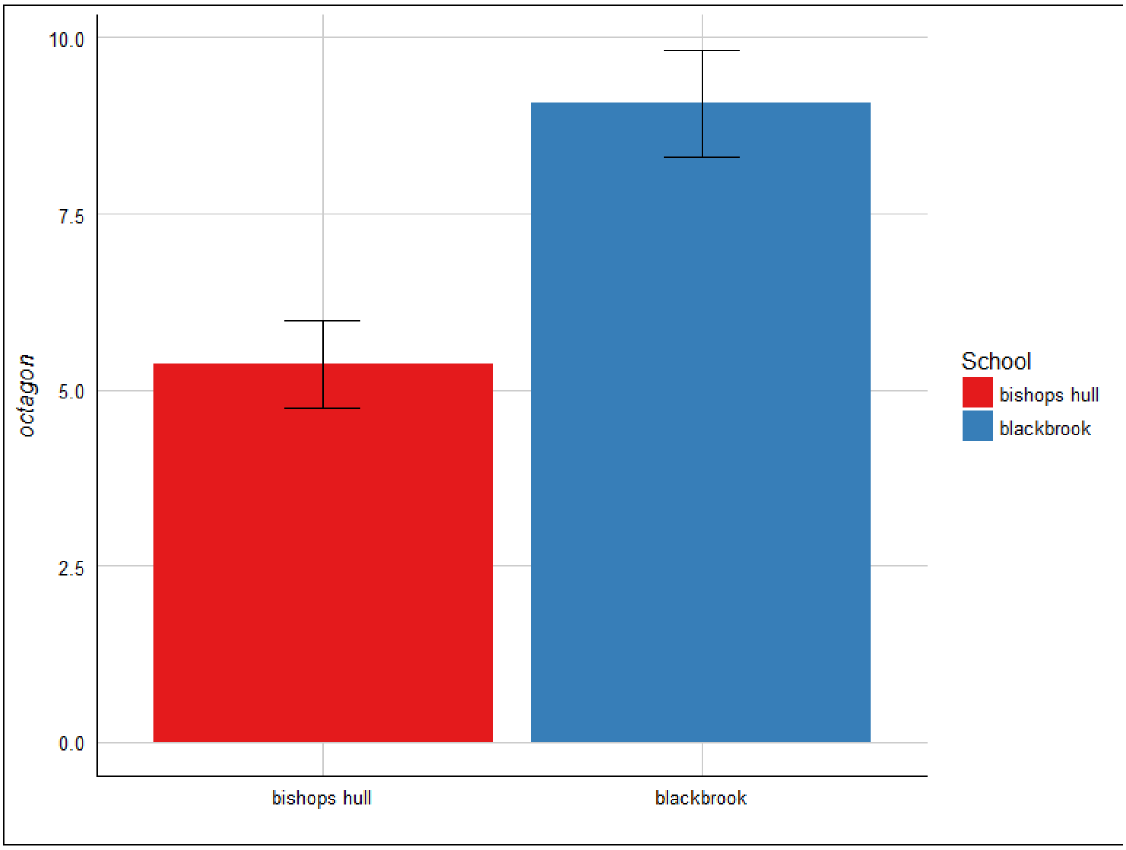
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	2.699	2.699	0.258	0.614
School	1	149.721	149.721	14.300	0.001
Sex:School	1	1.975	1.975	0.189	0.666

Residuals	40	418.804	10.470	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	octagon
bishops hull	5.36 (2.87)
blackbrook	9.07 (3.45)



