Digital Storytelling with Augmented Reality as Learning and Teaching Innovation for part-time MBA Students: Learning Styles and Perceptions.

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Dedication

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[mâI mii krai - gὲε - gəən - rian]

You are never too old to learn.

...

But it needs lots of coffee and long nights of work.

Abstract

Augmented Reality [AR] brings new dimensions of Technology Enabled Learning [TEL] to gamification, mobile devices, and self-directed learning. Whilst pre-designed interactive AR learning methods in Higher Education [HE] were promising, the student perspectives and the impacts on learning preferences when students would self-directed create AR content were not clear.

This study investigates learning experiences of Master of Business Administration [MBA] students using AR as a vehicle for TEL in HE, where students create own AR stories. There are three overarching themes to explore: the impact of AR storytelling as learning method on student learning style [LS] preferences, perceptions, and experiences.

A dedicated AR storytelling intervention creates the frame for relatively large sample. A mixed method design collects data on student experiences and perceptions in a pre- and post-survey, while applying Felder's LS inventory twice. Qualitative responses are analysed with manual and artificial intelligence [AI] aided methods, whereas Welch's test guided analysing scaled data. This approach helps understanding impacts, interrelating and comparing experiences with AR storytelling.

The findings suggest students prefer serial learning styles when creating AR stories. Despite favouring a balanced mix of learning and teaching methods, students perceive AR storytelling as supporting skill building and personal learning, likewise addressing the diversity of their learning preferences. Students consider creating actively AR stories fosters technology self-efficacy and motivation, and as a suitable TEL method benefiting their careers.

The unique student's perspective expands our knowledge in the field of applied AR storytelling in HE. This study adds a unique mix of pre-/post data collection methods in combination with less common AI and Welch testing methods for analysing scaled data to methods portfolios. Eventually, this study proposes valuable implications on HE policy, instructional design as well for extending further research based on question raised through this study's findings.

Keywords:

Education, Technology Enabled Learning, Immersive Technology, Engagement, Motivation.

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Glossary

Acronym	Definition
AC	Active
ACL	Active Learning Styles
ADDIE	ADDIE Model Systematic instructional design model consisting of five phases: Analysis - Design – Development – Implementation - Evaluation
AI	Artificial Intelligence
AR	Augmented Reality
ARCS	ARCS Model Attention - Relevance - Confidence - Satisfaction
AV	Augmented Virtuality
DST	Digital Storytelling
eaMBA	Executive Apprenticeship Master of Business Administration
eMBA	Executive Master of Business Administration
FS-ILS	Felder-Soloman Inventory of Learning Styles
FT-MBA	Full-Time MBA
g	Grade of ILS tendency variable
HARP	Heightening your Awareness of your Research Philosophy
HCD	Human Cantered Design
HE	Higher Education
HEA	Higher Education Academy
ICT	Information and Communication Technology
ILE	Interactive Learning Environment
ILS	Inventory of Learning Styles (Felder)
IPA	Interpretative Phenomenological Analysis
IPI	Prescribt Instruction
IQR	Interquartile Range with a minimum of 3 observations.
LMS	Learning Management System
LS	Learning Style
LSI	aka. Learning Style Inventory (Felder). See also ILS.
LSM	Learning Style Models
MBA	Master of Business Administration
MBTI	Meyer-Briggs Type Indicator
MD	Median
MIM	Mixed Methods

MR	Mixed Reality
MRE	Mixed Research
MS <Excel>	Microsoft
MUM	Multi Method
N_{ax}	Number of attendees (in group x)
N_{px}	Number of participants of the study or data collection method (in group x)
NLP	Natural Language Processing
OECD	Organisation for Economic Co-operation and Development
p	Participant variable for identifying specific quotations
PISA	Programme for International Student Assessment
PG Cert	Postgraduate Certificate
PT-MBA	Part-Time MBA
RQ	Research Question
S	Score of ILS tendency variable
σ	Standard Deviation
SAM	Successive Approximation Model
SN	Sensing
SNL	Sensing Learning Styles
SQ	Sequential
SQL	Sequential Learning Styles
STEM	Subject group of Science, Technology, Engineering, and Mathematics
SDT	Self-Determination Theory
TEL	Technology Enhanced Learning; Technology Enabled Learning
TELE	Technology Enhanced Learning Environment, Technology Enabled Learning Environment
UNESCO	United Nations Educational, Scientific and Cultural Organization
VS	Visual
VSL	Visual Learning Styles
VR	Virtual Reality

1 Introduction

1.1 Introduction to the Research Problem

The aim of this study was to investigate the often-neglected perspective of students on Augmented Reality [AR] in a Technology Enabled Learning Environment [TELE] as numerous publications focus on technology-driven instructor perspectives. A key objective in this research was to gain knowledge on what part-time Master of Business Administration [MBA] students at Aston Business School perceived and experienced in an e-learning intervention where the students created a digital story with augmented reality in comparison to traditionally (conventionally) designed learning. From a student perspective, the study investigated personal learning traits, perceptions towards AR enabled learning, learning experiences including motivational factors, in a pre and post evaluation.

The following sections draw on the background and context for this study, as well expand on the research problem and purpose that led to the specification of five key research questions. Further sections depict the research approach, followed by some underlying assumptions. I go on to consider the personal role of the researcher and conclude with a statement of the rationale and significance of this study.

1.2 Background and Context

The use of digital media in teaching should support students in learning and prepare them for the future career requirements. New innovative technologies, such as AR, can provide students with different and alternative perspectives during their taught programme. A prominent example is provided by the advent of the AR game 'Pokémon Go' (Anderton, 2016; Clark and Clark, 2016; Godwin-Jones, 2016), whose interactive and visual approach, novelty and topicality influence and shape student opinions of chosen methods in TELE. However, on a policy and departmental level Higher Education [HE] institutions look on innovation in TELE primarily in terms of feasibility, costs, or accessibility. Furthermore, the application of TEL innovations is often dictated by the possibilities, the will of adoption, or the educational status, of a lecturer or the organisations (Kirkwood and Price, 2016).

Numerous recent publications on AR in educational environments exposed a focus on the perspectives of educators on the application, as well implementation, of AR for learning and teaching (See a selection of literature in Table 40 in appendix 7.1). However, the literature regularly disregards student perspectives leaving their perceptions as a secondary concern.

For example, the study of Karlsson et al. (2016) might be a representative for exploring possibilities and potential issues of an AR teaching environment in a use case for stakeholder such as instructional designer, teachers, and management. Similarly, Miller and Dousay (2015) draw on challenges for educators when implementing AR in a classroom, mainly concentrating on conceptional aspects of AR in teaching. But the authors mention the possibility of integrating students to *"drive the creation of AR experience"* if instruction designers do not have the time to design new learning modules (Miller and Dousay, 2015, p.7). A further pattern in AR publications is often a presentation of a prototype of a AR environment and its applications in education, such as an AR textbook developed by as Ivanova et al. (2014) who draw on the implementation of content for a mechanical engineering student that is aligned to the course objectives. These previous three examples have in common that they report only on what students can do with an AR learning environment and imply that AR could be beneficial for student learning without asking students themselves. On the other hand, Cabero et al. (2019) represent some studies that have started to recognise student aspects of AR for teaching and learning by investigating student perceptions with a Technology Acceptance Model [TAM] and the impact of AR on student performance. However, the online literature search results for this study revealed the earlier mentioned emphasis on technical aspects of applying AR in teaching and learning environments, as well teacher perspectives on AR enabled learning, already in the headlines of numerous publications. For reference, a typical non-representative overview of examples in the literature is offered in Table 40 in the appendix 7.1.

Such a limited and teacher-centred perspective fails to consider the expectations and perceptions of students on eLearning innovations, such as their personal learning outcomes or acceptance of the adopted innovation, both of which are essential for the viability and veracity of e-Learning innovations. In a broader view of TEL as Kirkwood and Price (2005, pp.257, 260) clarify *"it is not technologies, but educational purposes and pedagogy, that must provide the lead, with students understanding not only how to work with ICTs, but why it is of benefit for them to do so"*.

Based on a study with part-time MBA students this thesis addresses relevant questions such as: What are the student's experiences with digital AR storytelling, how does this affect their perception of AR use in their learning process and motivation, and how will this affect the development of their learning preferences?

1.3 Problem Statement

Technology has become a crucial part of our lives in today's society. It has changed the ways people think, apply and gain knowledge. Subsumed in the term Technology Enhanced Learning[1] [TEL], a number of authors have commented on the problem of assuming that any technology will enhance learning (Bayne, 2015; Weston, 2012). Consequently, TEL gained more attention from educational researchers, who applied and addressed many different existing computer-based technologies, such as mobile-learning, Internet based learning, and virtual and augmented learning. AR technology has found its way into many areas of education and promotes concrete approaches to learning and can close methodological gaps in teaching, for example, applying AR to situations that could expose students to potentially dangerous situation or that were too expensive if a real object is used.

Publications focusing on technology-driven instructor perspectives (Bacca et al., 2014; Radu et al., 2010) have neglected student perspectives on technology enabled learning and teaching and how it might influence learning styles. Furthermore, many studies on AR in educational settings conceptualise students as passive consumers of prefabricated AR learning content, which come in form of learning applications and games (Gómez-Trigueros, Ruiz-Bañuls and Ortega-Sánchez, 2019; Hantono, Nugroho and Santosa, 2018; Shiue et al., 2019; Koutromanos, Sofos and Avraamidou, 2015; Li et al., 2015; FitzGerald et al., 2012), instead of enacting active and creative roles by, for instance, letting them to create their own AR enabled digital story.

[1] Recent literature defines more often TEL as Technology Enabled Learning because the term "enabled" seems for many educational researchers a less controversy interpretation due to not implying any (pre-)valuation of technology in learning and teaching environments. This issue is discussed in a later section (see 2.2.3) and technology enabled learning is the term used in this study.

1.4 Statement of Purpose

The purpose of this study was to explore student perspectives on an AR enabled learning and teaching method and the impact of technology enabled learning environment on student learning styles where students created their own AR digital story.

1.5 Research Questions

How do students perceive and experience Augmented Reality as an innovative technology enabled platform for personal learning in comparison to traditional methods?

This raised the three specific research questions:

RQ 1. Does creating an AR experience support the student's learning process and what features do they consider the most useful?

RQ 2. How do students perceive AR enabled learning and what are their learning preferences towards this method?

RQ 3. Does the experience of AR change student learning style preferences?

1.6 Research Approach

This study adopted a mixed method design as a combination of qualitative and quantitative approaches provides a more complete understanding rather than either approach alone, while countervailing some of the limitations of each single approach (McLaughlin, Bush and Zeeman, 2016).

The selected educational AR intervention suggested the application of a quasi-experimental non-equivalent groups design, since it was assumed that the participating students would not be randomly assigned (Muijs, 2004, pp.26–30). Nevertheless, the different MBA courses indicated that the groups might be of different sizes and likely dissimilar in some ways. This study collected data using a convergent parallel[2] mixed method where both forms of data were collected at the same time and the data integrated for analysis and interpretation of the overall results (Doyle, Brady and Byrne, 2016).

[2] Sometimes literature refers to this as concurrent triangulation design.

Primary data was collected pre and post an AR intervention for the purposes of answering the research questions by using two surveys of student learning styles using both open- and closed-ended questions and supplemented by observational data (Bickman and Rog (Eds), 2009, pp.297–298). The pre-intervention survey collected demographic characteristics and included the Felder Inventory of Learning Style [ILS] questionnaire. Similarly, the post-intervention survey included an ILS questionnaire, demographic questions, and additionally exploratory questions.

The mixed nature of the collected data required an analysis with statistical and text analysis methods. According to the characteristics of the questions in the questionnaires this study chose appropriate methods, such as Welsh test for Likert scaled questions (De Winter and Dodou, 2010). The mixed research approach provided a way to interpret quantitative data statistically, while investigating qualitative data for potential themes and patterns. Besides the initial manual interpretation of the collected qualitative data an Artificial Intelligence [AI] based sentiment and emotion analysis supported identifying clusters of potential themes (Russel and Ryan, 2003; Dong and De Melo, 2019). Both data sources, quantitative and qualitative, were additionally the basis for a cross database interpretation to connect qualitative themes to quantitative findings and vice versa.

1.7 Assumptions

Every study and researcher are influenced by certain assumptions since they do not exist in a vacuum and knowledge is imperfect. The following list is a set of assumptions made before the study started, which were important in shaping the design:

- MBA students will be interested in AR as learning and teaching method.
- The students might be more interested in pragmatic experiences that they could adopt to business and their future career.
- MBA student are older and more mature students than undergraduates due to course entry requirements.
- Part-time MBA students will be more self-directed learners in comparison to on-campus and younger students.
- MBA students compared to undergraduates and other taught postgraduate programmes exhibit a higher degree of motivation and expectation due to their investment in time and money in connection with other social commitments.

- MBA students have developed lateral thinking skills as they have managerial experience of adapting to environment changes requiring lateral thinking skills.

1.8 The Researcher

For the purposes of transparency and as it has implications for all aspects of research (data collection, analysis and interpretation), the background of the researcher and his experience, is briefly presented in the following.

Over the last 25 years I have had a career as an engineer and senior manager in Information Technology and Communication [ICT] within different industries. Additionally, I hold degrees in Electronic Engineering and Computer Science & Business, and I graduated from a full-time MBA program at the Aston Business School in 2011, which provided a wide multidisciplinary background and insights for my profession and this particular study. In recent years, these abilities were the foundation for developing new products, focusing on innovative digital technology for product application and knowledge management. Innovative technology, such as AR and AI played an important role in accelerating digital transformations within the information management and training environments in which I worked. These business experiences with AR led to the idea to go a step further and investigate deeply the role of AR as a learning enabling and teaching vehicle.

From the beginning it was clear that an MBA group would be the sample for this study. The part-time MBA programme crystallised as the target group for the educational AR enabled intervention. Some assumptions were that these part-time students were highly motivated, are away from academia for some time, and might welcome a practical approach to learning and teaching. Personally enrolling for a PG Cert for teaching and learning provided me with insights and guidance on how to approach classroom biases. Additionally, I held classes on online change management simulations, which offered me the opportunity to talk to current MBA students during and after the intervention, and the research environment at the university allowed me to talk to and to exchange with other academics and research students from diverse disciplines. These experiences helped me to become an academic and to identify potential issues within a mixed method research design.

This awareness included also managing the hurdles of qualitative and quantitative research approaches. In a perfect quantitative study, the researcher's role is, theoretically non-existent because participants should act independently of the researcher as if he were not there. However, since I had in this study also the role of a lecturer, I might have influenced the students in different ways. Students might, for example, have disliked the intervention or the research, which in turn might have influenced their responses in the questionnaires.

In general, I consider myself to be a pragmatic person, choosing the best method to gain the best results rather than 'what works best'. This is the result of many practical experiences in industry, in which I learned to dislike and to disagree with 'best practices' approaches in favour of 'good practices', because the application of methods, resources and processes are always relative to the pursued aim and context. This was also driving my decision for a mixed method research design as a good approach for this study.

In the qualitative aspects of this study, my role as researcher is different, since in this situation I am considered an instrument of data collection. The situation was twofold. Firstly, as a full participant in intervention for this study I was taking an emic role within the social group, but at the same time, I tried to take an etic role as a more distant observer. Each of the roles influenced the research because of assumptions and preconceptions that had to be surmounted to reduce bias. Therefore, as I became a more objective observant, I considered it as helpful to get some distance between data collection and analysis. This time shift and that the participants participated anonymously allowed to a certain degree to dilute personal bias, premature interpretations and expectation of the outcome of the collected data. Furthermore, I started as a loose member of the sample group and perceived it as a further reciprocal influence that challenged the aim of gaining relative objectivity.

Secondly, I had to develop instruments for the qualitative data collection, and being a human instrument resulted inevitably in including biases and assumptions, expectations, and experiences. Furthermore, the subject language was English, and not being a native speaker, required discussions and reviews with other academics to gain the best possible understanding of the participant’s responses. This added another level to the challenge of analysing and interpreting qualitative data, and my pragmatic stance led to integrated AI aided interpretation of student answers to balance any inadequacies of my personal interpretations and understanding.

1.9 Rationale and Significance

This research had the following aims: To scientifically explore the use of AR as a digital medium for active digital storytelling from the students' perspective. The study therefore intended to capture and relate the students' experiences and expectations of learning with an AR supported method, as well as the students' learning style preferences, in order to illustrate the potential pedagogical value of this TEL approach from the students' perspective. These findings can serve as a knowledge base to complement, further develop and integrate existing portfolios of learning and teaching methods with innovative student-designed AR learning environments as new didactics for e-education. The following is expanding this rationale and perceived significance in more detail.

The literature of recent years on educational research on AR application in HE suggests that the adoption and use of AR as a learning technology is still predominantly teacher-centred, with most of the learning impetus coming from teachers as well as the suitability as a pedagogical method being determined by teachers. However, this leaves out the students' experiences and expectations of learning with AR as a (technology-enhanced) learning method. The preparatory literature review to this study additionally revealed a trend in the applications of AR in the classroom towards passive-interactive AR learning environments that provided students with a predetermined learning structure and content rather than considering active integration of student in learning with AR methods.

The two main points, teacher centricity and *passive AR learning*, were the origin for the research questions that defined the novel approach for this study. The new approaches of this research were, first, considering the student's perspective on the application of AR as a learning method and, secondly, using an AR environment that allows students actively forming their AR learning by offering them to create their own digital story using an AR tool.

In addition to these two aspects, it seemed also to be methodologically important to examine the influence of AR on the student's learning styles at two measurement point rather than only survey them in a post survey as many past studies did, to reveal influence of AR on the student preference and to relate them to their experience and perceptions. Furthermore, the study sought to explore the extent to which digital AR storytelling interventions could enhance awareness for potential AR applications, not only within learning and teaching but particularly as beneficial skills that might prepare students better for their future career.

This contributes narrowing certain gaps in literature because the results of this study might provide instruction designers and organisations with guidance on how AR enabled learning could be an alternative to traditional methods. Furthermore, studying the impacts of creating a digital story with AR is significant because it could help to relativize perceptions on student learning by providing ideas on learning style changes and potential learning impacts through actively creating digital stories with AR and the importance of student perception on learning and teaching with AR.

The outcome of the later might be valuable aid for instruction designer, lecturers, educational decision makers, especially in the current time of digital transformation of all societies, to gain a better understand of the expectations and perceptions of AR as one TEL method. From an educational perspective, it can be concluded that this study contributes to the challenge to measure pros and cons of a digitalisation of education, for students as well as instructors.

From a research perspective this study could be a starting point for further research in the field of learning and teaching with AR environments, which should include, for example, longitudinal primary and meta research. Expanding studies through integrating analogue and digital methods might allow better prognoses, based on existing knowledge, for what students might find engaging and helpful for their personal learning from a medium-term perspective.

In summary, this study's intention was to solve some questions of the impact of creating AR stories on student perceptions, expectations and learning styles.

1.10 Introduction Summary

This chapter began with an overview of the research problem through connecting it to background information and establishing a context, followed by a specification of the purpose of the study that led to five specific research questions. Subsequently, an overview described the research approach and the research environment, what and how data was collected in relation to an intervention where students created a digital story with AR. Since research does not exist in a vacuum some assumptions were explained that led to the methodology. These assumptions were then explored in relation to a discussion of the personal background of the researcher. To complete the introduction the rationale and perceived significance of this study was considered. The next chapter sets out a literature review on the learning domain, motivation in learning with technology, policies and perceived gaps in the literature that are relevant to this research.

2 Literature Review

2.1 Introduction

Based on the previous context information, the assumptions made and the nature of AR, in general and a university business school educational context, the literature review discusses various themes from the learning domain, including the student perspective. As AR as learning technology is not yet as established as other TEL methods and environments in HE, such as Massive Online Courses [MOOC] and digital simulations, there is a lack of AR specific literature. With this literature review this study extends more general concepts, models and theories in education to learning and teaching with AR in order to highlight how this study can contribute closing knowledge gaps.

First, the review addresses learning in general and specifically technology-enabled-learning in higher education. The attention then moves to TEL and its commonly perceived relation to student engagement, followed by AR applied as technology enabled learning and teaching method. This leads then to a discussion of learning styles theory and their application to TEL and in AR enabled learning. A further two sections deal with students' learning and their perspectives on learning before considering specific themes related to digital storytelling with AR. Literacy in a general view of the student's ability, confidence and willingness to engage with learning, and digital literacy in relation to AR enabled story telling are explored in the next two sections. This leads then to storytelling and specifically to digital storytelling as it was applied in this study. The next three sections discuss more specifically the student perspectives, potential engagement issues and motivational factors that might influence student learning and thus their perception of AR in a learning and teaching environment. From an organisation perspective, the last section briefly looks at some potential Higher Education policy issues in relation to the integration of new technology in university strategies and programmes.

2.2 The Learning Domain

2.2.1 Learning

Since this study relates to TEL it will mainly focus on learning theories, general and specific, that are connected to this field of learning.

For explaining human learning and its processes numerous theories and models exist (Anderson, 2013; Bednorz and Schuster, 2002; Lefrancois et al., 2013). Many scholars relate three traditional theory approaches for learning influenced by media and technology, which are: behaviourism, cognitivism and constructivism (Ertmer and Newby, 2013; Merrill, 1991).