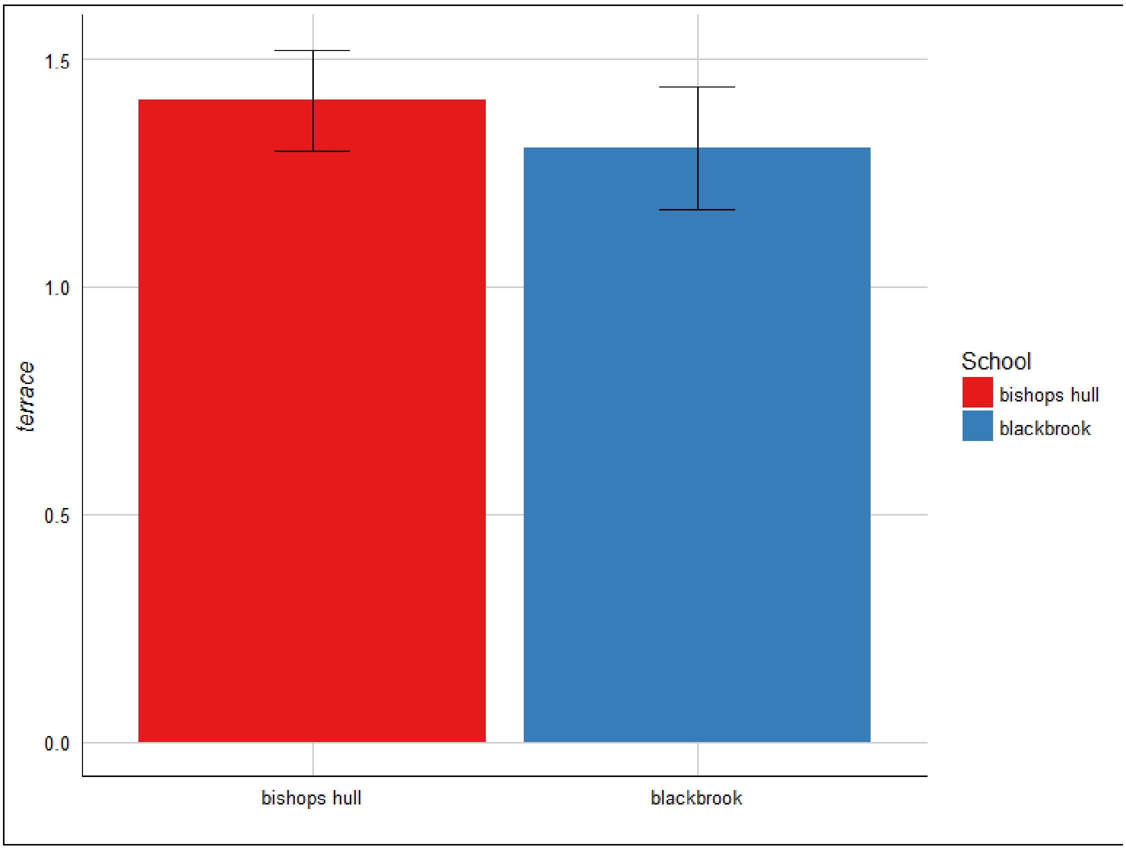
Punteggio terrace

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	0.001	0.001	0.003	0.955
School	1	0.125	0.125	0.365	0.549
Sex:School	1	0.119	0.119	0.346	0.560
Residuals	41	14.066	0.343	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	terrace
bishops hull	1.41 (0.5)
blackbrook	1.3 (0.63)



Punteggio chinese

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	0.000	0.000	0.001	0.970
School	1	0.000	0.000	0.000	0.986
Sex:School	1	0.667	0.667	3.504	0.068
Residuals	41	7.810	0.190	NA	NA