Nevertheless, there are further theories to learning, such as pragmatism, which was recently more often connected to TEL to explain phenomena when students learn with technology. Referring to e-Learning in particular, Kerres and de Witt (2004) perceive a paradigmatic approach to learning and teaching with technology as a misleading approach. They suggest that a central question is rather, under which conditions people can learn successfully with new media? This is a matter of describing the process of how learning media can be designed in order to reach specific target horizons. They do not see pragmatism in education as a competition to behaviourism or constructivism rather as a horizontal diversification that does not generally rate one over the other but questions, which concept might offer the best result in a certain situation or interaction for a learner.

Behaviourist learning theories understand learning as observable change in behaviour effected by environmental stimuli. Well known are classical conditioning studies of early behaviourists such as Pawlow, Watson, Guthrie or Thorndike, which have been extended by Skinner by associating also operant (instrumental) conditioning that ties stimuli to learned reaction in behaviour. The relation of stimuli and change in behaviour are central for behaviourism, which addresses the visual aspect of AR enabled learning, but does not account psychical or emotional aspects (Arnold, 2004; Baumgartner and Payr, 1999; Ertmer and Newby, 2013; Kerres, 2001; Schulmeister, 1995).

Cognitivists, in contrast to behaviourists, emphasise the importance of inner processes and cognitive structures of intellect, where learning is understood as a cognitive information processing. Cognitive theory explores changes in a student's understanding that result from learning, where students adopt cognitive structures for their perceived environment that are recursively changed to build up new knowledge.

Characteristically, students can select their own optimal way of learning, while stressing active student participation and reflective approaches (Anderson, 2013; Arnold, 2004).

In the 1990's the development of new constructivist learning and teaching research approaches emerged with a great variety of, sometimes contradicting base propositions, theory developments (Grasel et al., 2013). Broadly, constructivist learning theory is understood as an approach where learners are actively and autonomously gain new knowledge. Knowledge is not understood as the result of an information transfer but as an autonomous construction process of a learner (Jonassen, Mayes and McAleese, 1993; Reinmann-Rothmeier, Mandl and Prenzel, 1994). According to Loyens and Gijbles (2008) are the construction of knowledge, cooperative learning, self-regulation (homoeostasis) and authentic learning typical characteristics of constructivist learning environments. They furthermore argue that knowledge construction, often related to real-life issues, is based on actions and experiences make in learning environment. In summary, can these characteristics conform the earlier mentioned AR enabled learning characteristics.

2.2.2 Traditional versus Modern Learning

At this point it is worth to define the difference between traditional and modern learning and teaching approaches. This is challenging because there are no commonly agreed definitions for methods and methodologies for both, traditional and modern, approaches in the literature. Reason for this shortcoming might be different perspectives (teacher vs. students), varying learning experiences and perception of different generations of learners and teachers, view roles and power distribution (directed/self-directed) (Dewey, 1938; Freire, 2000; Karanezi, Rapti and Halimi, 2015; Novak, 1998). The following table shows a collection of methods and approaches that are attributed to either traditional and modern learning and teaching methods, which illustrates the difficulty to find a commonly valid definitions that embrace methods as well methodologies (see next page).

Table 1 - Typically Named Characteristics for Learning and Teaching Approaches

Traditional	Modern
Acceptance of pre-defined knowledge, facts, ways of thinking	Activity-based learning and learning labs
Addresses only a subset of learning types	BYOD – Bring your own device
Call and repeat approach	Collaborative learning
Chalk and talk methods	Continuous comprehensive evaluation
Close supervision	Cross-curricular connections
Facts based	Differential learning
Few technical tools	Digitisation in teaching, learning, learning assessment and feedback
Focus on textbooks (structure, path, content, etc.)	eDocuments
Highly structured with less flexibility	Emphasis on skill building, life skills and values
Improper alignment between objectives, activities and assessments	Emphasis on understanding of concepts
Knowledge transferred often perceived as not relevant for future life	Experiential Learning
Learning though recitation, explanation, and examination (rote)	Flipped classroom
Less collaboration and group learning	Formative and summative assessment
More passive role of students	Inquiry-based learning
Non-Web Technologies for teaching support	Integrative in Nature (holistic approach)
Often more emphasis on examinations and results rather than understanding of concepts	Interdisciplinary learning
One way for right answer, skills, and concepts	Learner-centred
Out-dated materials, cases, etc.	Linking curriculum to student relevant themes
Paper-based	Problem-based learning
Regimented classrooms	Promotes Learning among all Categories of Learners
Teacher-centric classrooms	Promoting Critical Thinking
Teachers in the mode of knowledge dispensers rather than facilitators	Resource-Based
	Self-supply of information through new media
	Smart interactive boards
	Technology-driven classrooms
	Use of Concrete Materials
	Use of eTools for tackling tasks
The above attributes are composed from non-representative selection of literature (Broughton et al., 2002; Conole et al., 2006; Del Campo, Negro and Núñez, 2012; Dominic, Francis and Pilomenraj, 2014; Kerres, 2001, 2001; Kuzu, 2007; Manolis et al., 2013; Methitham, 2011; Novak, 1998; Richards, 2006; Schulmeister, 1995; Scrivener, 2005).	

The previous table suggests that defining either learning and teaching approach is a difficult task since there are many components, views and influences that might make one approach a traditional method to one student but a modern method for another. Furthermore, some of the attributes are subject to changes and thus let one realise that a definition of traditional or modern learning and teaching approaches will in many cases not be stable over time.

In short, Richards (2006) suggests that traditional teaching and learning could be seen as a often teacher-led and fixed facts centred approach where the learning happens under a teacher's control, by making use of traditional methods and tools that do not comply with the current state of the art or Zeitgeist. Such teacher centric methods can be found in various literature where, for example, Brown (2002, 1995) describes a traditional approach to learning and teaching from his pedagogical self-conception as the perceptions of teachers of what is important for learner to learn based on preconceptions, assumptions and theoretical underpinnings. These approaches build on teaching and learning methods that in general are *"a specific set of procedures more or less compatible with an approach"*, which make use of techniques that apply *"a very specific type of learning activity"* (Celce-Murcia, 1991, p.9).

A potentially well-known critique of traditional learning and teaching approaches, as well methods, comes from Freire, who proposed radical ideas about education and the roles teachers and methods for student learning. He claimed that education and a teachers' role cannot be neutral by the means of solely transferring undifferentiated, homogenized fact-based knowledge. In his view of the teachers as an instrument for facilitating learning, where *"the teacher is of course an artist, but being an artist does not mean that he or she can make the profile, can shape the students. What the educator does in teaching is to make it possible for the students to become themselves"* (Horton and Freire, 1990, p.181).

Based on Freire's ideas (Freire, 2000; Horton and Freire, 1990), this creation of development possibilities might be the key for the definition of modern teaching and learning methods, especially with technology that enables the learning process of students. In a learning environment that adopts modern methods the students have usually more control over their learning and the set of knowledge that is intended to transfer usually follows a less static path. With this in mind, modern teaching and learning could be considered as a set of more dynamic student-centred approaches and methods, that address student needs and make use of recent technologies to support learning and teaching (Darder, 2015).

2.2.3 Technology Enabled Learning

Less effort has been made to explain technology in relation to TEL in the past but educational technology research is including this deficit more and more in a 'philosophy of technology' and other fields of research (Jaldemark, 2018; Mørch, 2009; Oliver, 2013).

In recent years, the term TEL seemed to have substituted previously used terms, such as, 'learning technology' and 'e-learning', specifically in English speaking countries (Bayne, 2015; Kirkwood and Price, 2016, p.2). However, there is ongoing discourse of the validity of the enhance attribute in the term TEL. For example, Kirkwood and Price (2013) argue that it is difficult to define what TEL actually means, since the term has been used often without clear definition. Several researchers also questioning the enhancing attribute of TEL, arguing that there is no absolute proof that technology will always enhance the learning of students (Kirkwood and Price, 2013; Price et al., 2010; Bayne, 2015). Some educational researchers started to replace TEL in favour of a technology enabled learning discussion, even started an initiative for technology enabled learning (Kirkwood and Price, 2016, p.V). This reorientation highlights that technology should be seen as enabler for new learning methods and processes, which is supported by Ertmer and Ottenbreit-Leftwich (2013, p.181), who argue that technology in education should play *"a supportive rather than a starring role, enabling the successful achievement of both instructional and learning goals"*. Nevertheless, an enhancing effect of technology is not neglected rather seen as a potential of technology in learning environments and for personal learning process (Fisher, 2010; Commonwealth of Learning, 2019; Ferguson, 2019).

Using technology as form of knowledge transfer raises often specific demands for learning and its environment. Learning shall be fast, easy, autonomous from time and location, individual in terms of individual's learning speed and content presentation. In comparison to traditional teaching and learning methods TEL is expected to be entertaining, more interesting and effective (Attwell and Hughes, 2010; Clark, Mayer and Kay, 2011; Dichanz and Ernst, 2001).

Many people understand TEL as some new teaching and learning discipline, but technology has been used to enable or enhance learning for a considerable time. In 1588 Agostino Ramelli developed a reading-wheel to ease the access to several literature sources at once (Wikipedia, 2016). The first patent for a learning machine was secured by Halycon Skinner[3] in 1866. A more sophisticated multiple-choice machine for testing intelligence was introduced by Sidney Presley and just 10 years later Burrhus Skinner and Holland offered linear learning programs that promptly gave feedback to learners. Preparing the way for today's hyper-media methods Croder's programs integrated in 1959 first individualisation through branched programming and for higher education, while Bob Jensen and Petra Sandlin determined and described detailed hypermedia and hypertext systems (Jensen and Sandlin, 1995; Wikipedia, 2017). These mechanical and electronically solution depict nicely the earlier mentioned expectation on TEL.

[3] Due to identical last names the first names of the inventors are preserved in the text.

2.2.4 Augmented Reality applied to Learning Environments

The next sections are expanding on AR applied to the practice of learning and teaching in higher education.

2.2.4.1 Definitions and Differentiation of Augmented Reality

Augmented Reality needs some brief definition to distinguish it from apparently similar technology such as Virtual Reality [VR]. A definition is additionally important since in some educational literature and some AR providers adopt certain terms interchangeably and inconsistently, such as Microsoft is using the Mixed Reality for its AR products (Microsoft Corp, 2021). Furthermore, such definition enables a basic understanding what the positions and possibilities AR and other virtual environments could take in educational settings.

Based on Milgram, Azuma and Mann this study proposes to use a simplified general definition defining Augmented Reality [AR] as a combination of reality and virtual reality, in which users can interact in real-time, while virtual objects may not be limited to superimposed visual impressions but may address auditory, olfactory, gustatory or somatic senses as well (Azuma, 1997; Mann, 2002; Milgram and Kishino, 1994).

A first comprehensive definition comes from Milgram et al. (1995), in which AR connotes a computer aided sensation or representation, which expands the real world by virtual aspects. The authors introduced the 'Reality-Virtuality-Continuum' to illustrate the position of AR in context to the real and (mostly) computer generated worlds.

One side ends in the 'perfect reality' and the other in the 'perfect virtuality'. The space between these extremes characterises the degree of applied virtuality, called ‘Mixed Reality’ [MR]. AR is then defined as an element of MR, which consists of AR and Augmented Virtuality [AV]. If an application can be attributed to AR or AV is determined by the degree of the real or virtual spheres within the Reality-Virtuality-Continuum. If only a view of virtual objects is embedded in the real environment it is defined as ‘Augmented Reality’, which is located closer to reality. However, the area where virtual objects predominate real world elements is, in contrast, termed ‘Augmented Virtuality’.

To define AR Ron Azuma (1997) proposed four characteristics: a virtual picture is laid on top of a real-life scene that (1) *combines* the reality with the virtuality. Inserted objects or characters need to (2) be *registered* in 3D, while this registration needs to take place in (3) *real time*. Finally, in general would AR be (4) *interactive*, which involves the integration of different kind of sensors (see graphical illustration in the appendix - 7.9.1).

Additionally, Tamura (2002) explains that MR spans a continuum from graphics enhanced reality to reality enhanced graphics. He, however, argues that there are visual information processors that do not align with this continuum, such as glasses that simulate visual experience of elderly people where focus and colour are manipulated. To heal this issue and to generate a more general definition for MR Mann added a second axis, 'Mediality', to cover all possible manipulations. This refined continuum defines additionally mediated reality and mediated virtuality in a two-dimensional space (Mann, 2002) (see graphical illustration in the appendix - 7.9.2).

In mediated reality, an observer can experience reality in different facets that can be changed by the underlying system by adding (AR), removing (diminished reality) or manipulating (modulated) the perceived reality. To some extend a diminished reality can be seen as the opposite of AR because it removes real existing objects from a real scene (Mann, 2002, 1994). On the other hand, in diminished reality, existing real components are removed from the environment. Thus, diminished reality is in a way the opposite of augmented reality (see graphical illustration in the appendix - 7.9.3).

It should be noted that when exploring introductory literature on AR readers will recognise that most AR definitions are based on the work of Milgram, Azuma and Mann. However, from the previously introduced definitions it becomes evident that those encompass some difficulties with the precision and distinction of different modi operandi. For example, Milligram and Azuma set (total) virtuality [VR] apart from mixed reality, while Mann determines it as a subsection of mixed reality [MR].

To improve these weaknesses Siltanen proposes to define Virtual Reality [VR] as an immersive environment generated through a computer and to expand it to Augmented Virtuality [AV] by integrating real objects like live video into a virtual environment - a reverse approach to Milgram and Azuma, claiming that a majority of AR applications applies visual AR, which is sometimes extended by tactile sensations for haptic feedback. Siltanen summarised his taxonomy for mediated reality [MR] in putting the mediating factors on one axis and the type of environment on the other. Thus, in his model all types of mediality in mixed environments are embraced by mediated reality. Furthermore, he defines the intersection of *change* (mediation) and *mixed environment* as mixed reality [MR] that, relating to Azuma definition, includes interaction, 3D registration and real-time components. A comprehensive diagram in the appendix - 7.9.4, intends to visualise coherently Siltanen's inclusive concept of the Reality-Virtuality-Continuum and the position of AR in it (Siltanen, 2012, p.9).

2.2.4.2 Affordance of AR in Higher Education

Maturing AR technology makes it more feasible to integrate augmentation into educational curriculums. Early adopters were mostly fields with more or less tangible objects that could be superimposed by digital objects by making, for example, experiments more visual comprehensive, enabling students to experience chemical elements and bonds (Prefrontal Cortex 2015). Medical education conceived early applications for visualising body parts, bodily functions and processes (DAQRI 2017). Less material fields also adopted AR for education such as transferring students back in history (University of Wisconsin-Madison 2015; University of Wisconsin-Madison 2010) or supporting students in language learning. Furthermore, managerial education is exploring the possibilities of AR for instructional support, for example, (safety) introductions or decision making support, and interactive management training in form of AR and VR role plays (Lim & J. Lee 2013), which relies heavily on *distance meeting* AR solutions as mentioned above. The later might also change ways of operating distance learning programmes in HE.

Some researchers could already report that the application of AR has positive effects on counteracting the issue of student engagement in certain HE fields (Bressler & Bodzin 2013; Hsu et al. 2017). In the form of digital and online elements in courses, such as e-tests or online lecture recordings, AR has regularly found its way into HE and technologies and is increasingly complementing teaching and learning environments in HE (Cabero and Barroso, 2016).

The potential of AR in terms of didactic integration and evaluation of effectiveness is, however, far from being fully recognised or exploited. In HE setting AR offers the advantage of visiting rooms and places that are difficult or impossible to access, for example, due to climatic conditions, moral and safety concerns, financial consideration or other restrictions. AR in education can furthermore be used for visualising abstract or hidden and thus difficult-to-imagine processes, objects and contexts and thus making them more tangible to students, which may support their learning and subsequently increasing their retention (Bower et al., 2014; Munnerley et al., 2014).

There are different proposals in literature for approaches to the digitisation of higher education teaching. In a top-down approach digital educational tools are created at a higher level such as the introduction of a learning management system [LMS] for the entire university. In contrast, a bottom-up approach is often based on the initiative of the instruction designers and lecturers, who plan and align the use of a TEL tool. However, TEL tools are only suitable for the bottom-up approach if all technical and organisational prerequisites are fulfilled or conceived easily by instructors themselves. Furthermore, rather low technical and organisational requirements ensure low thresholds for use TEL tools, such as AR. If a (new) AR tool is considered to be useful it has the potential to expand the TEL portfolio for a qualitative improvement of teaching and learning in HE, which could easily be adapted by other lecturers for various learning and teaching scenarios (Ferguson, 2019; Singh and Hardaker, 2017; Lisewski, 2004).

The next sections present a small collection of present affordances that applied AR can bring to the practice of learning and teaching in HE:

The discipline of civil engineering deals with planning, constructing and operating structures, such as buildings, roads, and bridges. Technical infrastructure is a discipline in which learning success can traditionally be achieved through the practical impressions of walking through the real-world structures or their surroundings. A project at the Bauhaus-Universität Weimar (Söbke and Wolf, 2020; GeoMotion Games, 2019) expanded this learning experience with an AR application that augmented site-specific information on a smart-phone to complement the actual real environment rather than supporting video see-through AR using a head-mounted-device (HMD). This less immersive AR approach has been perceived as conducive to learning for such on-site visits, as reality has been complemented with additional information and thus, which can support the student's learning processes from the perspective of the cognitive theory of multimedia learning (Mayer and Fiorella, 2014; Mayer and Moreno, 2003).

In the field of management education in HE, students are often confronted with abstract, dynamic processes that require conceptualisation and visualisation. Although a large number of AR-based teaching and learning applications already exist, they often only address primary or secondary education (Yilmaz and Goktas, 2017; Hantono, Nugroho and Santosa, 2018; Vate-U-Lan, 2011; Radu, 2014), or further education for adults who want to learn in an more entertaining way (Lee, 2012; Bacca, Baldiris and Ramon Fabregat, 2018)

However, a gap arises that so far abstract processes and concepts, such as those of management issues, are not overly represented by means of AR. With the help of AR, however, abstract and difficult to imagine processes and concepts could be depicted, visualised and taught. Due to additional possibility of designing AR learning applications as group scenarios AR could bridge practical teaching towards making abstract processes more tangible. This includes management challenges, which could previously only be taught in theory, which affect groups and teams by designing AR intervention that integrate interactive teamwork or learning in groups. AR is considered a good medium in HE for immersive collaborative simulations, particularly suitable in group settings, such as those that take place daily in the context of lectures, colloquia or seminars, due to the potentials of AR to communicate learning content and abstract processes (Wichert, 2002; Martín-Gutiérrez et al., 2015; Schiffeler et al., 2019).

The innovation of this AR approach for learning and teaching in HE lies specifically in the fact that a manipulation of the virtual object by one or more students is simultaneously visible to all participants in an AR group scenario (Söbke and Wolf, 2020; Microsoft Research, 2021; Marketing Aumentado, 2015). This makes interaction possible in order to make further information about it visible to all other participants, or to put together various individual aspects into a complex virtual object together with several students.

This approach of collaborative AR opens up further exciting use cases for which AR technology can represent added value. For example, in the subject of architecture, the joint creation of building models or joint urban planning (Marketing Aumentado, 2015) could be supported via a collaborative AR environment. Or in the field of mechanical engineering and product design, students could collaboratively train factory hall planning and the project management behind, as well design new products or fashion, in a practical and resource-saving way (Marcel, 2019; Ibáñez and Delgado-Kloos, 2018; Scaravetti and Doroszewski, 2019; Elfeky and Elbyaly, 2021; Farrugia et al., 2016).

Students in the medical sector benefit equally from innovative AR technology, as it is highly efficient and revolutionises medical education, among other things. In this way, procedures, processes and organs can be visualised precisely and independently of time, and physical models or real bodies no longer have to be used for a significant part of medical training (4Medical - Elsevier, 2021; Tang et al., 2020; Kwon, Park and Han, 2018; Herron, 2016; Kiourexidou et al., 2015). The current Covid-19 pandemic highlights an additional affordance of AR in academic medical education. Various researchers claim that AR can offer here a *safe place* for students to study and experiment virtually with viruses in a first step of their learning process, solitary or collaboratively, without the need for a laboratory and the exposure to potential risks (Kayyali, 2020; Bolton and Emery, 2020; Wang et al., 2020). However, despite any mentioned field of study, AR offers the opportunity to provide sophisticated learning environments and content for *home-studying* or *distance-learning* situations that require the closure of universities and social distancing (Ahied et al., 2020; Nesenbergs et al., 2021; Makhkamova et al., 2020).

The previous discussion revealed that Constructivist and Connectivist theories can be related to TEL in general. In many aspects AR supports the Connectivism theory of learning since the instructional design in an AR environment requires students to make connections between factual knowledge, ideas and concepts. For the field of blended learning in HE Al-Huneidi et al. (2012) discuss how new technologies support the Constructivism theories of learning, where students construct their own knowledge from their own experience. In this theory the student is the active creator of their knowledge. For this study it is interesting that these theories have also been connected directly to AR enabled learning, since they seem to explain augmented and immersive aspects of learning with AR appropriately. Nevertheless, there are various less common theories that have been applied to AR learning and teaching by researchers such as just-in-time, situated-learning, self-determination and flow theory to explain student motivation and learning approaches (Antonioli, Blake and Sparks, 2014; Dunleavy, 2014; Siemens, 2014; Techakosit and Wannapiroon, 2015). The latter two theories are of further interest since they potentially connect well to student learning motivations and engagement in AR enabled learning and teaching environments.

2.2.4.3 Self-Determination as one Aspect of Motivational Attributes of AR Learning

This general theory of human motivation, developed by Edward Deci and Richard Ryan (Deci and Ryan, 1985), has its main concerns in how learners fulfil their basic psychological needs; the more they achieve these basic needs, the more their behaviour is self-determined. The Self-Determination Theory [SDT] deals specifically with the conditions for the development of intrinsic or extrinsic motivation. The authors again distinguish between different types of extrinsic motivation, which differ in the degree of perceived self-determination (autonomy) (Ryan and Deci, 2000a, 2000b).

According to Rigby and Przybylski (2009) can AR be linked to the SDT since it defines learning that occurs through motivation, because people have the natural tendency to do what is healthy, interesting, important, and effective. Hereby, the focus on self-determination allows the learner to perform out of interest and clearly established goals. The authors point out that some learners may struggle with establishing internal motivation during eLearning courses because they view it as a degree requirement instead of a meaningful experience, thus AR developers should influence students' learning motivation positively by maximising their autonomy, competence and relatedness.

These positive effects on motivation of the use of AR learning environments could be found in various learning situations (Buchner, 2017). Especially the interest in the learning topic and the feeling of self-determination could be promoted through the application of AR in learning and teaching environments (cf. Deci and Ryan, 1993).

Thus, learning and teaching interventions with AR allow a high degree of autonomy, interactivity and potentially working in teams[4], which promote the experience of autonomy and social integration. The feedback through digital media can furthermore support the learners' competence experience, such as technology-self-efficacy[5]. As recent studies indicate a high motivation in AR enabled learning environments should therefore also have a positive effect on the performance of the learners (Goff et al., 2018; Gopalan, Zulkifli and Bakar, 2016; Di Serio, Ibáñez and Kloos, 2013; Diegmann et al., 2015; Gargalakos et al., 2011).

2.2.4.4 Augmented Reality as Opportunity to Experience Flow in Learning

As described earlier, the Flow-Theory explains how people, who are engaged in meaningful activities, are more likely to stay focused, while the access to flow and the experience of flow are different for each individual. According to Csikszentmihalyi (2000) can flow develop from the control of a complex and fast processing events in a region between mental overload (fear) and underlay (boredom). Such phenomenon can also be applied to the activities within an AR e-Learning environment. For example, Bressler and Bodzin (2013) investigated a science gaming experience in relation to flow experience. Their study found a mean flow experience score of 82.4%, which indicates that the average student experienced flow throughout the science mystery game that they played on a smartphone.

According to Sherry (2004) applying educational media, such as AR, requires an understanding how to facilitate a flow experience, thus gratification, to foster engagement with the medium. Furthermore, taking the individual cognitive abilities into account supports this, especially when student lack in experience with a new media. Interestingly, Sherry concluded further that

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[4] See 2.2.11 - Digital Storytelling in Learning Environments for team working within an AR intervention.

[5] Technology Self-Efficacy will be reviewed in section 2.3.3 - Technology-Self-Efficacy in regard to learning with technology.

weaknesses in an educational subject area can be eliminated by designing engaging interventions that respects flow aspects and cognitive challenges while students are engaging with a new media.

Some recent studies on AR in educational environments research found that the flow experience of students might be positively impacted by learning and teaching with AR. For example, in comparison to Web technology Giasiranis and Sofos (2017) found that AR excels in two potential fields. Beside the positive contribution of AR enabled learning to students' performance improvement AR helps students to experience the psychological state of flow, which in turn improves their performance. In another study on AR learning with tablet PC, Huang and Lin (2017) found that students in the experimental group performed better than the control group in terms of the overall flow experience and leaning achievement. They claim that the results for each dimension of flow experience were significant, as they observed the students being deeply involved and enjoyed the AR enabled learning activity. They further concluded that AR enabled learning could potentially better capture and retain students' attention, which resulted in better learning performance.

Influences of cognitive challenges, self-regulated learning and previous experiences on student learning will be subject in later sections[6].

2.2.5 Learning Styles and Models as Scale for Learning Preferences

Neuerburg (2005, p.11) offers an invitingly short and clear definition of learning styles [LS], which are *"preferences of an individual in terms of modality of assimilating, processing and reproducing information"*, shortened by Pashler et al. (2008, p.106) to *"the view that different people learn information in different ways".*

Those definitions induct that learning content should be personalised, considering education and pre-knowledge of learners. Preferences refer to utilised media to present learning content, while individuals present different strengths for certain media. The literature regularly identifies LS, sometimes critically, as subclass of cognitive styles with three main straits as cognition, personality and activity centred (Riding and Rayner, 2013; Sternberg and Grigorenko, 1997). This view

[6] See chapter 2.3 - Motivation in Learning with Technology, 2.3.1 -Idea of Self-Regulated Learning, and 2.3.3 - Technology-Self-Efficacy for motivational aspects that relate to engaging with AR enabled learning and teaching through flow.

suppressed some learning straits that correlate to the characteristics of AR as mentioned before, which are summarised in Vester's and Hüholdt's classical learning styles. Vester recognised that people receive knowledge differently and classified them into learning types. He concluded that there are infinite combinations of learning types, which he grouped in four learning styles. Nevertheless, Hüholdt recognised style combinatorics but suggests extending Vester's definition by some basic mixed-forms of existing styles and newly advanced styles (Hühholdt, 1995; Vester, 1998). The following summarises those learning styles and connects them to AR enabled learning (Table 2).

Table 2 - Learning Styles Related to AR Enabled Learning.

Learning Style	Learners learn optimal when …	TEL applications & media (Depend on learning content and context)	AR enabled learning	
			Now	Future
Vester				
Visual	receiving the majority of information through their eyes. They prefer pictures and graphics but textual information promise learning success.	CBT Online learning Mobile Learning Blended Learning Virtual Learning Texts, images, sketches, videos (incl. augmented and virtual realities)	Fundamental concept of AR through smartphone, tablet and stationary computer, HMD.	Contact lenses
Auditive	receiving the majority of information through their ears. Promising learning success when listening to the spoken words and when reading aloud.	CBT Online learning Mobile Learning Blended Learning Virtual Learning Text to speech, audio files, conversations, videos	Applied for instructional and feedback media.	3D audio Intercommunication
Haptic / Motoric	having the opportunity to feel the learning object. Prefers to try and be integrated into the learning process - "Learning-by-Doing". (See constructivism)	Blended Learning Virtual Learning Simulations Interactive elements	The visual concept allows easily to address haptic learning styles.	More sophisticated object recognition algorithms. Hardware improvements Interactivity
intellectual / abstract-verbal	thinking about and reflect critically on information. Memorising is a strength of this style, e.g. Mathematical formulas.	CBT Online learning Mobile Learning Blended Learning Virtual Learning Simulation Logical thinking	Depending on context and content. Might come in joint with other LS modes	
Hüholdt				
Communicative	participate in discussions and conversations. Talking about the subject seems favourable for learning. Requires communications channel with other learners.	CBT Online learning Mobile Learning Blended Learning Virtual Learning Online meetings and discussions or Feedback sessions (synchronous). Written blogs and forums (asynchronous), delayed but active learning.	Currently limited implementations by textual message or moderation.	Linked communication with other learner, lecturers, or avatars.

Olfactive	associate scents with learning content. Recalls information best when the learning environment offers certain scents.	Blended Learning Currently, research is working on combining scents with video.	No known application yet.	Integration of scent generator in HMD and other virtual environments (Augmented Virtuality, see Milgram's AR continuum).
People oriented	in contact with other people, similar to the communicative type. Learn optimal when reference person perceived as sympathetic with striking voice.	CBT Online learning Mobile Learning Blended Learning Virtual Learning Use of persons or avatars in videos, images or dynamic content.	Avatar or moderator used for guiding and communication channel.	AR meetings (real) avatars to enable Interpersonal interactivity
Media oriented	acquiring learning content autonomously, similar to haptic type, by using preferred media.	Difficult if leaner rejects certain media.	AR is one media and could be disqualified by learners.	New form factors for AR devices, e.g. contact lenses
Sense-making	receiving detailed background information that contain deeper explanations and proof. The question "why" regarding facts are very important.	CBT Online learning Mobile Learning Blended Learning Virtual Learning This addresses general curriculum and learning design questions.	One main characteristic of an augmented aspect is to deliver explanation for leaning objects.	Connecting AR learning environment to adoptive Learning Management Systems and Environment for different depth of learning content.

A common idea to all Learning Style Models [LSM] is the assumption that people assimilate information in individual ways and are probably aware of the most appropriate way that can maximise learning, personally and for a class. Generally, learning styles differ in the specific way each theory differentiates and categorises different types of learners. More recent scholars recommend thinking of patterns of traits rather than types when applying categories to think about people. Nevertheless, learning styles are still a very controversially discussed theme (Felder, 1996; Graf, Viola and Leo, 2007).

There exist many different types of learning style models and Coffield (2004) identified seventy-one models (n_{lsm}=71) in a comparative study. Nevertheless, there seems to be no commonly accepted approach such as an agreed taxonomy. Some critics address weaknesses in some models in psycho-metrics, for example, due to lack of reliability, reproducibility, consistency and predictive validity. Validity is often seen as an issue since learning styles preferences are not stable of time or in different learning situations. An issue that relates to the research field of TEL is that when reading definitions of different learning style model, one will recognise that actual models orientate towards traditional ways of teaching and neglecting often modern technology supported learning preferences. Some studies conceive characteristics of traditional learning aspects, such as books versus e-Books or face-to-face learning versus distance-learning (Coffield, 2004; Curry, 2005; Popescu, 2017; Willingham, Hughes and Dobolyi, 2015). Fortunately, several researchers investigated the fit and validity of certain LSM for adoption for TEL, while Graf et al. and Hunang were explicitly validating LSM for the use in mixed mode TEL environments (Coffield, 2004; Graf, Viola and Leo, 2007; Huang, Kinshuk and Spector, 2013). Felder's Learning Style Inventory [LSI] is a prominent learning style model, which has been successfully applied to previous research design similar to this study, and additionally reflects most of Vester's and Hüholdt's learning styles, which makes it even more interesting for this study's research design.

Nevertheless, Coffield's (2004, p.136) study indicates that for pedagogical and business purposes a *"proliferation of concepts"* exist that try to measure different aspects of learning preferences is enormous, which he argues led to a conceptual confusion. The following table offers an overview of dichromatic learning style dimensions.

Table 3 - Dichotomies of Learning Style Dimensions based on Coffield (2004)

convergers	divergers		random	sequential learners
verbalisers	imagers		initiators	reasoners
holists	serialists		intuitionists	analysts
deep	surface learning		extroverts	introverts
activists	reflectors		sensing	intuition
pragmatists	theorists		thinking	feeling
adaptors	innovators		judging	perceiving
assimilators	explorers		left brainers	right brainers
field dependent	field independent		meaning-directed	undirected
globalists	analysts		theorists	humanitarians
assimilators	accommodators		activists	theorists
imaginative	analytic learners		pragmatists	reflectors
non-committers	plungers		organisers	innovators
common-sense	dynamic learners		lefts, analytics, inductives, successive processors	rights, globals, deductives, simultaneous processors
concrete	abstract learners		executive, hierarchic, conservative	legislative, anarchic, liberal

The identified terms in the table above allow to anticipate the multitude of underlying ideas, conceptions, and fields of application. Nevertheless, the idea of comparing studies, validating existing models, developing new models, inspired researchers to transpose between different learning style dimensions (Coffield, 2004; Felder and Brent, 2005; Graf, Viola and Leo, 2007; Heenaye, Gobin and Khan, 2012; Vaseghi, Ramezani and Gholami, 2012).

Learning Style Models and Learning Styles are still controversially discussed and have raised critique from different perspectives. Cognitive psychologists have examined learning styles and related studies in more detail. In a review article, Pashler et al. (2008) analysed various studies on learning styles. The authors emphasize significant methodological flaws in those studies that demonstrate that learning styles have a positive impact on learning outcomes. On the other hand, the authors also found methodologically robust studies that showed no effect of learning styles.

Based on this study, Rogowsky et al. (2015) removed the criticised criteria for experiments and conducted an improved study without methodological flaws. However, this study failed to provide evidence that learners perform better when the learning material matches the learning type.

The theory on learning styles and types relates learning to perceptions and different sensory channels. Declarative knowledge, knowledge about facts and concepts, however, does not reach the long-term memory directly from the sensory channels. This assumption is not supported by experimental psychology and neuroscience. That is, memory formation is not dependent on the sensory channel (Meinhardt, 2019; Dantas and Cunha, 2020; Li et al., 2016; Arbuthnott and Krätzig, 2015). In addition, the theory of learning styles and types raises the question of where the intellectual type of learner gets his information from, if this is not to be done via the sensory channels (Metallidou and Platsidou, 2008). Unanswered is also the question of whether learning styles and types would be stable across different (instructional) subjects and contexts[7] (An and Carr, 2017; Pashler et al., 2008; Lee and Kim, 2014).

Furthermore, the learning style tests themselves expose deficiencies in quality criteria, for example in the re-test reliability, which raises the question whether a student is assigned the same learning style as in a previous survey. Another claim is the systemic methodological weakness of repeated person-based tests. Learning style surveys are regularly based on student self-reports, and to be reliable students must correctly recall their learning behaviour and want to report it truthfully (Gokalp, 2013). Another issue has been pointed out by Coffield (2004) in a comparison of learning style models: sometimes models are declared to be learning style models, whereas in reality they are, for example, personality tests such as the MBTI. Some critics of learning styles question whether applying a 'measured' learning style also positively affects student learning, just because they generally prefer it. They argue that the preferred learning style may not always be the most effective. Additionally, some authors claim there is a danger that learners focus too much on one learning style or type instead of choosing their learning strategies and methods according to the learning content (Gudnason, 2017; Pelley, 2014, p.98 pp.; Li et al., 2016).

However, this overestimation and overweighting of learning style models and surveys has been repeatedly discussed by various learning style researchers, including Felder, who point out that learning styles are only preferences that students volatile adapt their learning preferences to the

[7] See the learning style preferences for different types of students and fields of study in the appendix 7.6.4.

situation and learning content and the results should serve as a first starting point for a personal learning strategy (Felder and Brent, 2005; Felder, 2016; Özbaş, 2013).

2.2.6 Dynamics of Student Learning

How students learn is closely related to their individual Learning Style [LS]. Researches on LS have found that students' LS affect performance in a learning environment (Sadler-Smith, 1996; Willingham, Hughes and Dobolyi, 2015). Student's unique learning preferences are influenced through LS and knowing them can help instructors to plan a new learning environment (Kemp et al., 2010). The later see learning styles as peculiarity that pertains to how students cope with learning tasks and how they process information. Jensen (2003) similarly defined LS as a favourite way of thinking, processing, and understanding information. He implies that LS refer to a student's characteristic ways of acquiring and processing information in learning setups and solving problems, thus supporting the first cited definitions.

A further aspect in literature is the student centric learning and teaching approach, diverting from the traditional, comfortable, and close, face-to-face learning. Baloian et al. (2000) claim that in the light of TEL such traditional approaches cause extensive costs of time and money. Furthermore, future employers require certain professional skills that should be developed in HE since they are a requirement for success. Students need to accomplish an ample part of the learning work since they shall not only offer factual knowledge but be prepared to use information technology, solve problems, to present or to work in teams (Winteler, 2009). Discussions during my training for a postgraduate certificate [PG Cert] in higher education and recent surveys confirm Winteler's claims that in many countries HE did not respond adequately to those demands and the inadvertent consequences are reflected in negative views of student on academic courses, being not prepared well enough for a professional start and in high withdrawal rates of students (UCISA - University of Oxford, 2016; Aston University - Centre for Learning Innovation and Professional Practice; Evans, Muijs and Tomlinson, 2015; Winteler, 2009).

Publications from different countries and disciplines suggest a paradigm shift from teacher-centric to student-centric learning, which implies the mentioned personalised and flexible learning (Felder, 2009; Garrett, 2008; Kasim, 2014; Liang, 2004; Marghescu, Marghescu and Marghescu, 2008; Moate and Cox, 2015; Schreurs and Dumbraveanu, 2014). That shift could be summarised as moving from *teaching by telling* to *learning-on-demand* or *learning by asking or doing* (Zhang and Nunamaker, 2003).

2.2.7 Fostering Reflective Learning with AR Learning Methods

In the past, reflections on experiences by students have not received immense attention, possibly because it was often seen as professional practise where students are supported to learn from experience (Brockbank and McGill, 2007; Coulson and Harvey, 2013). Kolb and Kolb (2005) call it Reflective Observation of the experiences, which they see as particularly important for detecting any inconsistencies between experience and understanding, which was later the basis for Gibbs' (1988) never-ending reflective cycle. Reflection is furthermore a basic principle for the development of competencies and arises particularly at the points where thinking or action is blocked. It is an interpretation process with the aim of understanding a new, unknown situation on the basis of existing experiences (Dewey, 1938). In the process of reflection, a problem or question, which can be theoretical or practical, becomes a new secondary experience (Dewey, 1933, ch. 2).

The Open University (2000, p.53) proposes a concept for Reflective Practice that includes fostering self-awareness, critical thinking and reflecting, which other educational institution adopted in their program descriptions, such as of the Aston Business School (2017). King and Strom-Kitchener expand this concept by Reflective Judgments, where students learn to construct potential solutions, which might challenge reciprocally, for existing problems by evaluating existing information, opinions, and potential explanations. They claim that reflective learning and thinking with the aim to establish reflective judgment will help students to become better problem solver in their future live (Fry, Ketteridge and Marshall, 2009; King and Strohm-Kitchener, 1994).

Reflection is increasingly recognised as essential for effective learning, as it is an essential part of experiential learning by transforming experience into learning (Boud, Keogh and Walker, 2013; Fry, Ketteridge and Marshall, 2009; Moon, 2004). During the last decades many researchers and practitioners contributed pedagogic methods that can foster reflective abilities of students. Depending on the learning content, target group, and different methods have been successfully applied, such as reporting on own experiments, creating theatre pieces, and academic reflective writing. According to Moon (2004, p.84) reflective methods have the potential to enhance understanding, critical review skills, decision making processes, problem solving, and foster creative activities and processes of students. One particular method gained more popularity as reflective practise in HE, which is storytelling that provides a source for reflective learning (Alterio and McDrury, 2003, ch. 3). Additionally, Alterio and McDrury (2003) claim that storytelling, in general, as a teaching pedagogy got it merits through its ability to engage students in reflective learning, which is especially beneficial for prospective professionals seeking work-based learning experiences. Storytelling offers students, as a considerable advantage, an opportunity to reflect on their experiences, generalise those experience to other situations and decide how to translate their *lesson-learned* into future actions and then evaluate the outcome of chosen approaches (Fry, Ketteridge and Marshall, 2009; Alterio and McDrury, 2003).

The traditional storytelling process reached another level through adoption of affordable access to digital media and computer technologies to create digital storytelling. The combined use of digital images, audio and narrative to tell personal stories of experiences and learning lead literally into a digital storytelling movement (Lambert and Hessler, 2013; Teacher's Lift, 2020). Digital storytelling as reflective learning method with multimedia seen a remarkable step-up with the advent of AR, which adds additional characteristics to digital storytelling, such as interactivity, new approaches to link different media. Such characteristics can involve engaging and motivation effects, which can help students to enhance their reflective learning processes and abilities (Abas and Zaman, 2010; Yilmaz and Goktas, 2017; Wu and Chen, 2020).

2.2.8 Contribution of Learning with AR to Student Literacy

Literacy is generally a collective term for reading, narrative and writing culture and skills. It includes, for example, understanding texts and their meaning, reading and writing skills, or competent handling of media.

In a society shaped by the culture of writing, literacy is an important part of an individual's communicative possibilities. It is therefore a core element of cultural integration. The organisations United Nations Educational, Scientific and Cultural Organization [UNESCO] and Organisation for Economic Co-operation and Development [OECD] consider literacy to be a key qualification for lifelong learning, including in mathematics and the natural sciences (OECD, 2011, 2020).

Furthermore, literacy is of great importance for participation in social life and social equality of opportunity. The PISA Consortium (2003, ch. 1) even considers literacy to be a very decisive prerequisite for a satisfying life, both professionally and privately, especially in the age of the Internet.

As described before, Digital Storytelling, especially trough AR, offers a large portfolio to students to express their stories and thus might impact their own literacy in different disciplines (Jones and Flannigan, 2006). The 'digital' can train them in applying diverse multimedia tools and implement results in their personal AR world. Due to this variety students will be involved in decisions processes for choosing the right tools that, in their opinion, fits best to transport a certain part of their story and that can be adopted in their AR world. Such skills can prepare students for work life when forced to evaluate decisions (Bawden and Lyn, 2002; Fry, Ketteridge and Marshall, 2009).

2.2.9 Digital Literacy as one Key Competence

Universities are currently experiencing a transformation from content focus to competence orientation, where competence-based curricula are grounded in the understanding of the demands of the learners' context. This requires from universities to equip students with competences that enable them to adapt to and effectively meet challenges of their future careers (Marope, Griffin and Gallagher, 2017). These skills that students need to be able to move effectively in their careers and in society are changing, sometimes rapidly, as a result of digital *"changes that the digital technology causes or influences in all aspects of human life"* (Stolterman and Fors, 2004, p.689). Since the 1980s a term that is repeatedly mentioned in this context are the so-called Digital Literacy competences (Pietrass, 2007; Lankshear and Knobel, 2008, pp.1–15; Pool, 1997; Bawden and Lyn, 2002; Tornero, 2005).