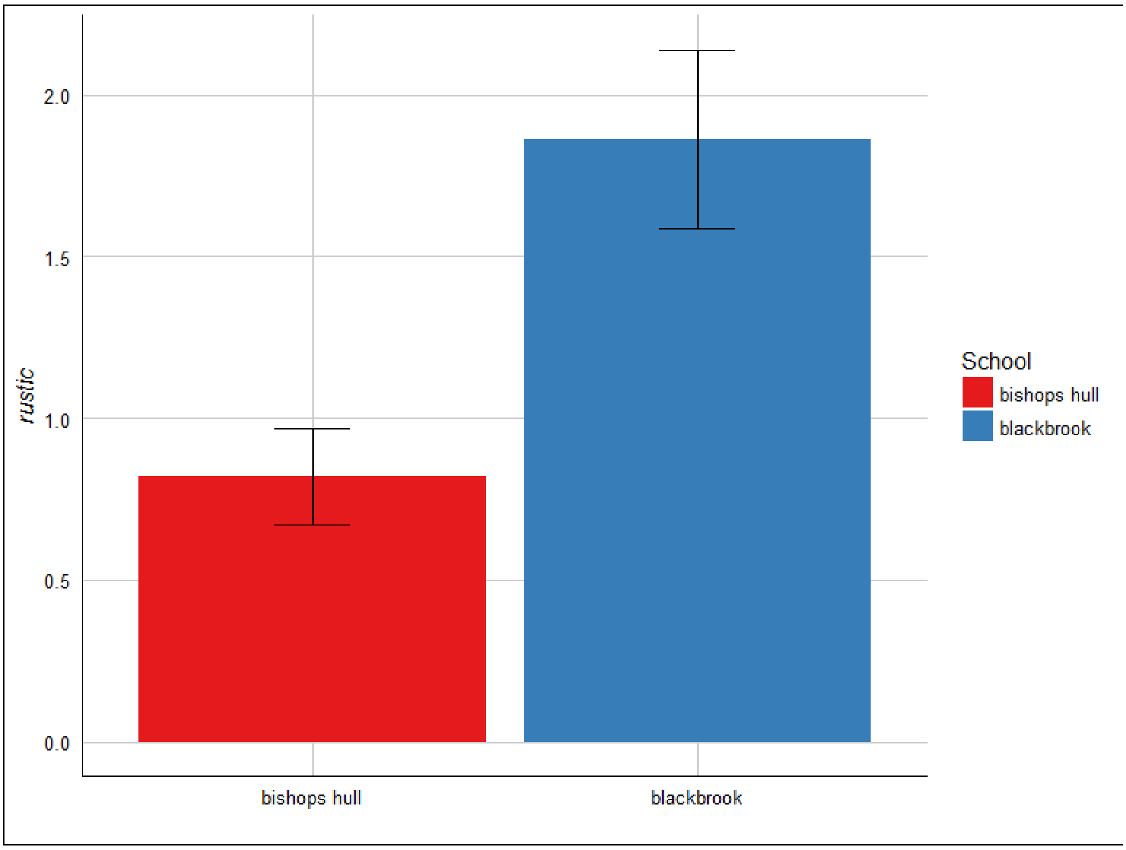
Punteggio rustic

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	0.846	0.846	0.793	0.379
School	1	11.193	11.193	10.481	0.002
Sex:School	1	0.133	0.133	0.125	0.726
Residuals	40	42.714	1.068	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	rustic
bishops hull	0.82 (0.68)
blackbrook	1.86 (1.26)



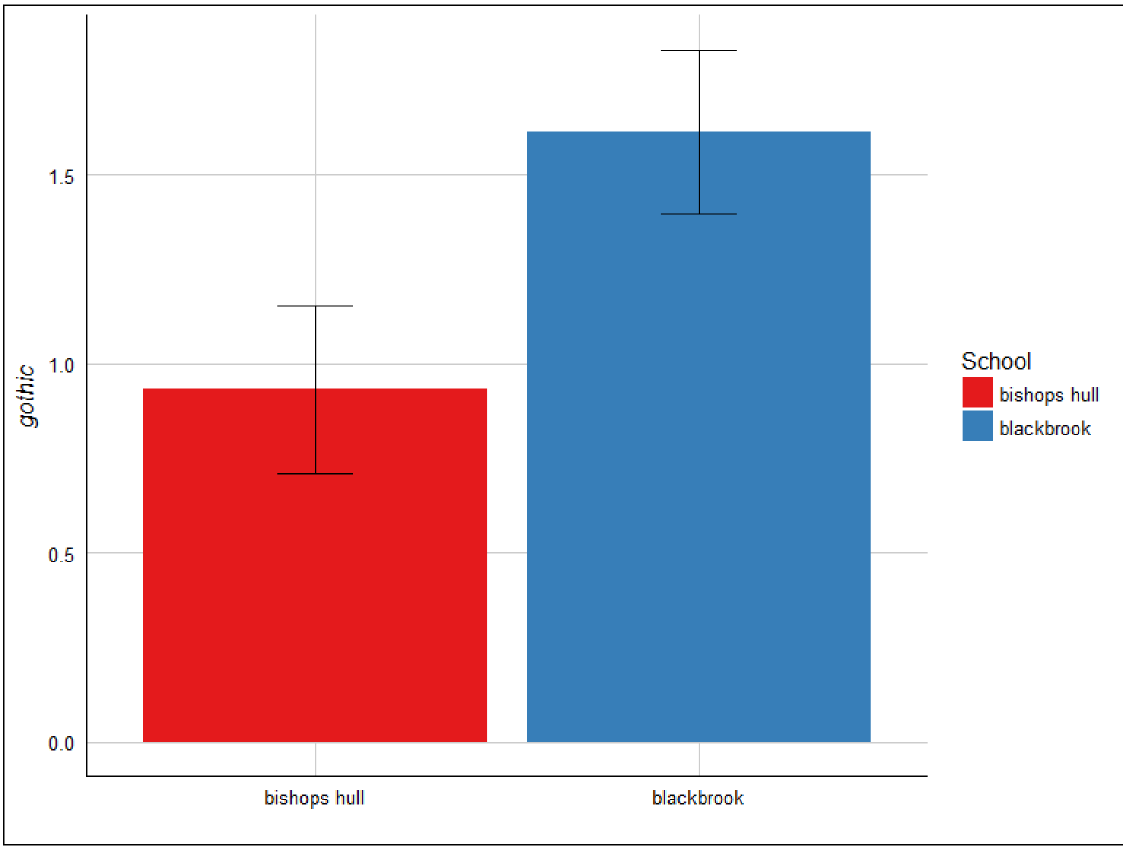
Punteggio gothic

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	0.003	0.003	0.003	0.957
School	1	5.459	5.459	5.293	0.027
Sex:School	1	0.513	0.513	0.497	0.485
Residuals	40	41.253	1.031	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	gothic
bishops hull	0.93 (1.02)
blackbrook	1.61 (0.99)