For new and emergent literacies Buckingham (2015) suggests to extend the idea of multiple literacies by a literacy that embraces new technology and media in education. He argues that Computer Literacy is not a properly defined term, which is often limited to *"vocational relevance of computer skills or about the inherent value of learning with computers"* (Buckingham, 2015, p.23) and thus is a functional description. However, digital literacy steers into the direction to embrace not only technical aspects of literacy.

In the field of academic learning, however, digital literacy has a large overlap with the terms Media Literacy and Information Literacy, which are adjacent to terms such as Data Information Literacy, Science Data Literacy, or Statistical Literacy. These terms often refine digital literacy for application in specific subjects, such as statistical literacy competencies are relevant to deal with big amounts of data in business knowledge management or linguistic network research (Jones and Flannigan, 2006; Jaseena and Moosa, 2020; Koltay, 2011). In educational environments digital literacy can be summarised as, firstly, the ability to identify, select and obtain information efficiently and in suitable media types. And secondly, as the ability to further process, convert and create information, and to communicate via suitable channels (O'Brien and Scharber, 2008).

From this it can be seen that digital literacy is closely linked to data literacy, which describes the ability to deal with data in a planned manner and to be able to consciously use and question it in the respective context. In HE digital literacy is becoming increasingly relevant in the course of digital transformations and represents a central competence in all sectors and disciplines (Seres, Pavlicevic and Tumbas, 2018; Balyer and Öz, 2018; Wilms and Meske, 2017).

Nevertheless, when addressing digital literacy in HE, organisation and instructional designers research suggests that they need to be aware that today's student characteristics are very heterogenic. They come from very diverse backgrounds, have different levels of experience, differ in perceptions, expectation, and goals for learning and teaching in HE (Correa and Tulbert, 1991; El-Khawas, 2003; Ford and Whiting, 2007; Grubb et al., 2011; Happ et al., 2016; Jabbar et al., 2020; Powell et al., 2019). Additionally, diversity characteristics and attributes, such as gender and age, can influence their access and acceptance of digital literacy skills trainings (Markic and Abels, 2014; Sliwka, 2010; Spelsberg, 2013).

Lastly, since technology is evolving fast and diffuses more and more aspects of personal, public and organisational environments, a further literacy might be useful to mention in relation to digital literacy that is Emerging Technology Literacy. This not new term is defined by Shapiro and Hughes (1996, pp.34–35) as the ability to

> *"[...] ongoingly adapt to, understand, evaluate and make use of the continually emerging innovations in information technology so as not to be a prisoner of prior tools and resources, and to make intelligent decisions about the adoption of new ones".*

This definition goes in line with proposed skills for the 21st century workforce as outlined by researchers and educational. This would add mainly to two important skills sets to an educational portfolio for preparing students: informed decision making, ability to adopt (to) new technology and awareness to retain flexibility towards new emerging innovations in technology policy (McDougall and Pereira, 2017; Jones and Flannigan, 2006; OECD, 2016). Flexibility and adaptability to new environments and technologies are potentially important skills of the 21st century that educational organisation can foster. Nevertheless, nobody can predict the conditions for the students in five or more years because today's students *"[...] exist in times that are driven by rapid evolution of digital technology, and the changes we have seen in the past fifty years will be nothing compared to what lies ahead in the next fifty [...]"* (Robinson, 2017a, para.12). Therefore, to counter this issue business professionals, policy, and educational research support the development of these skills as imperative teaching assets to develop leadership skills and general abilities necessary to manage future technology innovations (Iordanoglou, 2018; OECD, 2018; Open Sourced Workplace, 2019; World Economic Forum, 2016; Huda et al., 2017).

2.2.10 Gaining Essential Communication Skill through Storytelling

Storytelling in its most original form is a long known social phenomenon. Since time immemorial, people have gathered together to share experiences with others, especially with the younger generation, in order to pass on important wisdom and experiences to them on their path through life. Stories often have the power to re-experience past events in the community, giving history a common meaning (Huffaker, 2004; Combs and Beach, 1994; Chung, 2007). For a long time, it was not possible for lower social classes to experience stories through reading, which in many cultures led to the profession of storyteller. These people were known, for example, in Europe as *troubadours* and *minstrels* (Bahn and Bahn, 1970, p.72; Southworth, 1989, pp.3–4), in Japan as *rakugoka* (落語家) (Morioka and Sasakiv, 2020, ch. 1; Brau, 2008, ch. 4). However, sometimes the storytelling was the laying in the hand of the oldest or wisest in a community, as it could be found in American Indian tribes (Hodge et al.), and in Thailand it was common that every city had its own well-known *tale-spinner* and in Thai language exists an old Pali term that stands for a pedagogical teaching method that passed knowledge only orally[8] (múk kà bàat – มุขบาฐ) (Vathanaprida and MacDonald, 1994; Princess Maha Chakri Sirindhorn, 2018).

The ability to tell a good story is crucial in communication nowadays - on the Internet as well as on the job. In recent years, the Internet has brought forth various new communication channels. These range from simple websites to virtual spaces and social media offerings that convey advertising, political messages and knowledge (Lambert and Hessler, 2013, pp.46–49). In times of the Covid-19 pandemic, storytelling, consciously or unconsciously, is increasingly used in education to convey learning content and is seen in organizations as a complementary alternative to face-to-face communication (Bahl, Figueiredo and Shivener, 2020; Bob Freitag et al., 2020; Scott, 2020). Storytelling is used in organizations for internal communication with their own employees, since the content of training or introductions as well as values, knowledge and corporate culture can often be communicated better and more comprehensibly through positive

[8] Should not be confused with the rote method that focuses on memorization by involves learning by repetition (Mayer, 2002).

success stories than, for example, through a dry enumeration of facts (Lambert and Hessler, 2013 ch. 11; Robin, 2006).

Storytelling has also become increasingly popular in research. Two examples show the scientific application of storytelling as a communication media *"to outline the main episodes that make up the [Covid-19] virus' brand personality as process and structural components"* (Rossolatos, 2020, p.1) and to investigate potential supportive effects of storytelling as treatment for pediatric residents during the Covid-19 pandemic (Babal, Webber and Ruedinger, 2020).

The communication form storytelling works by giving a product, a company, a person or an idea an exciting, interesting and meaningful form. With stories, products, ideas or company traditions can be conveyed in a more emotional and easily understandable way (Denning, 2006; Mossberg, 2008). Accordingly, storytelling has already been discovered by many public relations, marketing, and communications departments and in companies and education. It can help, for example, salespersons to inspire customers for their product, motivate teams or convince an HR manager of one's application (Gillett, 2014; Pulizzi, 2012; Kuşay, 2019). Subsequently, MBA students are regularly confronted with buzzwords such as content marketing or content strategy (Burgess and Burgess, 2020 ch. 6; Hall, 2017). It's all about content - content is still King, which is very welcomed. But content is a technical term, without soul, blood, and character. Content could be simply text. The crux of the matter is that text alone often does not touches and moves anyone (Finnemann, 2011; Meerman Scott, 2007, p.37 pp). But stories do and Duarte (2011, time: 02:28) argues in a recorded talk that people *"[...] actually physically react when someone is telling us a story"*.

The literature further suggests that in a learning and teaching environment personal storytelling has the potential to foster student reflectiveness through telling stories by word, picture or film that inspire their own learning and their audience so much that they are immediately recounted. Eventually, digital storytelling increases the number of possible tools for telling a story, which fulfils the demand of a more and more digitised world (Alterio and McDrury, 2003, ch. 7; Duarte, 2010; Lambert, 2010).

2.2.11 Digital Storytelling in Learning Environments

This section expands the term of storytelling by a digital component, which indicates its intentions. Nevertheless, the term Digital Storytelling demands some definition, especially in regard to learning and teaching environments. According to Clarke and Adam (2012, p.159) digital storytelling could be broadly defined as *"[...] the application of multimedia resources within learning environments for the production by students of multimedia narratives"*.

Reflective digital storytelling is an exciting approach with a variety of application scenarios as well as an integration option for creative media education (digital literacy) in the lecture room and beyond.

Literature suggests that the method is suitable for integrating new media in the classroom and for promoting language and writing processes, while especially skills in storytelling and self-reflection are also being developed. The method is action-oriented and enables a student-centred teaching and learning, in which the focus is then on the individual activity of the students (Brockbank and McGill, 2007; Moon, 2004).

One example that makes AR a medium for digital storytelling is the Kent State AR experience, which focuses on the history of the May 4th shooting. For this exciting digital history story both physical and digital components invite users to view perspectives of the Kent massacre through the lens of AR, using historical images, sound recordings and related experiences. The digital connects the present and past for a situated narrative in which distant events are presented "here and now" to evoke immersion and engagement of the active audience (Kent State University, 2020; Business Journal Daily, 2020).

Lambert's approach, for instance, focuses on self-reflection and a biographical narrative but the method can also be used for factual topics. The context of traditional lectures could be expanded with this digital form of presentation, for example, graphical material of work results or recognised issues, the work steps could be provided with an audio commentary by the students and can be presented at the end of a series of (traditional) lectures (Lambert, 2010). Nevertheless, digital storytelling as a learning activity or as an assessment must be reconciled with the desired learning outcomes, requesting the need for constructive alignment, and therefore must be modified accordingly depending on the application scenario (Biggs and Tang, 2007; Kennedy, Hyland and Ryan, 2006; Wildt and Wildt, 2011). This requires adopting an instructional design, which should pursuit a purposeful and systematic design, development and delivery of instruction based on principles of technology enabled learning and teaching.

2.2.11.1 Digital Storytelling from a Student Perspective

In recent years, the method of digital storytelling has changed dramatically and now covers a wider range of topics. New research and projects show a wide range of application possibilities for topics such as sustainability, e-Learning, integration, and the use of this format in digital lifestyles. Digital storytelling is increasingly being integrated into project workflows or even made the main component of storytelling. The usefulness and effectiveness of this kind of knowledge transfer makes storytelling an ideal tool for both beginners and advanced learners (Brockbank and McGill, 2007; Moon, 2004).

The various models for instructional design, such as the ADDIE model[9] offer comfortable frameworks for digital storytelling with AR as a TEL method, since it adds a teaching design component to a more holistic framework model. Each stage of the ADDIE model provides itself a framework for collecting information necessary to complete related tasks (Robin and McNeil, 2012). These models can be linked to digital storytelling because they address the development of abilities and skills in building-up knowledge in conceiving, planning and creating the digital story as it is required from students when creating a digital story with AR. Additionally, AR enabled digital storytelling potentially promotes skills that might prepare our students better for their future careers, where students are required to create content. Thus, when student create digital AR stories they need to able to handle digital media and proof further literacy competencies such as critically interpreting, validating their created content, and implementing their ideas and materials (Abas and Zaman, 2010; Agogi, 2011; Laar, 2019). According to Niemi and Multisilta (2016) can team based creation of digital AR stories foster collaboration and networking skills since it promotes to work together and teams might benefit from synergies of other people's expertise. Robin (2006) summarizes skills that digital storytelling potentially enhances:

- Research skills
- Writing skills
- Organization skills
- Technology skills
- Presentation skills
- Interview skills
- Interpersonal skills
- Problem-Solving skills

[9] The ADDIE will be discussion in the succeeding section on Instructional Design Process for Digital Storytelling (2.2.11.2), together with the SAM model and the Design Thinking Theory.

- Assessment skills

Regarding the MBA students in this study, it should be highlighted that students may develop enhanced communications skills by learning to organise their ideas, ask questions, express opinions, and construct narratives when creating a digital AR story. These acquired skills can also support students in creating stories for a specific audience and present their ideas and knowledge in an individual and meaningful way, which can be later useful at work when creating stories for a board, for staff or a conference. Beneficial for potentially very pragmatic and goal oriented MBA students might be that they could use the gained skills in any kind of presentation, whether it is an online training or a live presentation (Frey, Fisher and Everlove, 2009; McNeil and Robin, 2012; Moon, 2004). These skills become even more important in this Covid-19 time, where more work tasks are transferred in a digital space.

When students know their audience, it enables them to reflect on their emotions and experiences. This can help students to reshape knowledge into something meaningful and as learners begin to see themselves in the story and to identify with it (Moon, 2004), they start to care, described as a moment of *"emotional appeal"* by Nancy Duarte (2010, pp.100–101). This emotional aspect might help students to learn to maintain an audience's attention more likely through storytelling since most people are often taking time for a good story.

Finally, Digital Storytelling can impact student's skills to give meaning to data. Often data is disconnected from the student's experiences or not seen as important (referring to student engagement issues). However, when placing data in the context of a story, such as the students in this study did when creating their digital AR stories, the 'raw' data comes alive and creates a personal connection for the students (Brockbank and McGill, 2007).

Table 4 - Reflective Learning through Story Telling and the Map of Learning [10]

Map of Learning (Moon, 2004)		Learning through Storytelling (Alterio and McDrury, 2003)
Noticing	↔	Story Finding
Making Sense	↔	Story Telling
Making Meaning	↔	Story Expanding
Working with Meaning	↔	Story Processing
Transforming Learning	↔	Story Reconstruction

2.2.11.2 Instructional Design Processes for Digital Storytelling

For pedagogical purposes there are various instructional design concepts available, which have been widely used in education and can also be applied to digital storytelling. Three examples the ADDIE [Analyse, Design, Development, Implement and Evaluate] model, which has been known since the 1970s, the SAM [Successive Approximation Model], and a process concept based on the Design Thinking Theory. Under different names all mentioned concepts have often been applied to project management, such as application programming or industrial design.

These concepts have been selected because they reflect a typical five step design process that includes determining needs, design and development of materials, and then evaluation of the effectiveness. These models are closely but improve each models' deficiencies in order of presentation in this section, which make them suitable for the instructional design of the AR intervention in this study (Allen, 2006; Beckman and Barry, 2007; Allen and Sites, 2012 ch. 2). Furthermore, the characteristics of these concepts can serve as valuable structured frameworks that support students to create their digital AR story.

2.2.11.2.1 ADDIE Model

The ADDIE model[11] provides instructional designers and with a roadmap for the creation of learning and teaching instructions in a technology enabled environment. It is a model that found wide adoption in educational environments and in business human resource development (Werner and DeSimone, 2012, p.26; Roberts, 2006). This model offers a systematic concept, comparable to a production line or programming of computer applications, where each step is

[10] Adopted from "Learning through Storytelling in Higher Education", (Alterio and McDrury, 2003, p. 47).

[11] The ADDIE model has been mentioned in literature since 1975, however, it was also known as SAT (System Approach to Training) or ISD (Instructional System Design) model depending on the sector that applied this instructional model.

based on the successful completion of the previous step. Based on project management ADDIE can be described as a sequential waterfall model (Gawlik-Kobylinska, 2018; Ragalutu, Ibrahim and Nomida, 2020). However, this is only true if one adheres to this model as a formative instruction, rather than as a guideline. Rather it should be compared to real-world design applications, where designers have to correct discovered errors and iterate certain previous steps (Bahl and Alam, 2012; Allen, 2006). The acronym ADDIE stands for the model's five phases in in instructional design process:

[A] - At the beginning of the ADDIE model there is a detailed *analysis* that belongs at the beginning of every e-Learning project. Questions about the working environment, learning goals, tasks, content, and target group are answered in this elementary phase (Branch, 2009, pp.24–25).

[D] - The analysis is followed by the *design* phase, during which the chosen strategy is assessed for cognitive, affective, and behavioural goals, taking into account the objective for the e-learning project. The pedagogical, external, and technical strategy is also defined, which in turn helps to determine the learning environment and materials. Here, based on the results of the analysis, a decision may be made in favour of an instructional design model or a combination of several (Branch, 2009, pp.60–61, ch. 2).

[D] - After the design of the TEL course the instruction designers enter the *development* phase, the actual creation of the e-learning course. In this phase, based on the design, the media are produced, the programs are developed and tested, the materials are developed, and a script is written (Branch, 2009, ch. 3). The development phase considerably contributes to the quality of a TEL enabled course. In is important that this phase is aligned to the abilities of the organisation and instructional designers, the financial and other resources. Comparable to industrial environments this demands a strategic decision, whether the development tasks are to be carried out by the participants themselves or whether media and applications are to be purchased or commissioned (Frydenberg, 2002; Du Mont, 2005; Doval, 2016).

[I] - In the *implementation* phase the results of the preceding development results are now delivered to the learners. The decisions made in the design phase now influence how this is actually implemented. Additionally, further necessary resources are provided such as the provision user accounts in the AR development environment or additional teaching material in an LMS (Branch, 2009, ch. 4).

[E] - In the final *evaluation* phase the results of the analysis phase are used as baseline for evaluating the TEL course. The results of the needs analysis are then compared with the finished course and various questions are asked: Were the expectations fulfilled? Can the improvements be measured? It should be noted that the opinions of the learners are one side of the evaluation, the achievement of objectives the other (Branch, 2009, ch. 5).

As stated before the ADDIE model consists of a linear sequence of phases, which Merriënboer (1997, p.3) argues is a limitation of this model since *"the phases may be listed in a linear order, but in fact are highly interrelated and typically not performed in a linear but in an iterative and cyclic fashion"*. Therefore, the ADDIE model in its pure form is sometimes not flexible enough to react, for example, to errors or to allow iterations of refinements in a creative process. This deficit is also reflected in extended more dynamic ADDIE models, such as of the U.S. Airforce, which puts all phases in relation to each other and allows them to be used simultaneously (United States. Department of the Air Force, 1979, p. 1-1; Allen, 2006).

Furthermore, many publications on the ADDIE model forget or make only little reference to the important test phase, which should include the technology, interactive and logic flow. However, this is a crucial part in any project that adopts technology because it adds massively to the overall project time schedule and it can influence the quality of the resulting product, such as a TEL module. The quality might be one key factor that influences the acceptance, motivation, and perceived benefits from a TEL learning module from a student perspective (Botturi et al., 2007, ch. 6; Ahamed, 2009; Sandars, 2010).

Nevertheless, the ADDIE model can be usefully applied to multimedia enabled courses and programs. For an instructional designer ADDIE offers systematic and generic structure for the development of a course (Peterson, 2003). However, from a student perspective, each stage of the ADDIE model provides itself a framework for collecting information necessary to complete related tasks (Robin and McNeil, 2012). These attributes allow to link the ADDIE model to digital storytelling in general, because it addresses the development of abilities and skills in building-up knowledge in conceiving, planning and creating the digital story.

Furthermore, the literature suggests that ADDIE is a suitable model for digital storytelling projects that make use of AR, created by instructional designer and students. For a case study Koçak et al. (2019) investigated seven AR projects where students created content for AR projects, following an ADDIE design process. Interestingly, the AR project topics included to create and to listen to stories with basic AR tools. Differently from the previous, Pantelić and Plantak Vukovac (2017) favoured and applied the ADDIE design process model from an instructor's view when they designed AR content for students. From a similar perspective Gopalan and Zulkifli (2014) applied the ADDIE model to design a prototype of an AR enhanced science text book, while actively integrating students in the evaluation phase. With these examples in mind, it comes clear why Lengnick-Hall and Sanders (1997) summary of the ADDIE model claims that the model is capable to be integrated in any learning strategy, which made the ADDIE model a suitable basic model for this study where the students were asked to create their own digital story with AR.

2.2.11.2.2 SAM Model

Nevertheless, in order to achieve a certain degree of flexibility in comparison to the ADDIE model, the SAM model was developed by Allen in the area of instructional design (Gawlik-Kobylinska, 2018). This Successive Approximation Model [SAM] stands for a rather cyclical process that can be scaled from basic (SAM1) to extended (SAM2) to meet the requirements for a TEL course design.

For smaller projects that do not require much complicated technology, such as video or custom programming, SAM1 is defined as the basic SAM process. This SAM variant is a cyclic model with three iterations of the known steps for Instructional Design: evaluation (analysis) - design - development. There is additionally a SAM2 variant, which is an extended version of SAM1 that is suitable for more complex e-Learning projects or tasks. It consists of eight iterative steps for Instructional Design, spread over three project phases: Preparation, iterative design and iterative development (Jung et al., 2019; Essel, Tachie-Menson and Yeboah, 2016; Allen and Sites, 2012).

While ADDIE typically follows a linear waterfall methodology, SAM is more of an *agile concept*, such as Scrum in project management (Bahl and Alam, 2012; Scrum.org, 2020). Proponents of agile approaches to creating e-Learning products point out that models like SAM can face numerous challenges that require, for example, a certain amount of flexibility, developing learner skills, and improving performance (Allen and Sites, 2012, pp.3–9). As a basis for a process of creating a digital story with Augmented Reality, SAM, or a combination of both presented models helps to find ideas, solve problems and finally create a digital story.

Finally, creating a digital with AR can be considered as a *creative process*, which can help instructional designers and students to approach a technology enabled intervention with higher degrees of flexibility and realism when designing and running an AR intervention as in this study.