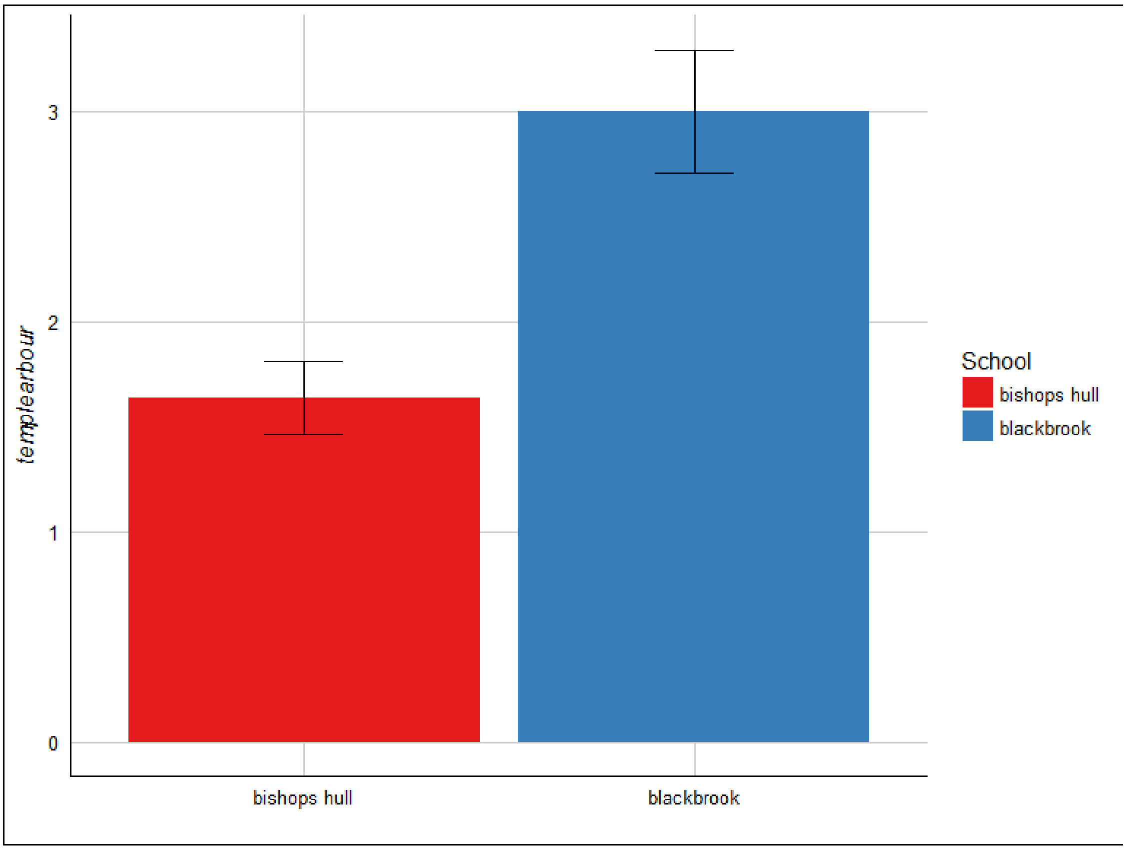
Punteggio Temple Arbour

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	0.354	0.354	0.296	0.59
School	1	20.308	20.308	16.976	0.00
Sex:School	1	2.035	2.035	1.701	0.20
Residuals	40	47.849	1.196	NA	NA

Scuola significativo.

Medie e deviazioni standard divise per scuola

School	templearbour
bishops hull	1.64 (0.79)
blackbrook	3 (1.33)