2.2.11.2.3 Design Thinking Theory – Creative Process

The Design Thinking Theory is that the creative creating process requires a certain sequential, but often iterative, approach that helps to deal with complex design problems by sustaining in-depth learning processes on problem perception and diverse solution paths (Kröper et al., 2011). In the past decades research in design thinking modelled various sequential, but iterative, process structures that support the idea of sequential learning methods and processes. For example, Buchhanan (2001) helps with the definition of design process with three main stages: conceiving, planning, and making. He explains that such approach helps people to identify the sequence of goals towards practical application. Mor and Winters (2007) opine that in 1969 Simon regarded first design as a science. Furthermore, they consider that his work influenced strongly design approaches for TEL in general, and specifically Interactive Learning Environments [ILE] such as environments that makes use of AR in education.

Design thinking has its roots in professional design research at first. Nevertheless, its elaborated strategies that are relevant to all disciplines and professions have been gradually adopted in academia and business. It supports deep-learning processes when students are confronted with complex design processes where it is necessary to reflect on diverse problem perceptions and paths for potential solutions (Kröper et al., 2011; Beckman and Barry, 2007). The authors suggest this as beneficial when AR enabled learning is adopted in education environments. When the researchers are explaining their topic of design research they relate directly to pragmatic characteristics, such as the learning process design, the general complexity of classroom situations, multi-faceted levels and contexts (Kerres and de Witt, 2004; Wang and Hannafin, 2005).

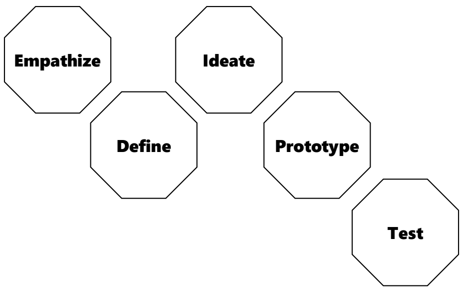
Additionally, Buchanan (Buchanan, 2001) emphasizes that to approach these issues diverse abilities and competences in multiple fields of knowledge are required from designers, as well students. He defines such competences structure as containing the also iterative process steps of conceiving, planning, and making the 'product', whereas the term product needs to be understood in a wider range, for example, the creation of a personal augmented digital story (Scheer, Noweski and Meinel, 2012). With this Buchanan and Scheer add a constructive characteristic to a pragmatist view on AR and other technology enabled learning approaches. This finds support and application in other related disciplines and professions such as software development, for example, for the development of an 'ready-to-use' AR creation environment or project based teaching (Noweski et al., 2012; Lindberg et al., 2012; Steinert and Hirschfeld, 2012).

Hasso Plattner and David Kelley developed in 2004 a model that would change the way engineers and designers, and other professions including educators (Meinel and Leifer, 2011). They created a human centred design [HCD] model of three unintuitive tasks that should encourage people to identify and solve problems:

1. Empathize
2. Work Together
3. Fail Effectively

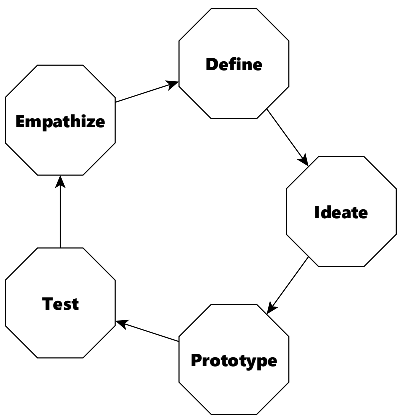
This HCD model has been further developed by the Hasso Plattner Institute of Design that offers elaborated guidance in a more sophisticated model (Doorley et al., 2018):

Figure 1 - Elaborated HCD Design Thinking Process Model



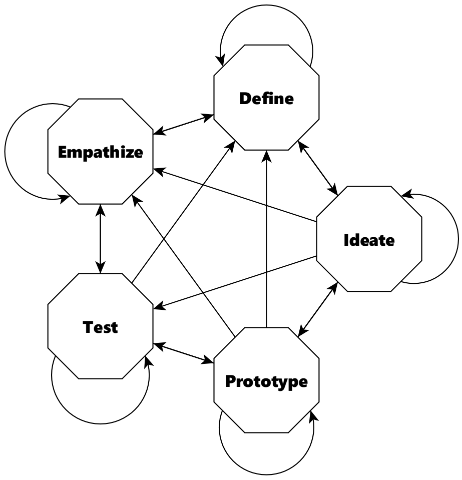
The previous graph does not show any direction or interactions, so that the following variant represents better the iterative character of a design process (Meinel and Leifer, 2011):

Figure 2 - Iterative HCD Design Thinking Process



Nevertheless, Meinel and Leifer (2011) argued that the preceding iterative graph still simplifies the relations between each task and inspired and proposed a more sophisticated graph that might come reality a bit closer:

Figure 3 - Extended Iterative HCD Design Thinking Process



The authors argue that this model considers that iterations can happen adaptive at any task stage and tasks can relate back to preceding tasks iteratively too. It is worth to mention that they claim that this model centres around the human, which might be therefore more suitable, for instance, as a guideline for new curriculum design and for student as a process to create a digital story with AR.

In this study the students adopted a design thinking process for creating there digital AR story, which requires the combination of creative confidence and creative competence. According to Rauth et al. (2010) does the iterative character of the design thinking process develops mindsets in students that in sum fosters creative confidence. In the digital AR storytelling intervention of this study the students tested approaches of communicating their story and enhanced them iteratively according to their own exception and the feedback of their peers. Similarly, each design process step allows students to enhance different competencies, such as capability of adopting other people's perspectives, planning and prototyping skills, emotional skills, and a certain mindset for creativity as a design process. A further advantage of this model is the possibility to adopt it for instructional design phase of this study as well as a suitable process model that supports students to create a digital story with AR. It could be argued that the design thinking process offers a sophisticated but still simple framework for designing an AR intervention as well as for students who are creating a digital story with AR.

2.2.12 Student Perspective on TEL

The perspectives of students on TEL depend on various attributes. For example, their motivation might be driven by the perception that certain qualifications might ultimately enable them for better jobs. Perceived usefulness can imply gaining new knowledge experiences and skills through learning technology. Extrinsic influences, often institutionalised by educational policy, such as employability or sustainability of education, specifically one aided through technology, shape student perspectives substantially since the acquisition of new competences such as approaching new (digital) media will gain crucial relevance for their future live (Biermann, Fromme and Verständig, 2013; Gilbert, Morton and Rowley, 2007; Hsu, Lin and Yang, 2017).

In general, students see TEL critically and differentiated. Technology should not be used for the sake of technology rather shall support their learning experiences. Thus, students perceive TEL as mindful tools but not as substitute for the benefits face-to-face lectures, tutorials or feedback (Conole et al., 2006; O'Donnell and Sharp, 2011).

Other researchers name intrinsic student perspectives such as a holistic view of their life or the integration of TEL in their social activities, but also that students experience learning in emotional terms. The differentiated adoption of the broad Emotional Intelligence concept on student learning incorporates already the management of personal learning and management of feelings and emotions but requires to related emotions and learning (Gardenswartz, Cherbosque and Rowe, 2010; Lee, 2011). According to Moon (2004) can relevant emotions directly influence student's structure of knowledge or process of learning, where the latter can also result in new emotions, but also indirect emotional effects are possible such as accelerating learning, moving into a flow state, remaining motivated.

Teachers repeatedly cite that motivation is an ongoing general challenge, which can impact student learning with and without learning technology. As mentioned before, motivation is considered as important because it highly contributes to achievement but, importantly, it should not be understood as automatically synonymous to motivation (Ames, 1990; Afflerbach and Harrison, 2017; Spector et al., 2016) . According to Flint and Johnson (2011) universities offer with grades extrinsic motivations to learners but it may be more important to support students to develop their own learning process. Frameworks, such as the mentioned self-determination and flow theory and learning style models, may offer explanations and approaches to reflect student perspectives applied to AR setups in TEL. Furthermore, the student perspective involves the often-called engagement issue, which will be discussed in the next section.

2.2.13 The Student Engagement Issue in HE

When immersing into the fields of TEL, learning and teaching, and higher education one will inevitably meet the term student engagement. Unfortunately, the literature frequently cites the issue of student engagement in diverse learning and teaching context but often without concrete reasoning. This dissatisfactory situation leads to the questions - what is and what is not the problem with student engagement, which has been raised provocatively by Wright (2013) and Prensky (2005). According to Baily (2010), it seems apparent that student engagement is often defined by the withdrawal rate as engagement measurement, which is caused by the monetising and commercialising policy developments in HE. The employment model has been quoted as a driver for engagement, which embraces factor such as employability and perception of usefulness from employer and student perspective, which indicates that many students are very goal-oriented and pragmatic. The experienced educator Prensky (2005, p.60) concentrated these threads as *"Engage me or enrage me – What today's learners demand"* in one headline.

The Higher Education Academy [HEA] (2017), picked up these issues, without naming the cause, and offers a holistic approach to cope with the engagement issue and the present situation in HE. One comprehensive review on student engagement identifies four main perspective or attempts in the literature. According to this study, these are behaviour, psychological and socio-cultural perspective and a holistic approach that combines issues from each of the three mentioned perspectives to eliminate their weaknesses in explanation attempts (Kahu, 2013). For this study such holistic approach was preferred, because it regards different reasoning and perspectives of students through designing the AR intervention. For example, the level of technical complexity has been put on a level that was perceived to correspond to the student skills and professional background. This should prevent an overload of the students, which might lead to undesired behaviour or psychological impacts on their learning. The latter prevention of creating a counterproductive learning environment connects very well to subject of motivation in student learning with technology in the next section.

2.3 Motivation in Learning with Technology

Technology Enabled Learning [TEL], elucidated by Kerres (2013), encompasses all forms of learning where digital media are used for presentation, distribution or communication. Havard et al. (2016) define TEL similar as application of information and communication technologies to learning but connect those to the purpose of engagement and motivation of students. Promising regards AR enabled learning is that researchers collected during the last decade evidence that teaching and learning with technology, especially with AR.

HE has early adopted AR to curricula because researchers and lecturers recognized the value of the observed positive effects of AR enabled learning and teaching on engaging students and fostering their learning (Chastine, 2013; Dede, 2009; Kaplan-Leiserson, 2004; Oblinger, 2004).

Teachers repeatedly cite that motivation is an ongoing general challenge, which can impact student learning with and without learning technology. The literature considers motivation as important because it highly contributes to achievement through, for example good grades, which leads to higher satisfaction that in turn can impact student engagement. It should be noted that especially achievement does not guarantee impacts on student motivation and should therefore not be understood as synonymous for motivation. For example, with grades universities offer extrinsic motivations to learners but it may be more important to support students to develop their own learning process (Flint and Johnson, 2011).

Research brought up various frameworks and models to explain kinds of motivation, how they are influenced, and how they impact especially students. Previous chapters introduced already theories and frameworks, such as self-determination theory (Deci and Ryan, 1985) flow theory (Csikszentmihalyi, 2000) and learning style models (eg. Coffield, 2004; Felder, 1996; Liang, 2004; Pask, 1976) , which may offer explanations and approaches to reflect such student perspectives applied in AR enabled TEL environments[12].

Nevertheless, literature offers a view models and frameworks that might especially be suitable for AR enabled learning and teaching environments and interventions. These guides were needed to develop a suitable AR intervention for this study, which should keep or even increase the levels of learning motivation of students. Especially, this study wanted to put design, implementation, and run of the intervention with a more complex AR technology on a sound foundation that considers various impact factors on student learning.

Therefore, will the next sections focus on four selected themes that can be related to motivational effects AR enabled learning and teaching on student learning in this study. The concept of self-regulated learning addresses topics that are related to the basic idea of the digital storytelling with AR in this study, where the students were asked to define their subject, evaluate the sources, and define their realisation approaches. The next theme addresses the ARCS model as

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[12] See section 2.2.4.3 - Self-Determination , 2.2.4.4 - Augmented Reality as Opportunity to Experience Flow , and 2.2.5 - Dynamics of Student Learning

motivational design model in this study. The four central elements of the ARCS model support here the understanding of motivational effects of learning and teaching with AR on student learning in the preparations and aftermath phase of this study.

Since AR is highly technology oriented the third theme reviews motivational effects of technology-self-efficacy [TSE] on students. The rationale behind this theme is that the sample for this study were recruited from MBA students who typically have a less technical background and their confidence towards technology was expected to vary. These factors might impact the motivation of students when learning with AR, which could be explained with the technology-oriented theory of TSE. The final section draws on the modus operandi of the integration of students in the learning process, where students can act as consumers or prosumers of learning content in general and in relation to AR enabled learning and teaching. This is of interest because this study let the students create their own digital AR story instead of letting them interact with prepare AR enabled content, which puts the student into different types of learner categories.

2.3.1 Idea of Self-Regulated Learning

For learning and teaching with AR, as in this study, due to its opportunities for interaction, flexible use and creation of own learning content, other concepts such as self-organized and autonomous learning could be applied (Di Serio, Ibáñez and Kloos, 2013). These are not new concepts for promoting motivation, because already in the Middle Ages the philosopher and founder of the didactics Comenius requested force-free learning (Misseri, 2017; Monroe, 1900, ch. 6). It could be observed in learning and teaching with technology that many educators and teachers use learning methods for self-directed learning to increase the motivation of students, since they can determine to a certain extent what, with what, and when they want to learn (Carneiro, Lefrere and Steffens, 2007; Cerna and Poulova, 2013; Douglass and Morris, 2014).

According to Schunk and Greene (Greene and Schunk, 2017, p.17), self-regulated learning can be defined as *" […] the ways that learners systematically activate and sustain their cognitions, motivations, behaviours, and affects, toward the attainment of their goals"*. The starting point of learning is thus the individual goal, which can consist, for example, in achieving a certain grade, passing a certain course, learning something new that will benefit the student's future career. The latter is of special interest for MBA students in this study, who invested much to learn skills that will be beneficiary for their personal career. Such expectations let self-regulated learners normally direct their thoughts, feelings, and behaviour towards achieving these goals (Greene and Schunk, 2017; Mega, Ronconi and De Beni, 2014; Pintrich, 1995).

In contrast to the related concept of self-controlled learning[13] that usually refers to situations in which learners choose a learning goal unreservedly from within themselves (Saks and Leijen, 2014), self-regulated learning usually defines at least one broad objective to accomplish. Hence, such indirect motivational support measures are closely related to self-controlled learning. Ideally, curriculum designers develop different types of learning environments, with the essential intention to foster self-regulated learning of individuals. Saks and Leijen (2014) further suggest that in such (e-)learning environment a common objective can be defined, but leaves the choice for a theme, the evaluation of sources, and definition of an approach in the responsibility of the students. In relation to technology enabled learning the creation of a digital story with Augmented Reality, as applied in this study, can serve as a suitable example.

2.3.2 ARCS Model for Motivational Design

Various learning psychology models have implemented the basic ideas of different approaches to individualized learning. Models such as the Individually Prescribt Instruction [IPI] (Andrews, 2014; Glaser and Rosner, 1975), the Audio-Tutorial Approach (Hechinger, 1976; Postlethwait, Novak and Murray, 1972), the Keller Plan (Keller, 1968) can be considered as the historic root in this field. But learning technology found its place in various forms of computer-based interactive tutorial learning systems, including intelligent tutorial systems (Gabrielle, 2003; Kunz, Schott and Hovekamp, 1987; Tennyson, 1993; Usun, 2003).[14]

In the following, the widespread ARCS model by Keller and Kopp (1987) is discussed, which found application in learning and teaching with technology. The development of the model was based on a problem statement that Keller formulated as that *"we have not given adequate systematic attention to the problem of motivation in instructional theory and technology, to the understanding of motivation in individual learners, or to the development of technology for influencing motivation"* (Keller, 1979, p.25). Furthermore, Keller criticised the fact that so far there have been few efforts to transfer motivational principles from basic research to the field of instructional design. These ideas led to the mentioned Plan Model, which has been further developed to the ARCS model, in order to propose a model that better addresses real pedagogical needs in teaching and is easier to apply (Keller, 2009, 1987a). Since then, the ARCS

[13] In literature many researchers used the term 'self-determined learning' often used synonymously (Saks and Leijen, 2014).

[14] Compare the early efforts in individualising learning and teaching with technology in section 2.2.3.

model has become a prominent example for explaining the complex matters of student motivations, in more traditional as well as technology enabled learning and teaching.

In principle, the ARCS model can be defined as a didactic motivation model, through which teachers can recommend courses of action for the design of learning environments that help to promote and maintain the motivation of learners. In addition, it also provides important information on how to improve one's own motivation in the learning and teaching process (Keller, 1987a).

The acronym designates four central elements of the model with Attention, Relevance, Confidence, and Satisfaction. Attention of students can be achieved by using new, surprising, contradictory, or uncertain events. Paradoxes, inconsistencies, complexes, or new things, such as new techniques, often stimulate the curiosity of students. Motivation can be sustained by encouraging information-seeking behaviour of the students, where the learners are confronted with questions or problems to be solved, or students can formulate questions and tasks themselves. This offers the opportunity for self-controlled discovery and exploration, which in turn can have a motivating effect on the students (Keller, 2009, 2000, 1987a).

With the advent of many new technologies applied to educational environments researcher applied the ARCS model to their studies in order to design and describe the effects of technology enabled learning and teaching methods on student learning motivations. The ARCS model has been applied to many new technologies in educational environments because the choice of methods can impact the level of student motivation for learning and require a framework for designing and assessing motivational learning and teaching environments. The literature offers a variety of examples AR related studies that applied ARCS, such as exemplary in language studies (Li et al., 2015; Mahadzir and Phung, 2013), visual arts (Di Serio, Ibáñez and Kloos, 2013), vocational training (Bacca, Baldiris and Ramon Fabregat, 2018), mathematics (Chen, 2013), science (Chiang, Yang and Hwang, 2014), and mobile AR learning (Khan, Johnston and Ophoff, 2019). In case of digital storytelling with AR, the technology has the potential to address all four elements of the ARCS model, for example, by drawing attention of the student due a novelty effect. Furthermore, AR enabled learning can foster several aspects of their confidence and offer a higher level of satisfaction, when the task has been accomplished and makes it possible to interact with the resulting AR story. The novelty and potential importance for the future career of the students might higher perceived importance of AR as method and the additional learning content (Cheng, 2018; Keller, 2000, 1999; Means, Jonassen and Dwyer, 1997; Wei et al., 2015).

Nevertheless, the ARCS model has been criticised for some weaknesses. In comparison to the ADDIE/SAM model Keller requires a linear adoption of all ARCS elements. For example, Keller argues that the preceding analysis of the targeted learners should be rigorously adopted because the analysis *"[...] identifies where the motivational gaps are; that is, the specific areas in which you might have to give greater than normal emphasis to stimulate and maintain audience involvement."* (Keller, 1987b, p.2).

This systematic procedure, based on the classic Instructional Systems Development, ensures that motivational deficits can be identified early on. However, Hattie et al. (2020, p.4) claim that *"it is likely the interplay of self or internal processes and external influences (our perception of others, teachers, bosses) that determine our motivations"*. It can be therefore assumed that this model is also prone to not being able to perfectly cope systemic issues, such as not being able to map the environment, characteristics, dependencies, and potential contradictions. These mentioned aspects might cause a drop in the current motivation of the students. Furthermore, this might explain why studies repeatably have shown that expected effects on the learning motivation of students could not always be fully achieved (Bohlin, Milheim and Viechnicki, 1990; Bolliger, Supanakorn and Boggs, 2010; Di Serio, Ibáñez and Kloos, 2013; Heckhausen and Kuhl, 1985; Martens, Gulikers and Bastiaens, 2004).

The next section will look at technology-self-efficacy and draw on motivational effects on student learning through AR enabled learning and teaching.

2.3.3 Technology-Self-Efficacy as Personal Success Factor

The general term self-efficacy refers to *"beliefs in one's capabilities to organize and execute the courses of action required to produce given attainment"* (Bandura, 1997, p.3). The concept is originally based on the social-cognitive action theory of Bandura, which was embedded into a goal setting approach. It is considered a significant moderator variable of the goal-performance relationship. According to the psychologist Bandura, the first advocate of the concept, self-efficacy is the product of past experience, observation, conviction and emotion (Bandura, 1997, ch. 1, 1977). Furthermore, Bandura argues that there are two factors that influence whether someone intervenes in a particular behaviour: outcome expectation and self-efficacy. This means in other words, our ability to achieve a goal or complete a task depends on whether we think we can do it (self-efficacy) and whether we consider it to have good results (result expectation). Therefore, Zimmerman (Zimmerman, 2000, p.83) argues that self-efficacy perceptions involve personal *"performance capabilities rather than personal qualities"*.

Furthermore, the perceived self-efficacy expectation affects ones cognitive, motivational, emotional and actional processes. This means that the expectation of self-efficacy the four main aspects of a person's actions (Bandura, 1997, pp.116–128):

- Facing a situation - The choice of facing a situation can be influenced in which people are either more likely to face a manageable situation or to accept a situation that seems unlikely to be manageable from the outset.
- Feelings - In a challenging situation, feelings can be influenced by experienced fear, stress, or confidence.
- Thinking - Existing solution possibilities or thoughts of failure can impact peoples thinking.
- Motivation – Self-efficacy can influence the degree of personal involvement in the accomplishment of tasks.

Consequently, in educational context self-efficacy has important implications on the amount of effort students apply to a particular task. Students with a high degree of self-efficacy for a particular task will be resilient and persistent in the face of setbacks, while students with a low self-efficacy for that task may solve or avoid the situation. Importantly, our level of self-efficacy changes from one domain to another (Bandura, 1997; Pajares, Hartley and Valiante, 2001). For example, students might have a high level of self-efficacy about the ability to speak freely in their native tongue in front of an audience, but have a low level of self-efficacy about their ability to do the same in a language they do not (Zimmerman, 2000).

Technologies have always been used in learning contexts to support the learning process[15], for example, to record information (wax boards – slate - pen computer), to navigate through several books for research (Ramelli's book wheel – microfilm – electronic books), to support learning arithmetic (calculus - slide rule – pocket calculator – computer spreadsheet), to illustrate relationships (pop-up books – mind mapping applications) and many other contexts.

The digitalization in all areas of life in the past decades stands for an ever-increasing presence of new technologies in learning environments. The access and use of these new technologies by students and lecturers are influenced by various factors, such as the perceived self-efficacy

[15] See 2.2.3 - Technology Enabled Learning.

(Juutinen, Huovinen and Yalaho, 2011; Hoffmann et al., 2009). According to Clagget and Goodhue (2011) has self-efficacy the face validity to be applied modern information systems such as AR. The specific term for the application of self-efficacy to technology is in general Technology-Self-Efficacy [TSE]. The refined definition for TSE is the belief in one's own ability to successfully perform a technologically demanding new task. This definition makes TSE is a vague construct. However, as well as self-efficacy can address many different fields, such as personal-self-efficacy in decision-making or collective policy-efficacy (Bandura, 1997, pp.450, 482), TSE allows to be applied to new emerging technologies in the future. Due to the specific difference of technology and how people potentially approach it this differentiation is already evident in adaption of TSE to specific types of technologies, such as computer self-efficacy or Internet-self-efficacy, and information technology self-efficacy (Joo, Bong and Choi, 2000; Fauzi, Ali and Amirudin, 2019; Mahat et al., 2012). In business and educational instructional environments these technology-specific self-efficacy subdimensions are apparent and are, however, usually subsumed the larger construct of technological self-efficacy. Past research selected TSE as a measurement for the success of applied technology in learning environments such as medical, language learning, business, and STEM subjects.

In relation to this study the motivational effects of TSE on students are of interest because the sample for this study were recruited from MBA students who typically have a less technical background. This means that their confidence towards technology could be less even distributed than compared to students in technical oriented courses. It was assumed that the students in this sample are typically older and, depending on their generation, had different access and relations to technology. Potentially resulting shortcoming in student TSE might impact their motivation negatively when learning with AR, for example when students think not being able to master this technology. To minimize such unfavourable impacts the design phase for intervention in this study was scaffolding the approach to the AR learning technology to *"lead the students from what they already know to a deep understanding of new material"* (Lipscomb, Swanson and West, 2004, p.229). Such pedagogical approach is keeping students from becoming frustrated (Gary K. Clabaugh, 2010). This way the students could enhance their TSE, leads to feelings of success which therefore could impact their motivation for (further) learning with learning technology such as AR.

2.3.4 Students as Consumer and Prosumer of TEL Environments

Research on TEL referenced often to learning with Web 2.0 technology. On the future of the Internet, O'Reilly (2005) elaborated that this term established itself very quickly and stands for a second generation of Internet companies, Internet software (applications) and Internet users who focus on the platform potential of the network. During this evolution of the Internet landscape the new term of Social Media has become generally accepted for this as a synonym, as it brings the social and communicative aspects of the modern Internet more into focus. The author furthermore argues that Web 2.0 harnesses a collective intelligence, where users create and add new dynamic content, collaboratively tag sites (taxonomy vs. folksonomy) with overlapping associations, pursue viral marketing. Nowadays, many people produce and consume digital content, hence became prosumers (Ritzer and Dean, 2019, ch. 6):

production ↔ consumption

produce ↔ consume

In economic context Ritzer coined the term Prosumer where the Customer not any longer just consume provided services but contribute, design, and produce new products and service. This means prosumer are consumers who are producers and consumers at the same time. According to Ritzer (Ritzer, 2014), there are weak and strong prosumers. A weak prosumer is only indirectly involved in the production, for example by consciously or unconsciously revealing his or her interests and preferences, which are then considered by a serving organisation accordingly. However, a strong prosumer is directly involved in the production process by taking part in certain or all steps, either as part of a collective or as an individual on his or her own initiative or on commission. Example for creative prosumer participation are contributions, such as, enabling user personally design fashion or other investment goods, as well as new trends as printing spare parts on a privately owned 3D printer where customers produce goods at their own expenses (Shang et al., 2019). An early example for a prosumer is a person who submits suggestions for products and services on idea and innovation platforms, motivated by the hope for rewards such as free samples. This motivation to contribute has drastically grown with the advent of e-commerce of the Internet on seller as well video platforms.

The Web 2.0 as the participatory Internet builds also on user-generated content for learning and teaching content. Typical examples of prosumers are visitors to a wiki who occasionally collaborate, bloggers who read and comment on other bloggers' posts, and customers of video platforms who post their own productions (Ritzer, 2018, pp.15; 83–87; Ritzer, Dean and Jurgenson, 2012; Ritzer, 2014; Giurgiu and Barsan, 2008).

Furthermore, based on the consumer to prosumer continuum might, furthermore, be an interesting approach to define level of integration of students in the learning and teaching process. As mentioned earlier the constructivist learning theory is emphasizing human agency by promoting learning-by-doing, building knowledge through purposeful interaction[16] with a learning environment, and technology (Harasim, 2017, p.84; Giurgiu and Barsan, 2008). These aspects of involving user in a creative process is interesting idea in pedagogic aspects of TEL. More TEL related studies understand the students in a prosumer role in their personal learning, where creativity is the key element of audio-visual and ICT content in the classrooms and plays an important role in influencing student engagement and learning motivation (Burlea and Burdescu, 2016; Ha and Yun, 2014; Ivashkevich, 2015; Leong, 2017; Wilen-Daugenti, 2009, 13pp.; 186pp.).

According to Morra (2013) can digital storytelling transform students from only consuming content to active creators of content. It establishes a creative process and enriches a narration of a story with texts, photos, video clips, audio, graphics, animation and sometimes to a certain amount interactivity. These characteristics can be found in applied AR, which is an interactive vehicle for asking students to create a digital story with AR.

In relation to Digital storytelling with AR, as applied in this study, allows students to approach learning as creative prosumer for *"[...]tangible knowledge building that can be personalised and shared"* (Charlton et al., 2018, p.1). Furthermore, the active involvement of the students in the whole creative design process can make it a potent tool for them because the involved activities[17] can generate interest, attention, and motivation towards a learning goal for the digital generation students in today's lecture rooms. Thus, the active creation process can capitalise on the creative

[16] This view is part of Piaget's standpoint that students cannot build up knowledge by mere vocal knowledge transfer rather through a purposeful interaction with the world around them. Harasim (2017, p.83) notes that Piaget never related this epistemological theory to technology enabled learning but argues that technology has always been interconnected with learning.

[17] Activities necessary to create a digital story with AR: ideation, planning, sourcing, storyboarding, creating an AR story, presenting the final AR.

talents of students as they begin to research and tell stories of their own perspective (Menorath and Antonczak, 2017; Yilmaz and Goktas, 2017).

Nevertheless, not all students are the same and can be engaged by promoting active participation with technology (Bacca et al., 2014). Previous section referred to differences of students in, for example, their preferred learning styles, their previous experience with TEL and related digital literacy, but also their personal perceptions and expectation towards learning and teaching with technology. Furthermore, due to special to learning and teaching methods special student groups, such as handicapped students, might have not benefit as desired or might not be able to cope with an active prosumer role (Diegmann et al., 2015; Hantono, Nugroho and Santosa, 2018).

Finally, it should be noted that educational organisations have often a different understanding of students in the roles of consumers and prosumers (Ritzer, 2014). Macro and micro environmental influences on education organisations caused debates to see students as consuming customer for an educational service. Institution interpret requirements and offers in an economic context where *"efficiency, scalability and responsiveness"* are key success factors (Hayes and Bartholomew, 2015, p.1). Potential engagement of students to contribute as prosumers in learning and teaching led in recent HE policy, according to Hayes (2019, p.22), to a discussion on exploiting this as a resource for strategic marketing. Such approach would instrumentalise the potential to engage students trough TEL by economic means rather than by aligning it with pedagogic such as aims, strategies, student needs, and perceived outcomes (Kahu, 2013). Furthermore, as Klemenčič (2015, p.22) highlights there are a number of sociologic factors that influence students beside potential engaging offers in HE because the *"[...] choice of study is not based purely on rational individual decision making by informed consumers in a market"*. Additionally, learning with technology and its perceived engaging aspects might be strongly related to novelty and actuality of the applied technology, which itself is impacted by the evolutional pace of technology that needs attention in strategic HE policy.

2.4 Policy Issues

The previous section hinted that learning and teaching in HE is highly influenced by policy on governmental and institutional level, especially when including learning and teaching technology. Very early in terms of the rising computer era McLuhan (1964, pp.350–351) assumed that information technology would *"cause learning itself to become the principle kind of production and consumption"*. According to Maasen and Stensaker (2011) this impact of information technology has been recognized by a more central policy because policy regards HE in Europe as core knowledge institutions. Therefore, they argue, policy wants to utilise HE as knowledge generator and innovator by initializing agendas that lead to reforms for a digital transformation in HE. They further summarised that HE was itself for a long time from external influence and needs support and stimuli through policy engagement for a digital transformation in HE.

In Europe the probably the best-known policy initiative for education is the Digital Agenda for Europe started by the European Commission Communication in 2010. This agenda focused on providing framework for digital infrastructure, which has been understood as the foundation for digital education (European Commission, 2014). Later generations of digital education policies addressed first fostering teacher and student digital literacy and later integrating digital education in a systemic and holistic approach (Braun et al., 2020). This way policy makers try to consolidate, align, and support the efforts and strategies of individual countries regarding TEL in HE in order to speed-up the digital transformation processes in HE, which are seen as one pillow of competitive advantage for European nations (Boahene, 2006; Gaebel et al., 2014, pp.19–21; Braun et al., 2020; European Commission, 2014). The importance of this subject is highlighted through the latest implementation of a Digital Education Action Plan for the years 2021 to 2027 (European Commission, 2020). Despite these initiatives for digital education, which have legally more a framing character, Crowfoot (2020) request more initiatives where HE should play a central role in a digital transformation.

When reading further on international educational policy it becomes evident that for governmental bodies, and educational institutions, competition, competitive viability, costs and resources are dominant considerations in shaping agendas institutional points of view (European Commission, 2013; Sage Publications, 2007; Sin, Veiga and Amaral, 2016). The OECD (2010) review of Berlin's HE strategies and policies is one example of commercialisation and its impact on HE. Another example comes from Laszlo (2016) who notes that such trends for commercialisations are already recognizable in the UK, because policy has moved on to apply business strategies to eliminate inefficient, costly and as unimportant seen field in HE. These commercial considerations frame education in terms of consumption and leads to considering learners and students as consumers and disregards the personal aspects of education (see Hayes, 2016). However, as discussed before, this study regards students as consumers in the way of consuming learning offers and content, as well, as being integrated prosumers who create own learning content with AR (see section 2.3.4 - Students as Consumer and Prosumer of TEL Environments).

However, the technology aspect of HE is often limited to the buzz key concept of generating innovation for commercialisation within and outside of HE. Few countries recognise the need for innovating in teaching and learning and established organisations that address these issues, because digitization poses special challenges to any society, company, or administration (Hayes, 2015; Hochschulforum Digitalisierung, 2017). Technological developments in recent years, such as AR, increase the complexity and often require new solutions, which in turn requires people with extensive digital knowledge and skills. In some countries, these digital skills have been declared a desirable core competence by government and industry, which considers them a guarantee for national economic success (Bundesministerium - Digitalisierung und Wirtschaftsstandort, Austria, 2018; Forschung & Lehre des Deutschen Hochschulverbandes, 2020; Institut suisse des médias pour la formation et la culture coopérative, 2020).

Other countries around the world have launched similar programs supporting digital transformation at great expense and produced detailed strategy papers for educational providers and the technology industry (Department for Education, UK, 2019), which suggests a different weighting of interests and priorities. Nevertheless, it is apparent that many Asian counties, such as Korea and Japan, have foreseen a need for the digitisation of their educational environments much earlier and invested resources, and these countries are currently further enhancing their existing lead in the area. This may be in part due to a generally lower barrier to new technology innovations and early recognition of digital abilities as favourable skills for a future work force, and thus are considered essential for national success and wealth (Education in South Korea, 2018; Grzybowski, 2013; Mitomo, 2020; Mizukoshi, Kim and Lee, 2000). This lower barrier to technology might be the reason that AR has been adopted regularly earlier in different levels of education, such as extending book content with AR in Thailand (Vate-U-Lan, 2011) or for supporting students to learn English (Liu, Tan and Chu, 2007).

The Covid-19 pandemic required organisation to introduce ad-hoc digital transformations or to extend existing TEL environments to ensure academic operation. These rapid implementations of TEL revealed already known issues, such as the digital-divide, and Barnes (2020, p.1) argues that *"the problems of digitalization have also been exacerbated and must be further understood and ameliorated in the post-COVID world"*. It could be implied that the current Covid19 pandemic will spark more intensive research on digitalisation and a digital transformation in educational environments, including higher augmentation and virtualisation of educational content, which needs exchange and integration with future policies for HE.

2.5 Gaps in Literature

This literature review gives an impression of the extensive range of issues relevant to the construction of digital storytelling with AR in education. The literature offers much research on different teaching and learning methods in HE and other educational levels, such as CBS and Web-based learning, in order to align TEL methods to existing theories and frameworks, or if necessary, to create new ones. Nevertheless, when it comes to applied AR in education, the literature offers fewer resources than for other TEL methods. Therefore, this study applied the introduced theories from two perspectives, the instructional designer and the student. This provides Instructional designers with insights into how they can address and motivate students by designing a course to suit their learning preferences.

Additionally, this study contributes a set of constructive processes that are suitable to frame an intervention design for creating a digital story with AR. This study suggests that these creative processes, introduced here, a framework which supports students to create a digital AR story but also offers beneficial skills for the future career. There are recognisable more studies that consider passive AR application, while applying AR in creative means by allowing students to direct and create their personal learning content is still rare[18]. This might be due to a perceived high level of complexity and need for resources for AR enabled interventions in a research design. However, this study addresses these issues through applying digital storytelling with AR to reduce this knowledge gap. Nevertheless, recent developments in AR technology and the advent of more competitors, offers easy to use and well-priced AR environments for education and might enable more research and generate more literature. Despite many available studies on learning styles impacts though various TEL methods, AR enabled teaching and learning was rarely included as a research topic, what this study wants to compensate for.

Furthermore, the literature review on AR in educational environments, revealed a lack of reported student perspectives when AR was applied as teaching and learning methods, especially when students adopted a creative role (prosumer).

Related to this point, there is view information on the how students perceive AR enabled learning and teaching methods as beneficiary for their future career, which should be interesting for the ultimate goal of preparing students for their future employment, and this study tries to contribute

[18] This draws on students using AR as consumers or as prosumers.

to the clarification these questions with perceptions and expectations of the participating students.

2.6 Literature Review Summary

The review of the literature related to digital storytelling with AR as a learning and teaching method revealed three main topics: the learning domain, some selected motivational aspects of TEL, and the role of TEL from a policy perspective.

Research indicates that the learning domain is a broad field that spans from traditional to modern learning and teaching. The two terms, traditional to modern learning and teaching, are still subject of discourse since the lack of clear delimitations impede a definition. Nevertheless, many sources highlight that learning with technology is not a new domain, and new innovative technologies are increasingly integrated in education. The related term *Technology Enhanced Learning* sparked discussions on defining the enhancing effects and benefits of technology in learning. This resulted in the advent of the term *Technology Enabled Learning* to recognise debates concerning technology in learning as a support or an enhancement.

Two theories in the literature help explain some specific learning aspects when creating a digital story with AR. In line with *self-determination theory* AR storytelling allows a high degree of autonomy, interactivity and potentially working in teams, which promotes autonomy and social integration. Furthermore, the literature suggests that feedback through AR enabled learning and teaching can support learners' gaining competence in, for instance technology-self-efficacy. In respect to *flow theory*, studies found that the flow experience of students were significantly positively impacted, as they observed that AR can deeply involve students and let them enjoy learning with AR enabled learning. It is furthermore suggested that learning with AR could potentially better capture and retain attention of students, which might result in better learning performance.

Literacy is defined in the literature as a core element of cultural integration, and some policy makers consider literacy to be a very decisive prerequisite for a satisfying life, both professionally and privately, especially in times of digital transformations. Researchers and industry agree that flexibility and adaptability to new environments and technologies are potentially important skills of the 21st century that educational organisation can foster, which require students to gain certain digital literacy skills.

Many studies conclude that personal storytelling has the potential to foster student reflectiveness through the use of diverse media. Extended by digital media, studies show that digital storytelling increases the number of possible tools for telling a story and can fulfil the demands of a more digitised world. Furthermore, the literature suggests that there exist various concepts which can be applied to digital AR storytelling to support pedagogic applications. Three concepts were consistently identified as relevant for digital storytelling, the ADDIE Model, the SAM, and the Design Thinking process, which can support instructional designers in designing an AR storytelling intervention, as well student in creating a AR story and as beneficial skill set for their future career.

The literature suggests that ADDIE is a suitable model for digital storytelling projects that make use of AR, either created by an instructional designer or by students, because it offers a systematic and generic structure approach. For example, for creating an AR story on the subject 'listening to a story' for a magic story book project Koçak et al. (2019) could successfully apply the ADDIE as framework for their analysis, design, development, implementation and evaluation phases. Another example adopted the ADDIE model for the creation of an AR intervention that explains computer components. Different from the previous example, Pantelić and Plantak Vukovac (2017) applied the ADDIE model phases solely as content creators, thus from an instructor perspective.

The literature highlights that the model provides a framework for necessary information collection and task completion for students. Additionally, the reviewed literature suggests this model as a potential guide to foster abilities and skills in building-up knowledge, in conceiving, planning and creating the digital story, especially for digital storytelling with AR.

Nevertheless, some researchers, such as Bahl and Alam (2012), complained that ADDIE is basically a linear concept, causing inflexibility. The literature proposes to extend ADDIE through the more agile SAM concept. Integrating SAM for creating e-learning products can ease systemic challenges of ADDIE, for example, a gaining a certain amount of flexibility in the creation process of a digital story (Allen and Sites, 2012, pp.3–9). Additionally, these researchers recommend a combination of both models as a suitable approach to creating a digital story since they complement each other in helping students to find ideas, solve problems and finally create a digital story with AR.

The third process identified in the literature for creating a digital story with AR is based on *Design Thinking* theory, which considers AR storytelling as a creative process per se. The literature describes the evolution of the original design thinking process as one that centres around humans, the extended iterative HCD, which is considered as iterative in nature (Scheer, Noweski and Meinel, 2012; Buchanan, 2001). The authors explain the advantages that iteration provides as it creates the basis for adaptation at different task stages and tasks can relate back to preceding tasks iteratively too. These attributes make the extended iterative HCD suitable for curriculum design and as a guide for students creating a digital story with AR.

Reflecting on a *student perspective towards digital storytelling* some studies found that students need to be able to handle digital media and prove further literacy competencies such as critically interpreting, validating their created content, and implementing their ideas and materials. Findings suggest that students may develop enhanced communications skills by learning to organise ideas, ask questions, express opinions, and construct narratives through digital storytelling (Abas and Zaman, 2010; Agogi, 2011; Laar, 2019). Additionally, the literature highlights the emotional aspects of digital storytelling, which might help students to learn to maintain an audience's attention (Moon, 2004; Duarte, 2010). Furthermore, digital storytelling can impact student's skills to give meaning to data, when students are allowed to make connections to personal experiences and when they can place data in the context of a story, which creates a personal connection for the students (Brockbank and McGill, 2007).

Within the literature it was apparent that the *perspectives of students* on TEL depend on various attributes. Student motivation might be driven by extrinsic influences, often institutionalised by educational policy, such as employability or sustainability of education. Particularly technology enabled learning can shape student perspectives substantially since the acquisition of new competences such as approaching new (digital) media might gain crucial relevance for their future live (Biermann, Fromme and Verständig, 2013; Gilbert, Morton and Rowley, 2007; Hsu, Lin and Yang, 2017). Studies found that perceived usefulness can include gaining new knowledge experiences and skills through (new) learning technology, and a holistic view of their life or the integration of TEL in their social activities can additionally impact on the intrinsic motivation of students (Flint and Johnson, 2011; Moon, 2004).

Rather than considering the student perspective *student engagement* often defined as the withdrawal rate as engagement measurement was far more apparent in the literature and associated with monetising and commercialising HE and the institutionalising of an employment model (Baily, 2010). However, there is evidence in the literature that organisations and researchers challenge this view and offer different attempts to explain attributes that impact on student engagement. In general, they suggest that behaviour, psychological and socio-cultural perspective and a holistic approach that combines issues from each of the three mentioned perspectives can overcome the weakness of such limited definitions (Kahu, 2013). Some studies moreover claim a lack of actuality and fit of curricula to the current zeitgeist as a source of a student engagement issue (Prensky, 2005).