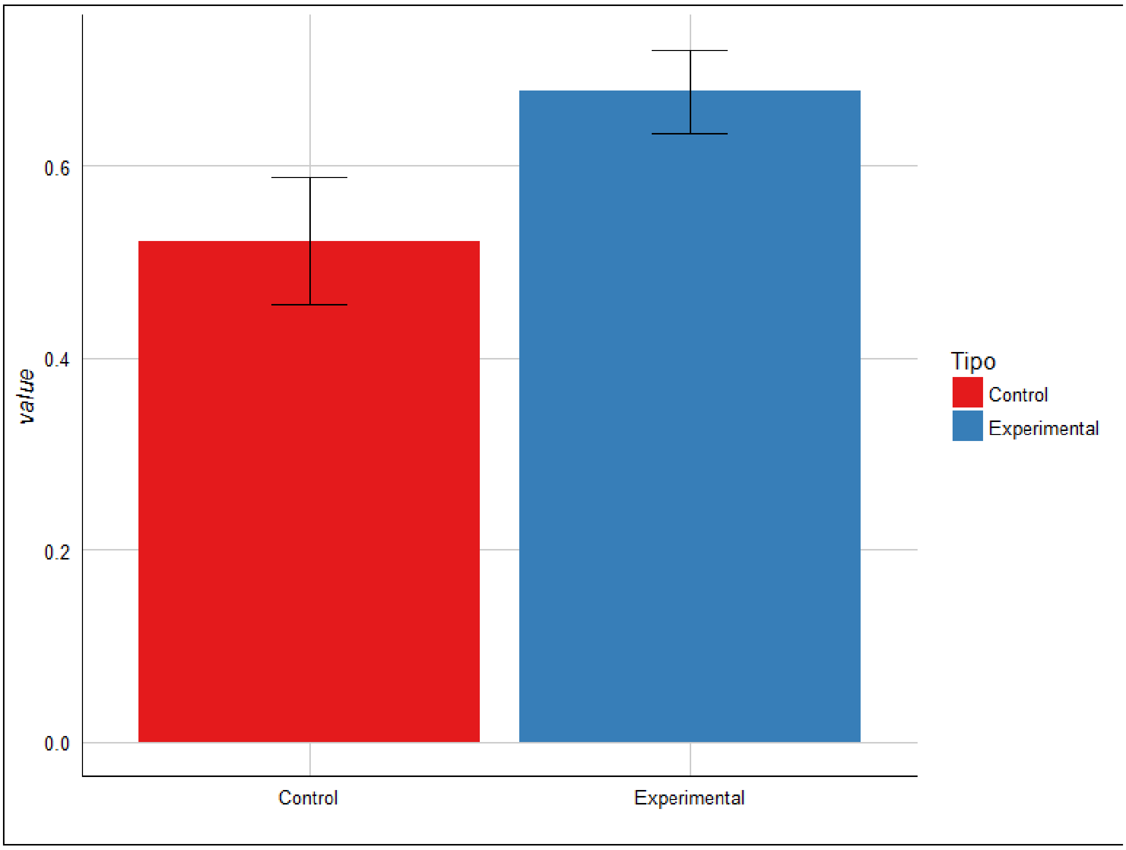
Confronto fra tappe seprimentali e non sperimentali

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
School	1	0.016	0.016	0.116	0.734
Sex	1	0.001	0.001	0.008	0.931
Tipo	1	0.544	0.544	3.942	0.050
School:Sex	1	0.489	0.489	3.542	0.063
School:Tipo	1	0.015	0.015	0.107	0.744
Sex:Tipo	1	0.000	0.000	0.000	0.985
School:Sex:Tipo	1	0.208	0.208	1.505	0.223
Residuals	82	11.326	0.138	NA	NA

è significativo il Tipo di tappa

Medie e deviazioni standard divise per scuola

Tipo	value
Control	0.52 (0.44)
Experimental	0.68 (0.29)



Medie e deviazioni standard varie

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso e scuola

Sex	School	score	octagon	chinese	rustic	gothic	templearbour	terrace
Female	bishops hull	8 (2.04)	4.79 (2.08)	0.71 (0.39)	0.93 (0.45)	0.64 (0.38)	1.21 (0.7)	1.5 (0.41)
Male	bishops hull	8.67 (2.96)	5.63 (3.2)	0.43 (0.37)	0.77 (0.78)	1.07 (1.19)	1.83 (0.77)	1.37 (0.55)
Female	blackbrook	12.67 (4.27)	9.08 (4.25)	0.38 (0.48)	1.83 (1.29)	1.62 (1.11)	3.12 (1.6)	1.29 (0.72)
Male	blackbrook	12.85 (2.47)	9.05 (2.39)	0.65 (0.47)	1.9 (1.29)	1.6 (0.88)	2.85 (0.97)	1.35 (0.58)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso e scuola

Sex	School.Name	C1	C2	C3	C4	C5
Female	bishops hull	0.39 (0.24)	0.54 (0.25)	0.11 (0.1)	0.07 (0.08)	0.39 (0.21)
Male	bishops hull	0.13 (0.12)	0.23 (0.14)	0.23 (0.16)	0.06 (0.03)	0.52 (0.21)
Female	blackbrook	0.29 (0.19)	0.18 (0.14)	0.14 (0.08)	0.17 (0.15)	0.39 (0.23)
Male	blackbrook	0.28 (0.17)	0.2 (0.11)	0.22 (0.11)	0.11 (0.06)	0.48 (0.2)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso e scuola

Sex	Name.of.the.School	C1
Female	bishops hull	0.48 (0.24)

Male	bishops hull	0.44 (0.14)
Female	blackbrook	0.49 (0.15)
Male	blackbrook	0.51 (0.13)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso

Sex	score	octagon	chinese	rustic	gothic	templearbour	terrace
Female	10.95 (4.23)	7.5 (4.12)	0.5 (0.47)	1.5 (1.13)	1.26 (1.02)	2.42 (1.62)	1.37 (0.62)
Male	10.34 (3.43)	7 (3.32)	0.52 (0.42)	1.22 (1.14)	1.28 (1.09)	2.24 (0.98)	1.36 (0.55)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso

Sex	C1	C2	C3	C4	C5
Female	0.33 (0.21)	0.32 (0.25)	0.13 (0.09)	0.14 (0.13)	0.39 (0.22)
Male	0.2 (0.16)	0.22 (0.12)	0.22 (0.14)	0.08 (0.05)	0.5 (0.2)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per sesso

Sex	C1
Female	0.48 (0.18)
Male	0.47 (0.14)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per scuola

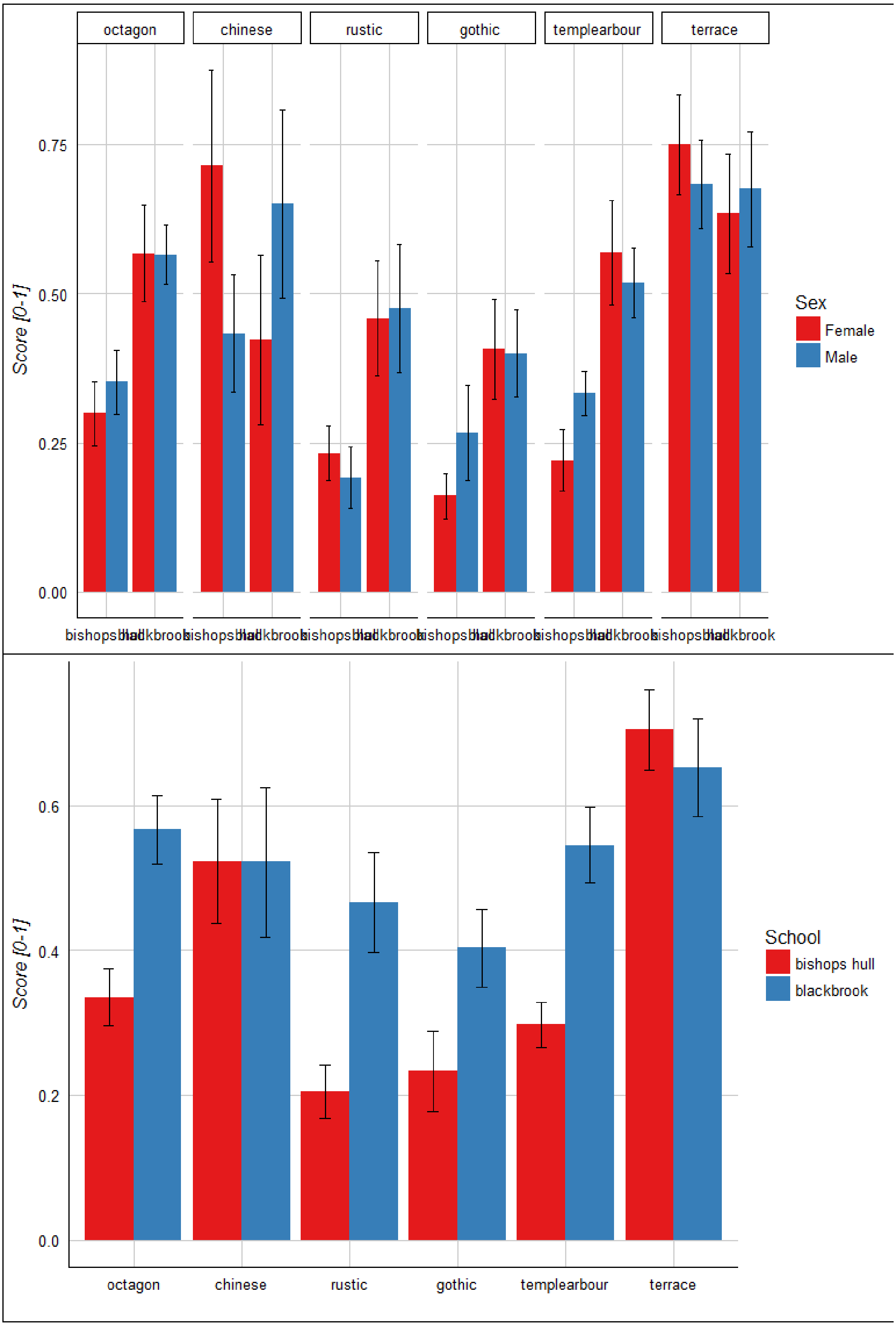
School	score	octagon	chinese	rustic	gothic	templearbour	terrace
bishops hull	8.45 (2.67)	5.36 (2.87)	0.52 (0.39)	0.82 (0.68)	0.93 (1.02)	1.64 (0.79)	1.41 (0.5)
blackbrook	12.75 (3.49)	9.07 (3.45)	0.5 (0.49)	1.86 (1.26)	1.61 (0.99)	3 (1.33)	1.32 (0.65)