Many studies suggest that *motivation* is an ongoing issue for teachers and is important because motivation contributes to the achievement, satisfaction, and engagement of students (Flint and Johnson, 2011). Concerning AR enabled learning researchers collected evidence that teaching and learning with technology, especially with AR, has positive effects on engaging students and fosters their learning. Research offers various approaches to adopt known motivational theories and concepts to TEL (Deci and Ryan, 1985; Csikszentmihalyi, 2000; Coffield, 2004; Felder, 1996; Liang, 2004).

Due to the opportunities for interaction, flexible use and creation of own learning content, concepts such as self-regulated could be applied to learning and teaching with AR (Saks and Leijen, 2014). Research suggests that self-regulated learners normally direct their thoughts, feelings, and behaviour towards achieving certain goals, such as achieving a certain grade, and learning something new that will benefit the student's future career (Greene and Schunk, 2017; Mega, Ronconi and De Beni, 2014; Pintrich, 1995). The literature on TEL reports that many educators use learning methods for self-directed learning to increase student motivation, since students can determine to a certain extent what, with what, and when they want to learn (Carneiro, Lefrere and Steffens, 2007; Cerna and Poulova, 2013; Douglass and Morris, 2014).

Literature defines *ARCS* as additional didactic motivation model, through which teachers can recommend courses of action for the design of learning environments that help to promote and maintain the motivation of learners. In studies the ARCS model has become a prominent example for explaining the complexity of student motivations, in traditional as well as TEL (Keller, 2009, 1987a). Applied to digital storytelling with AR, the underlying technology has the potential to address all four elements of the ARCS model, for example, by drawing attention of the student due to a novelty effect. Nevertheless, research assumed that this model is too weak to cope with systemic issues, such as not being able to map characteristics, dependencies, and potential contradictions due to its string linear character (Cheng, 2018; Keller, 2000, 1999; Means, Jonassen and Dwyer, 1997; Wei et al., 2015).

Student motivation is influenced by self-efficacy, which the literature defines as beliefs in one's capabilities to accomplish a task, has been expanded to technology (Bandura, 1997). *Technology-Self-Efficacy* can apply to new emerging technologies in the future. The adaption of

TSE to specific types of technologies is evident in educational research through the classification as computer self-efficacy or Internet-self-efficacy, and information-technology self-efficacy, depending on underlying technology and student's potentially approach to it (Joo, Bong and Choi, 2000; Fauzi, Ali and Amirudin, 2019; Mahat et al., 2012). Studies showed that TSE affects cognitive, motivational, emotional and actional processes, and highlighted four main aspects: facing a situation, feelings, thinking and motivation (Bandura, 1997, pp.116–128).

The literature discusses an interesting motivational approach, defined by the level of integration of students in the learning and teaching process, based on a consumer to prosumer continuum (Ritzer and Dean, 2019, ch. 6). Involving students in a creative process is as an interesting idea in pedagogic applications of TEL. More TEL related studies understand students in a prosumer role for their personal learning, where creativity is the key element of audio-visual and multi-media content in curricula with the potential to influence student engagement and learning motivation. Studies suggest that digital storytelling transforms students from only consuming content to active creators of content by establishing a creative process and enriching a narration of a story with multimedia, and a certain level of interactivity (Burlea and Burdescu, 2016; Ha and Yun, 2014; Ivashkevich, 2015; Leong, 2017; Wilen-Daugenti, 2009, 13pp.; 186pp.). As digital AR storytelling is seen as active creation process the literature summarises that it can capitalise on the creative talents of students as they begin to research and tell stories of their own perspective (Menorath and Antonczak, 2017; Yilmaz and Goktas, 2017).

Finally, researchers and practitioners agree that learning and teaching in HE is highly influenced by policy at governmental and institutional level, especially when related to learning and teaching with technology (1964, pp.350–351). International educational policy publications offer evidence that governmental bodies and educational institutions are shaped primarily by market economic conditions (European Commission, 2013; Sage Publications, 2007; Sin, Veiga and Amaral, 2016). Related discourse argues that this view disregards students as educational consumers who have their own perceptions and expectations and demotes them to objects (Hayes, 2016).

The ongoing digitization of society has implications for the continued digital transformation of education at all levels, from primary to tertiary education (Maassen and Stensaker, 2011). Consequently, decision-makers in policy and education consider the issue of digitisation in education and continue to develop instructions for action and political programmes and strategies to foster the dissemination of technology in learning and teaching environments, especially in the light of a post-pandemic era for digital transformation of HE (Grzybowski, 2013; Mitomo, 2020; Mizukoshi, Kim and Lee, 2000; Barnes, 2020).

3 Research Methodology and Methods

3.1 Introduction

The purpose of this study is to explore how MBA students perceived and experienced an Augmented Reality [AR] enabled learning intervention and how it might have influenced their personal learning style preferences and learning process.

In seeking to understand this phenomenon, the study addresses three research questions:

RQ 1. Does creating an AR experience support the student's learning process and what features do they consider the most useful?

RQ 2. How do students perceive AR enabled learning and what are their learning preferences towards this method?

RQ 3. Does the experience of AR change student learning style preferences?

This chapter describes the research methodology of the study and addresses the following areas: (a) research philosophy, (b) rationale for research approach, (c) description of the research sample, (d) summary of data collection, (e) overview of research design, (f) methods of data collection, (g) analysis and synthesis of data, (h) ethical considerations, (i) issues of trustworthiness, and (j) some limitations of the study. A brief concluding summary completes the chapter.

3.2 Pragmatism as Research Philosophy

The underlying methodological assumptions for this research are based on pragmatism. One basic assumption is that pragmatism stands for the general philosophical theory of knowledge, reality, and experience, instead of following the simplified credo 'what works'. In general, pragmatists consider reality as variable, inferring that future experiences will change and verify all knowledge, while meaning and thinking helps us to realize our interests (Morgan, 2014a; Rydenfelt, 2009).

How people perceive reality depends on their perspective. Moreover, the choice of perspective is made by individuals and thus it is individuals who determine how they perceive reality and what they comprehend as reality (James, 1907; James, Ferron and Madelrieux, 2007; Marchetti, 2012).

Personal experiences make up a good part of people's perceptions of reality. James suggests that pragmatism is poised to do anything, following logic or senses while accepting even the most humble and personal experiences (James, 1907, p.80).

Generally, there is no single perspective that can entirely provide a holistic picture of the world and there may be multiple realities, since there are different approaches towards interpreting the world and towards pursuing research (Saunders, Lewis and Thornhill, 2015). To use Einstein's ideas, a thing such as reality exists but it is ever changing since it is relative, and so is knowledge and its application, for each and every person. Based on Dewey's spectator theory, Morgan (2014b, Posted on 18th June 2014) even argues that *"[...] attempts to find an enduring, external reality are doomed to failure".*

Inspired by this understanding of pragmatism, this study accepts a universal, holistic, and purposeful approach to research challenges and changing circumstances and adopts a pragmatic approach.

3.3 Rationale for Mixed Methods Research Design

The educated freedom of choice of methods finds its pragmatic application in the field of Mixed Research [MRE], which is characterized by a Mixed Methods [MIM] approach (Morgan, 2013, 2007; Saunders, Lewis and Thornhill, 2015) that detaches a researchers choice from an absolute doctrine in favour of fulfilling the depicted necessities for proper research and results in a close relation to practicability.

As with a pragmatist stance it could be claimed that there will never be a single point of view that will be able to provide a holistic overview and that there might be multiple realities. This position is supported by other researchers that accept that there are various ways of interpreting our world and thus there are many different approaches for conducting research (Biesta and Burbules, 2003, pp.70–71; Saunders, Lewis and Thornhill, 2015, p.144). Morgan (2014b, 2014a) argues that to find an enduring, external reality cannot lead to success. He adds that within the scope of a single research project according to the nature of the research question a pragmatist researcher can combine both, positivist and interpretivism positions.

Applied pragmatism in research involves engagement and triangulation to allow researchers to elaborate their own questions and aims, as well as capturing the voice of others. So, pragmatism regards various positions and values, while choosing and using a feasible set of tools to pursue this (Fendt, Kaminska-Labbé and Sachs, 2008). Nevertheless, this does not mean that pragmatists are forced to always use multiple methods.

The choice of methods relies on practicability to ensure credible, well-founded, reliable and relevant data to be collected that contributes to one’s research (Kelemen and Rumens, 2008). Specifically, in education the application of new technology is a sophisticated matter that demands more than only accepting isolated results based on quantitative effect indicators (Ross, Morrison and Lowther, 2010). Furthermore, Ross claims to rely on a researcher’s subjective qualitative conceptions is not scientifically adequate.

It was the prospect of a higher perceived objectivity that leads many educational researchers to see an added value in collecting quantitative and qualitative data and combining in this way their strengths, which made a mixed methods approach appealing for this research (Johnson and Onwuegbuzie, 2004; McLaughlin, Bush and Zeeman, 2016; Onwuegbuzie and Leech, 2005).

The literature offers three basic design approaches for conducting research using mixed methods: exploratory, explanatory and triangulation.

In an Exploratory Design a significant characteristic is that the qualitative data works as the foundation for the development or refinement of the quantitative measures. This implies that quantitative data uses qualitative data to explain or scaffolding findings or phenomena. Conversely, an Explanatory Design favours quantitative data while gathering and analysing quantitative data, which are subsequently enriched or cleared. In the third option, often known as triangulation design, researchers collect qualitative and quantitative most times simultaneously and in the same situation, which leads to a more complex design construct.

To combine the strengths of both types of methods one treats both data sources similarly by triangulating (comparing) them to verify if the data provides similar findings (McLaughlin, Bush and Zeeman, 2016). The concurrent use of multiple methods has potential to deliver a more holistic impression of the research field and more credible results.

All mentioned designs are pure forms and do exist in modified constructs, for instance, in terms of timely order or preferences in data types (Bressler and Bodzin, 2013; Hesse-Biber, 2010; Tashakkori and Creswell, 2007; Watkins and Gioia, 2015). This thesis draws on qualitative and quantitative data at the same time at the beginning and the end of each full-day intervention.

3.4 Rationale for a Mixed Survey Methodology

Within the framework of a mixed method approach, given the maximal expected sample size ($n_{max}=142$) and the characteristics of part-time MBA programmes, such as the profession of students and consolidated study weekends of the programme, the study was most suited to a mixed exploratory and explanatory survey design. These design features flexibility, understanding the student's learning preferences and their influenceability, developing contextual understanding, facilitating interactivity between researcher and MBA students, and adopting an interpretive stance.

To collect the data, two surveys were sequentially employed at two stages of the AR intervention. The surveys collected both quantitative and qualitative data including Felder's Inventory of Learning Styles [ILS] ($n_q=44$). The ILS was identical for the pre- and post-intervention, while the mixed survey differed for the pre- and post-intervention. Purpose of the pre-intervention survey was to collect demographic and contextual data, while the post-intervention survey addressed the student's perceptions and experiences. Finally, the collected data were enriched with contextual data from teaching observations of each of the three workshops.

This approach was essential for the elaboration and extension of specific findings emerging, on the one hand, from the quantitative data, such as statistical differences among the pre- and post-intervention. On the other hand, from the qualitative data, such as unexpected and seemingly contradictory results revealed in the participant's own words and perceptions of AR in learning and teaching. Additionally, exceptional results from the two collected ILS questionnaires could be connected through the sub-questions relating to each learning style domain to the quantitative and qualitative result of the survey to better understand the student's perception towards AR enabled learning and teaching. Furthermore, it put highlighted if, how and why an AR intervention influenced the student's learning process and learning style straits (Castro et al., 2010; Creswell and Creswell, 2018; Feilzer, 2010; Johnson, Onwuegbuzie and Turner, 2007).

3.5 Research Sample

The data for this study was collected from three part-time MBA[19] cohorts enrolled in either the eMBA, part-time MBA, or apprentice MBA at Aston Business School in Birmingham, UK. These

[19] The study uses the abbreviation PT-MBA or MBA student to refer to the deviating heterogenous groups of different MBA programmes.

MBA programmes required the students to join a three-day study-weekend, where they had to attend several mandatory modules and workshops within the Aston Edge initiative. This initiative was the umbrella for providing MBA students further skill building opportunities in themes such as digitalisation in the context of digital transformation processes. This led to the development of a full-time workshop (intervention) where the MBA students learned the basics of augmented reality and digital storytelling to ultimately create their own digital AR story.

The target group for this study was part-time MBA students. As distinctive from full-time MBA students which usually constitute only a small population of students in any academic year, part-time MBA programmes include much higher numbers of students due to integrating different programmes and academic years. The opportunity to reach a larger sample size and target as many as possible MBA students suggested the application of a convenience sampling method, inspired by pragmatic body of thought. Gall, Borg, & Gall (2003, p.175) support this approach by claiming:

> "*Researchers often need to select a convenience sample or face the possibility that they will be unable to do the study. Although a sample randomly drawn from a population is more desirable, it usually is better to do a study with a convenience sample than to do no study at all– assuming, of course, that the sample suits the purpose of the study.*"

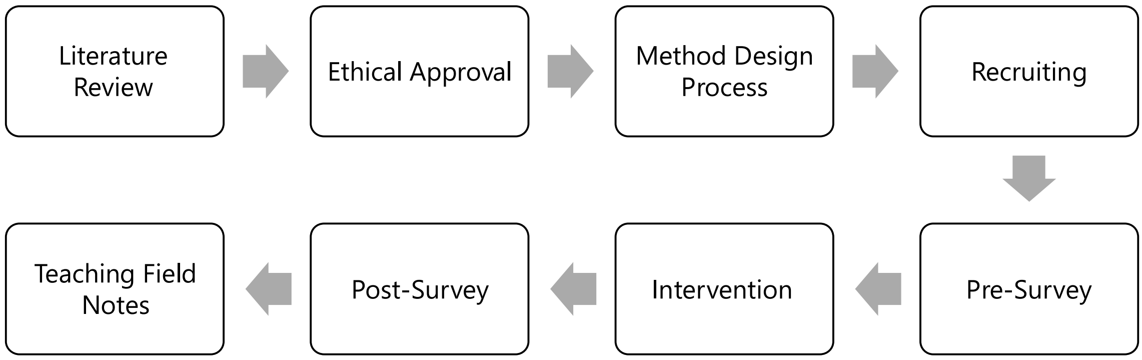
Consequently, this study used a purposive sampling method, accounted as a variant of convenience sampling, with a total population size of $n_p = 94$. From this total n_p 92 students ($n_{pre}=92$; $n_{female} = 35$; $n_{male} = 57$) participated in the pre-intervention survey and 73 students ($n_{post}=73$; $n_{female} = 28$; $n_{male} = 45$) in the post-intervention survey. The surveys were completed in the classroom using a paper and pencil format.

3.6 Research Design

3.6.1 Overview

Figure 4 illustrates the research stages used to conduct this study, followed by a brief summary of each stage. The succeeding section offers a more thorough discussion of each stage.

Figure 4 - Research Process



1. Literature Review

   This study started with the identification of topics and a literature review. Aim was examining contributions from other researchers and authors in the broad fields of higher education and adult education theory related to the use of augmented reality as a learning method and the perspective of students.

2. Ethical Approval

   Succeeding the formal qualifying report and the proposal defence an application for the mandatory ethical approval was submitted and approved.

3. Method Design Process

   According to the proposal and the committed MBA intervention format the surveys and the intervention were developed.

4. Recruiting

   The purposive sampling of participants required the briefing of the participants in advance of the study weekend in close collaboration with the Aston MBA office. The students received in written form a description of the study and the intervention, and informed consent document.

5. Pre-intervention Survey

   Each workshop started with an introduction and reiteration of the informed consent for this research. All attendees were asked to complete the pre-intervention survey, in pen and paper form, prior the workshop and return the form before the actual start of the workshop.

6. Intervention

   The workshop was divided into two main sections. The first section provided a theoretical introduction to AR, digital storytelling, and the use of the selected AR tool, while the second section was the actual AR intervention, where the students were asked to ideate, outline, and design their personal AR story. During each intervention the researcher observed how the students engaged and took draft notes of these observations. Later these draft observation notes were transferred in more detail to a teaching journal.

7. Post-intervention Survey

   Each workshop ended with asking all attendees to voluntary complete the post-intervention survey in pen and paper form.

8. Observation – the teaching journal

   The draft notes, taken during the intervention, were transferred to a standardised teaching journal. Retrospectively, distinctive behaviours, activities, events, and other features were supplemented in more detail to complete the journal as basis for the later analysis and better understanding of the collected qualitative and quantitative data.

3.6.2 Ethical Approval

The regulations of the university prescribe the mandatory approval of the ethics committee for research work. The process requires outlining the proposed research design and identifying potential ethical issues. Furthermore, ensuring to adhere to standards, including not exposing participating persons to disadvantages or exceeding customary dangers, and guaranteeing participants anonymity and informed consent. The ethics approval incorporated several stages at both the university and faculty level. The process required the submission of the standardised surveys as well as written research descriptions, a risk analysis, and precaution to ensure anonymity and data protection. Finally, the official ethics committee reviewed and granted ethical permission for this study.

3.6.3 Data Collection Methods

To understand student perspective on AR enabled learning and teaching approaches and its potential impact on learning traits of the students, the use of multiple method was critical. Qualitative and quantitative data were used to obtain a deeper understanding of the subject under study.

Prior to the planned study weekend, the Aston MBA Support Office contacted the MBA students officially via email to inform them about the workshop, the embedded research and received a written version of the informed consent. The Aston MBA Support Office expected more than hundred attendees for that weekend and assigned three groups for three interventions between Friday and Sunday.

3.6.3.1 Pre- and Post-intervention Surveys

This section illustrates the aspects of data collection in the pre- and post-intervention survey [20]. The basic framework for data collection was to collect data with two surveys, one before (pre) and the other after (post) the AR enabled intervention. Each survey followed a mixed method design to collect pure nominal profile data, data that provides nuance and insight into participants' opinions, as well as combined closed-open and purely open questions to collect student opinions and perceptions. Both surveys included Felder's standardised ILS questionnaire[21] (Felder, 1996) to collect the same dataset pre and post the AR enabled intervention.

Open questions from qualitative research are characterized by the high expenditure of time in the evaluation, which potentially increases with large numbers of participants, and the limited possibility of their automation, while collecting in-depth insight from participants. In comparison, closed questions offer the advantage of being relatively unobtrusive and easily administrable, while delivering a large dataset that researchers can statistically evaluated. A way to achieve both the depth and breadth that qualitative and quantitative methods offer was through a combination of open and closed questions.

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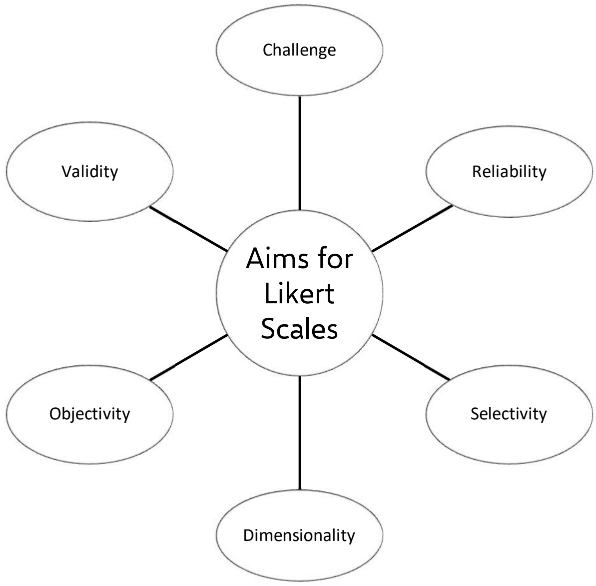
[20] I used the term "survey" for describing the final product of the combined "questionnaires" for a better differentiation.

[21] See appendix 7.1 - Excerpt of Literature Focusing on Teaching and Educational Perspectives

This ensured furthermore to not overload participants and that the amount of data the study would receive remained at a high level (Bryman and Bell, 2011, chap.10; Foddy, 1993, chap.10; Singer and Couper, 2017).

This study sought to gain insights of the student's perceptions and expectations. Questionnaires applying categorical Likert-based scales offer one effective instrument for one-dimensional adjustment measurement with respect to different aspects (Kumar, 2011). Attitudes are captured, for example, by asking the respondents a question in which they can give their assessment on a scale from 'extremely unlikely' to 'extremely likely'. The number of response categories is a very important property of rating scales for understanding the rating dimension because it determines the degree of differentiation of a rating scale (Parducci, 1983). Krosnick et. al (1996) concluded that an optimal measurement, in terms of reliability, validity and degree of differentiation, can be achieved with five to seven categories. They saw preferences of the interviewees usually lie in this area, commenting that too many categories dilute the meaning of each category hence making it more difficult for participants to answer. Conversely, a scale does not differentiate enough if the number of categories is too small (Krosnick, Narayan and Smith, 1996; Krosnick and Pressner). However, later studies revealed a linear correlation of the number of categories and psychometric quality criteria where the quality increase with increasing number of categories. The studies made use of 10 and 100 categories (Pajares, Hartley and Valiante, 2001; Pospeschill, 2013; Preston and Colman, 2000; Saris and Gallhofer, 2014), but in practice prevails a range from five to seven categories (Hartley, 2014). This study followed the determined scale for Felder ILS in order of being able to apply the original algorithm for the analysis, to compare the results with previous and future research, and to apply similar analysis approaches. The remaining Likert based question adopted a five-point scale for attitude questions as well. The latter was also important since the analysis of the data does not usually apply at the level of the individual questions (items), but at the level of the scales of a survey (Pospeschill, 2013, p.114).