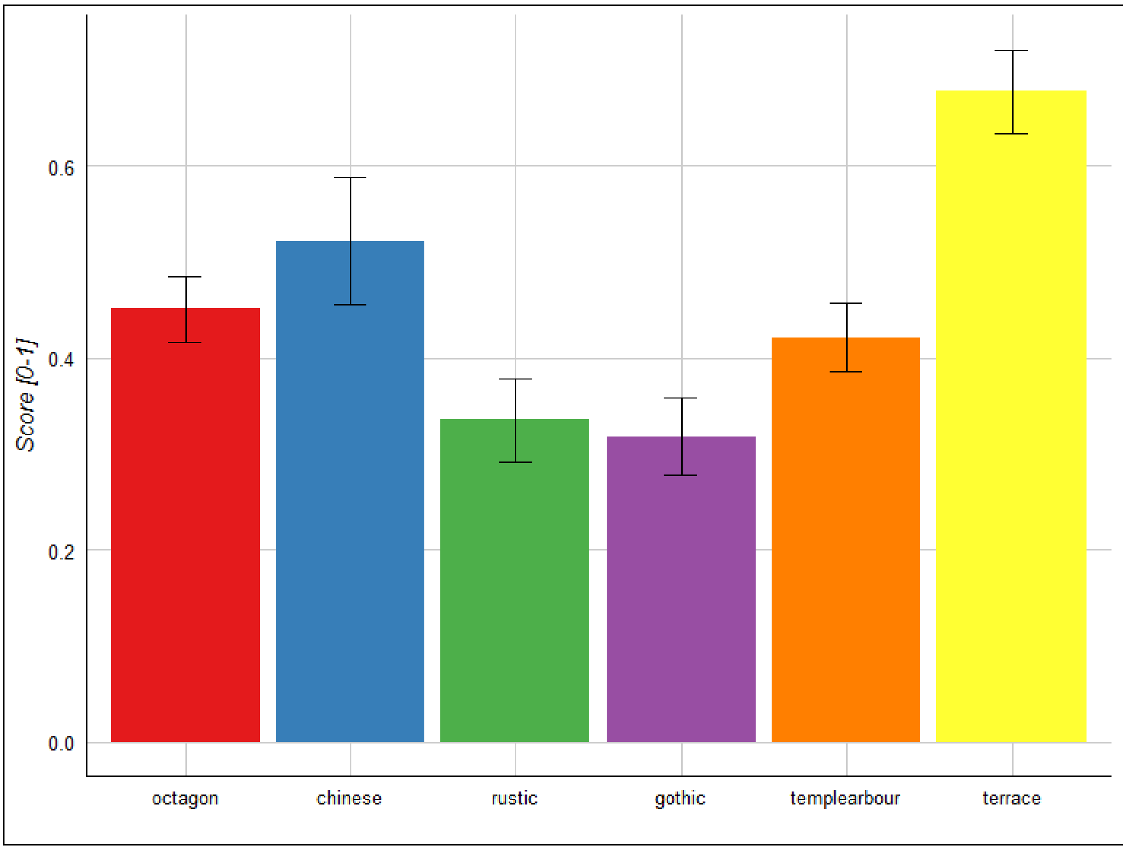
Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per scuola

School.Name	C1	C2	C3	C4	C5
bishops hull	0.25 (0.22)	0.36 (0.24)	0.18 (0.14)	0.07 (0.05)	0.47 (0.21)
blackbrook	0.29 (0.18)	0.19 (0.12)	0.17 (0.1)	0.15 (0.12)	0.43 (0.22)

Tabella medie e deviazioni standard per ogni punteggio e conponente diviso per scuola

Name.of.the.School	C1
bishops hull	0.46 (0.18)
blackbrook	0.5 (0.14)


octagon
chinese
rustic
gothic
templearbour
terrace
Score [0-1]
0.75
0.50
0.25
0.00
bishops hull
blackbrook
Sex
Female
Male
Score [0-1]
0.6
0.4
0.2
0.0
octagon
chinese
rustic
gothic
templearbour
terrace
School
bishops hull
blackbrook


Score [0-1]
0.6
0.4
0.2
0.0
octagon
chinese
rustic
gothic
templearbour
terrace

Appendix 3: Drawings

Please find the drawings in the CD-ROM ‘Appendix 3 – Drawings’ attached or at the following links:

Verona drawings:

https://www.dropbox.com/sh/owq00lo67guodzo/AAAzCCvSTl0TBZSXFs6y3vRra?dl=0

Hestercombe drawings:

https://www.dropbox.com/sh/6uyvrafkhkvh1a2/AABDV8ZjY3dq7H6sJlC2RQsla?dl=0

Résumé en Français

Le doctorat étudie l'impact des nouvelles technologies sur la transmission et la promotion du patrimoine culturel sur les élèves des écoles primaires afin de démontrer l'importance d'une pensée éducative qui allie 'histoire', culture visuelle et 'technologie'. Deux études de cas à partir de deux « corpus » distincts ont permis de conduire deux expérimentations in situ : l'architecture antique en Italie à Vérone et le jardin paysager du XVIIIe siècle en Angleterre à Hestercombe. La co-tutelle été encadrée par un spécialiste italien du story-telling éducatif en réalité augmentée (Prof. Corrado Petrucco, Padoue) et un spécialiste français des jardins et du paysage dans la culture britannique des Lumières (Prof.Laurent Châtel, Lille). Il ressort de l'étude que l'apprentissage par réalité mixte mobile (Augmented and mixed Reality Mobile Learning) est particulièrement pertinent. L'apprentissage mobile est né dans les années 80 lorsque l'ordinateur portable (sommet de la technologie de l'époque) a été introduit dans la classe sur une base expérimentale (Kukulska-Hulme et al., 2009). Puis sa popularité est venue à la fin des années 90 grâce à des programmes éducatifs expérimentaux pour explorer le potentiel éducatif du PDA (Personal Digital Assistant). Depuis le milieu des années 90, on a pu identifier trois principales phases de l'apprentissage mobile, qui ont trois approches paradigmatiques différentes: les outils, l'apprentissage en dehors de la salle de classe, la mobilité des étudiants (Sharples, 2006). Le rôle de l'enseignant devient plus fondamental encore: l'utilisation d'une application sur tablette ne vise pas à remplacer la guide ou l'éducateur culturel, mais à compléter et à enrichir la visite. Du point de vue pédagogique, l'accent sera mis sur une approche constructiviste de l'enseignement et l'apprentissage qui va stimuler les étudiants à devenir des citoyens actifs, bien conscients de leur identité historique : en tant que personnes informées et responsables, elles sont en meilleure mesure de préserver leur patrimoine. Dans sa publication " Cultural Heritage Counts for Europe (CHCfE) Vers un indice européen pour le patrimoine culturel" (CHCfE Consortium, 2015), le Conseil de l'UE des ministres européens considère le patrimoine comme une "ressource stratégique pour une Europe durable" et une source importante de créativité et d'innovation, qui génère de nouvelles solutions aux problèmes, tout en créant des services innovants - allant de la numérisation des biens culturels à l'utilisation de la technologie de la réalité virtuelle de pointe - dans le but d'interpréter les espaces et les bâtiments historiques et les rendre accessibles aux citoyens et aux visiteurs.

English Summary

The thesis studies the impact of new technology on the transmission and promotion of heritage on primary school pupils in order to demonstrate the importance of an alliance between history, visual culture and technology. Two case studies with two distinct types of corpus generated two experiments in situ : ancient architecture in Verona (Italy) and eighteenth-century landscape garden at Hestercombe (Britain). Verona and Hestercombe are two sides of the same patrimonial coin. The co-supervision was done under a specialist in digital story telling of history, Corrado Petrucco (Un. of Padua) and one in eighteenth-century garden and landscape history, Laurent Châtel (Un. of Lille). Mobile Learning began in the 80's when portable computers (the "in-thing" in those days) where first introduced into the classroom on an experimental basis (Kukulska-Hulme et al., 2009) being a genuine take-off in the late 1990's thanks to experimental educational programs aimed to exploring the didactic potential of PDAs (Personal Digital Assistant). From the mid 90's to today, three different phases can be pinned down : a tool-focused phase, extra-mural learning, and an emphasis on student mobility (Sharples, 2006). What this study shows is that the teacher's role is of fundamental importance. The learning process is on site, situated and enhanced by AR tools and devices (which are equipped with an 'app' developped specifically for this project): the 'app' is however not intended to replace the guide or the cultural educator, but to be complimentary and to enrich his/her route. In its documents such as "Cultural Heritage Counts for Europe (CHCfE). Towards a European Index for Cultural Heritage" (CHCfE Consortium, 2015) the EU Council of European Ministers recognized heritage as a "strategic resource for a 'sustainable Europe" and a source of benefits – a source of creativity and innovation, generating new solutions to problems. This thesis shows why and how heritage education when augmented via technology improves the interpretation of historic environments and buildings, and also makes them accessible to citizens and visitors.