Figure 5 - Aimed Analytic Characteristics of Likert Scales



With this approach this study tried to record different degrees of expression of the characteristics, provide reliable and accurate measurements, differentiate between different characteristics of the participants. Further aims were to only capture the desired dimensions within the scale, offer a (relative) evaluable objectivity, and ensure validity of the capturing construct (See Figure 5).

3.6.3.2 Qualitative Data Collection

This study included seven short-answer qualitative questions in the post-intervention survey, which were supplemented by insights from three teaching observations that documented the environmental impressions and workshop observations.

In summary, qualitative methods offer more flexibility, tend to reduce researcher assumptions and may identify key issues for participants. They also allow the consideration of the social impacts of experience and establish connections between various areas of the participant's experiences (Griffin, 2004). Thus, to reach a more holistic view the study adopted in the post-intervention survey open-questions in addition to the quantitative questions, where the questionnaire offered three paired Likert-Open question and four independent open questions.

3.6.3.3 Teaching Observations

In general, recurring observations and corresponding field notes can be seen as the systematic grasping, capturing and interpreting of sensually perceptible behaviour at the time of its occurrence. The literature suggests furthermore a conceivable diversity of observations and field notes types which are limited in the empirical reality of research (Atteslander et al., 1995; Montgomery and Bailey, 2007; Mulhall, 2003). The observations took place in a natural situation as field and teaching observation during the theoretical part of the learning event and the succeeding AR intervention. The role of the researcher as a lecturer during the interactions of this AR storytelling intervention, a type of participatory observation, allowed researcher to be generally accepted in that particular social situation, and thus granted access to this social field. As is usually the case with participant observations, impressions were recorded subsequently after exiting the field. Nevertheless, brief notes were taken at each of the three workshop days when the students were engaged with tasks. The aim was to capture experiences, perceptions and observations of the environment, the group behaviour, outstanding incidents, and to take other events into account (Johnson and Christensen, 2017, pp.240–243; Lodico, Spaulding and Voegtle, 2007, pp.118–119). After each workshop it was necessary to write-up the short 'in-session' notes on two-page forms to dilute memories as less as possible.

In the analysis phase the field notes were informed the analysis of the answers given by the students and other events, such as the breakdown of the internet-based AR tool and the participation of the students at the post-intervention survey. Furthermore, these impressions were used to understand or explain possible impacts of the environment and circumstance on the students' responses.

3.6.4 Sampling and Selection

In preparation for this study discussions on the proposed research took place with stakeholders at Aston Business School and the director of the MBA programs on several occasions. Instead of the current FT-MBA, the Business School offered the opportunity to run a full-day workshops with PT-MBA programmes.

The potential FT-MBA sample provided a small group of approximately 35 students but were readily accessible as students lived either on-campus or within the city. Nevertheless, a small sample group had the potential of attracting only a small number of participants for the study.

The PT-MBA programme consisted of three cohorts that incorporated approximately 140 students who might attend the study weekend. Despite their living away from the university and their daily work commitments this population suggested a potentially significantly larger sample size. These characteristics and the limited accessibility justify choosing this group but had the consequence of sacrificing the option of focus groups or interviews as additional data collection methods. In a pragmatic stance this study adopted the research design to the situation and extended the surveys with standardised questionnaire and field notes, to the mobile PT-MBA student population.

In close cooperation with the MBA Support Office the workshop was designed and integrated it into the Aston Edge initiative. The MBA Support Office contacted all of the students enrolled in the study-weekend ($n_e=127$). All students received a description of the workshop and a briefing on the embedded study. Additionally, all students received a letter seeking their Informed Consent.

At the beginning of each workshop day all attendees were re-briefed on the workshop content and aims, the study, and sought their Informed Consent before asking the MBA students to participate in the study. The MBA Support Office also assigned the participants to the single workshop days according to their groups, their academic year, and other lectures. Thus, the groups showed very different sizes, while the first one was the smallest with only five students attending ($n_{a1}=5$) but all agreeing to participate in the study ($n_{p1}=5$). The groups on the second and third day were substantially larger. The second day workshop group had 71 students attending ($n_{a2}=71$) and 56 participated in the study ($n_{p2}=56$, 78%) while the third group had 48 attendees ($n_{a3}=48$) and 31 students that agreed to participate ($n_{p3}=31$, 64%).

3.6.5 Intervention

As presented in the literature review, instructional design methods (see 2.2.11.2), such as the design thinking method, are solution-based methods for addressing complex problems that are not well defined or (yet) unknown, for example, creating a course adopting AR technology for digital storytelling. Some of the methods used in especially design thinking include understanding human needs, person-cantered redesign of problems, brainstorming new ideas and possibilities or alternatives. The preceding steps, some of which are iterative, lead to the adoption of a practical approach to prototyping and testing, which eventually culminate in the final event concept.

Beside answering the research question, this study has set as a secondary aim to promote potentially useful competencies for the participating students. Therefore, the instructional design established the Design Thinking ideas as a framework for the methodology of the digital AR storytelling intervention and the actual application by the students. In this process, the lecturer / researcher takes the role of a proactive learning coach, while the students work together in heterogeneous learning groups on a self-imposed topic for digital storytelling and complete "learning challenges" in individual stages to ultimately arrive at their own digital AR story.

The five phases of design thinking were thus applied during the design, as a methodological concept for the course and as a pedagogical method to develop the best solution approach for this event and at the same time to provide the students with a proven tool for their own creative creation of a digital AR story. In the following, the design of the intervention is explained in detail.

For this research, the study weekend for the MBA students provided the framework for the intervention and the two data collection points. Assuming the students participated with different levels of pre-knowledge the workshop was divided in two main parts: the first part addressed the theoretical background of AR and storytelling and in the second part students applied this understanding to create a personal AR story in the AR enabled learning intervention. The plan in Table 5 provides the detailed sequence for the AR intervention.

Table 5 - Workshop Intervention Plan

DIGITAL STORYTELLING WITH AUGMENTED REALITY			
Subject		Length	Domain
Introduction, setting the scene		00:10	Theory
Pre - Questionnaire	Student activity	00:15	
Work in groups (5-6) What is your experience with AR and storytelling Where do you see possible applications?	Student activity	00:15	
Sharing the results of the discussion	Student activity	00:10	
AR intro + 2 videos		00:15	
Storytelling Concept, 2 videos, Comparison, find a topic, decision making, storyboard example		00:25	
BREAK		00:20	
Collecting ideas	Student activity	00:10	
Selecting a topic	Student activity	00:05	
Compiling details, creating some structure with e.g. mind mapping	Student activity	00:25	
Creating a storyboard	Student activity	00:25	
BREAK		01:00	
Verifying ZapWorks login	Student activity	00:10	Practice
Installing ZapAR on mobile device	Student activity	00:10	
Collecting resources	Student activity	00:20	
Creating target image	Student activity	00:20	
Creating AR experience in ZapWorks Designer	Student activity	00:45	
BREAK		00:20	
Post - Questionnaire	Student activity	00:20	
Sharing AR creations	Student activity	00:20	
Sharing opportunities and limitations of AR	Student activity	00:20	
Optional variable buffer: AR in Business Environments / Virtual Reality		01:00	
END		00:00	

The Workshops lasted eight hours and included three breaks to not overload the students and give them the chance to network and discuss the current workshop (Ivanova and Ivanova, 2009; Eze and Misava, 2017; Wilson and Korn, 2007). After an introduction, the participating students completed the pre-intervention survey and this was followed by a presentation of basic background information on AR and storytelling with a mix of textual and multi-media enhanced resources, and opportunities for group discussions. After a longer break the students were asked to create their own framework for an AR enabled digital story. In small groups they chose a subject of personal interest that related to their experience of being a part-time MBA student.

Ultimately, the students created their own personal AR story with the web-based AR Designer development tool from ZapWorks (2020). Close to the end of each workshop groups were asked to explain and present their ideas behind the created AR story. Since the workshop left only time to create an AR story in prototype quality and the chosen tool offered only limited functionality, the attendees presented their vision rather than a completed AR story. Each workshop ended by asking the students to complete the extended post-intervention survey to capture student perceptions and experiences, as well as a second Felder ILS questionnaire.

Following the study weekend, the Aston LMS provided a modified copy of the workshop presentation for students that contained additional information, such as references, further reading on AR technology and storytelling, as well as further references to examples of AR business applications.

3.7 Data Analysis

The analysis included two phases: data processing and theme identification. The challenge in this two-step process was to first collect large amounts of data in a meaningful way, reduce the volume of information generated, identify patterns that were significant and create a framework for the analysis.

To avoid the risk that the researcher is overwhelmed by tremendous amounts of data, unnecessary repetition in the process or loss of focus, data collection and analysis should be parallelized (Merriam, 1998; Merriam and Tisdell, 2016; Saunders, Lewis and Thornhill, 2015). In this study, this was only possible to a limited extent, as the data collection took place in a very condensed period. Therefore, a theoretical evaluation had to be carried out during conception phase to avoid the possible negative consequences.

The choice of the correct analytical tools for this study were based on the characteristics of the data and the level of expertise of the researcher. The list below (Table 6) summarises the chosen tools for the analysis of this study.

Table 6 - Selected Analysis Tools

Tools (all on Windows 10, 64bit)	Application
IBM SPSS	• Reliability testing
Excel 365	• Felder's ILS Scoring Algorithm • Graph generation for ILS • Filtered ILS comparisons • Analysis of closed questions • Platform for AI based sentiment and emotion analysis • Identification of themes in conjunction with imported graphs from KH Coder
KH Coder, version 3, (Higuchi, 2019)	• Analysis with o Hierarchical Cluster Analysis of Words o Multi-dimensional Scaling of Words o Co-Occurrence Network of Words o Self-Organizing Map of Words • Generation of graphs
Voyant Tools (version 2.4), (Sinclair and Rockwell, 2019)	• Simple Word Frequency Lists • Phrase Analysis

The basic design of the study collected data at two points, pre and post of the AR storytelling intervention. At the same time, the surveys collected quantitative and qualitative data requiring different analytical methods for each type as well as an approach to integrate the results. Nevertheless, the study followed the same procedure, starting with the preparation phase for the collected data.

3.7.1 Preparation

The first preparation pass sought to identify all valid responses, differentiating between complete null-responses and skipped questions by highlighting them on the original paper, enumerated each returned survey, and added a group code. Due to the anonymous mode of the surveys, it was not possible to assign a dedicated number to any individual participant.

At first, all responses were digitised and saved to electronic PDF documents for secure storage and later digital review. For all three groups all responses from the pre-intervention survey, the demographic as well ILS questionnaire responses were entered into an intermediate Excel sheet. This transfer required more work since the post-intervention survey additionally contained open questions and their transcription was challenging due to readability. The responses were transcribed, and any problematic words or questions were highlighted on the original response forms. Unclear passages were collected and a native English speaker asked to review all anonymised text passages and provide the correct transcription, as well as review those previously transcribed, in accordance with the ethical framework for the study. Subsequently, the quantitative data were imported into IBM's SPSS and adjusted to the formats that the application can use for certain statistic solutions, such as transforming the Likert-scale answers. The decision to split certain analytical tasks was based on the premise that different applications have advantages and disadvantages in processing tasks, and that they apply different assumptions and approaches to calculate certain tests, for example, MS Excel calculates the R^2 value for two data series in graphs with different approaches, which leads to a wrong and thus not comparable R^2 value for the second dataset (Microsoft Corp, 2018a, 2014, 2018b). On the other hand, SPPS requires more steps from the researcher and possible repetition of the whole process to flexibly adjust graphs.

3.7.2 Analysis of the Quantitative Data

For processing quantitative data SPPS's offers advantages for repeated procedures on different data sets, such as the adaption to scaled data. Therefore, SPSS was used to produce Pearson-correlation and t-tests, as well- Cronbach's test to verify the reliability of the post-intervention questionnaire. In this context, it should be noted that this study did not perform any test to verify the ILS, as this standardized test has been previously validated (Felder and Spurlin, 2005; Graf, Viola and Leo, 2007; Hosford and Siders, 2010; Litzinger et al., 2005). All SPPS results were saved to new Excel tables and the corresponding SPSS scripts was stored for further processing and later reference, such as the Welch p-test for scaled date which was not offered as a function within the current version of SPSS.

The non-parametric Welsh test is important and interesting because the main data derive from Likert scale responses that are discrete, ordinal and have only a limited range, which does not meet the assumptions for parametric tests. Furthermore, the sample sizes of the pre and post were not equal, and in consequence the homogeneity of variances were unequal. The Welch test is not sensitive to this Behrens-Fisher problem[22] as it adjusts the degrees of freedom to compensate for unequal variances. Due to these two advantages of applying the Welch test to Likert scale based data, this study used the Welch test for the ILS survey and all remaining Likert questions as a base test (De Winter and Dodou, 2010; Ruxton, 2006; Zaiontz, 2015; Rasch, Kubinger and Moder, 2011).

The next steps focused on demographic data and the data from the two ILS questionnaires, and were all processed in MS Excel. Due to the nature of the post-intervention questionnaire, the scale-based questions were analysed separately and then related to the other demographic results in post-intervention survey in cross-reference tables. The data tables were then used to create visual representations to explore, make sense of, and communicate these data. These representations revealed the data's essential characteristics and patterns that describe the nature of change through time (pre- and post-intervention), how values were distributed, and correlated. To determine additionally how similar and different discovered patterns are the study compared them crosswise. These graphs revealed an overview of the data set by illustrating the big picture and supported the triangulation with the qualitative findings.

[22] The Behrens-Fisher problem is a problem of mathematical statistics whose exact solutions have proven to have undesirable properties, which is why approximations are preferred. The Behrens-Fisher problem generalises the t-test for two independent samples, because it assumes that the variances of both populations match. There are several approximate approaches to the Behrens-Fisher problem. One of the most commonly used approximations comes from Welch as the Welch-test (Ruben, 2002).

The data for Felder's ILS questionnaires from the pre- and post-intervention surveys were also processed in MS Excel to create graphs that comply with Felder's and other researcher's results for a comparison of the learning style preferences with students of similar or other study fields. Additionally, data filtering allowed flexible analysis and data visualization for demographic characteristics.

First, the algorithm of Felder's questionnaire key was implemented and then verified with previously results of Felder's Internet-based test-questionnaire based on the same input data. The verified algorithm implementation was then been applied to all responses and generated an overall result of learning style preferences. Additionally, the results were filtered according to the demographic data, such as gender, to discover specific characteristics and patterns in these data subsets.

In a next step the numerical ILS results for each participant were imported into SPSS and cross-tabulation and Chi-Tests were conducted for each ILS domain against the demographic data for later comparison steps. Finally, to reveal further findings and potential explanations the slope of each question was compared to identify interesting differences in the pre- and post- intervention results and identify them for further integration with the results of the qualitative responses.

3.7.3 Analysis of the Qualitative Data

A sentiment and emotion analysis attempts to take into account the mood of the survey participants on a topic. These generated data, the quantified sentiments and emotions, can serve as additional characteristics for later triangulation. For this task, artificial intelligence based on Natural Language Processing [NLP] and data mining can be utilised and was applied in the first step of analysing the qualitative data in this study (Dong and De Melo, 2019; Liu, Li and Thomas, 2017). For this an Excel-Addin from ParallelDots was used, which evaluated the responses anonymously with internet-based AI algorithms (ParallelDots, 2020a; Jain, Aggarwal and Singh, 2019). Nevertheless, participants often tend to answer open questions in questionnaires with short statements, which can influence the AI based analysis. Because AI models and algorithms currently do not handle short statements very well, especially if the responses are, for example, sarcastic or rhetorical statements (ParallelDots, 2020b), a manual verification step was added to ensure the quality of the results. For Likert-questions the AI responses required a comparison with the scaled responses and manual interpretation when the AI comparison differed from the scale result. For open questions, an additional manual interpretation was necessary for verification.

Next, the study applied a quantitative text analysis tests on the qualitative responses, such as hierarchical word cluster and multi-dimensional scaling correlations. For these tasks two scholarly tools were adopted. The selected tools for this study were Higuchi's (2019) well cited locally run KH-Coder (version 3) and Sinclair's and Rockwell's (2019) web-based Voyant Tools (version 2.4). Due to the short character of many responses the tools were configured to take only keywords with two and more appearances into account. The resulting graphs were then used to identify themes within the responses.

Since the environment influences people's reality by impacting experiences and mood (James, 1907, p.80; Saunders, Lewis and Thornhill, 2015, p.203,442), field notes were taken into account and interpreted in relation to the sentiment and emotion data to reveal further findings and potential explanations for previously discovered patterns. Finally, for the latter aims the qualitative findings were then related to Felder's definitions of learning style domains.

3.8 Ethical Considerations

Research does not take place in a social vacuum, it rather comprises social process to gain, use and distribute knowledge, and this has ethical implications. Considering ethical issues can provide protection from the negative consequences and requirements on research and praxis of stakeholders, such as research participants, employees, colleagues, or clients, which could lead to ethical issues.

The following table (Table 7) illustrates typical considerations in the study's research environment, applying qualitative as well as quantitative research methods (Aston University, 2015; Deutschen Gesellschaft für Soziologie (DGS), 2017; Institute of Education; Silverman, 2013; Woodthorpe and Tilley, 2011).

Table 7 - Possible Ethical Issues for Stakeholders in Research

Stakeholders	Attributes	Possible issues (selection)
Researchers, clients	Truthfulness	Data falsification
	Transparency	Conflict in interests Hidden clients Unscientific contracts
	Validity	Application of results Consequences of interpretation
	Best possible methodology	Data accuracy Usage of known deficiencies
Participants	Electoral freedom	Choice for participation Constraints
	Informed consensus	Hidden participation No opt-out Over-burden Compromised by role
	Data protection	Disclosure Anonymising Falsification
	Modus operandi	Preventing risks and danger Potential vulnerability No boundaries
	Legal	Absence of the right to remain silent
Employees	Acknowledgement	Plagiarism Originator
	Interactions	Fairness Discrimination
Colleagues	Fairness	Proportionality of critique in peer-reviews

The study made use of qualitative and quantitative methods with divergent implications. The selected questionnaire and its results algorithm Learning-Style of Felder and Solomon has been widely applied in research has undergone extensive validation, and thus did not require further ethical considerations. The first aim was to generate no harm for any participant, either physical not mental, closely followed by assuring privacy by applying appropriate methods for anonymisation, confidentiality and data protection (Gurzawska and Benčin, 2015, pp.10–13; Hesse-Biber, 2010, chap.4; Morgan, 1998, chap.10). Beside other issues set out in Table 7, setting boundaries for designing a questionnaire seemed to be an important point to control potential ethical issues, for example, by carefully defining the questions and peer reviewing them. Ultimately, the study went through the assessment of the Aston University's ethical committees, which included a detailed risk assessment besides a standardised questionnaire on study content, fields of potential danger, and data protection measures.

3.9 Reliability

Enhancing reliability will ensure resulting data stay consistently comparable over time, for which this study applied great diligence in constructing the research design, the creation of the survey questions and the choice of Felder's ILS as learning style preferences test.

Reliability for a mixed methods approach has its origin in qualitative scientific research. A high degree of reliability means that the measurement results of a study are reliable and stable. If the study is repeated with the same instruments and methods and under the same conditions, other people should arrive at the same results.

From the point of view of a pragmatist and the nature of qualitative methods, this criterion can be problematic in purely qualitative research, since the pragmatic principle assumes that the research variables, especially environment and research subjects, are constantly changing (Biesta and Burbules, 2003; Bryman and Bell, 2011, pp.157–158; Morgan, 2013). For participants in the study, this could mean that their new experiences might change their perceptions and knowledge, and thus, if repeated, would change the qualitative data decisively. Thus, a repetition would only lead to similar results at best.

The latter may also be the case in empirical social research, but it may be compensated for or corrected by a sufficiently large number of participants; the approach adopted in this study based on the sample of a large group of PT-MBA students. However, the homogeneity of the groups of participants in the current and repeated study must be taken into account here in particularly if results are to be compared in one dimension in order to verify reliability.

To counter this potential problem, this study applied various methods in a mixed method research design. On the one hand, the questions in this study were formulated in such a way that they have as neutral a character as possible and refer to the research questions. This means, for instance, that the study did not use any specifics from the current research environment that would make re-use difficult or even impossible. This is also true of the scale-based questions, where this study paid additional attention to in order to select balanced scale definitions.

In combination with the quantitative methods, it was also necessary to use a learning style questionnaire verified by other researcher (Felder and Spurlin, 2005; Graf, Viola and Leo, 2007; Heenaye, Gobin and Khan, 2012). This study adopted Felder's Inventory of Learning Style [ILS], because it was validated by different researchers and applied successfully in studies in cross-cultural settings and in different languages, which contributed to its reliability (Heenaye, Gobin and Khan, 2012; Marambe, Vermunt and Boshuizen, 2011; Ovariyanti and Santoso, 2016; Platsidou and Metallidou, 2009; Wang and Mendori, 2015). Nevertheless, there have been critiques of Felder's ILS such as Litzinger et al. (2007), who questioned the missing of a neutral position in the ILS, thus tested a modified version against the ILS that resulted in impacting the detailed results but not the overall reliability. A personal opinion was that the introduction of a neutral position in such a test would be counterintuitive since the purpose of the scale is to highlight straits, which can change over time, and not to act as a marking instrument with absolute measurements.

3.10 Research Limitations

Within the discussions about the combination of different approaches to the exploration of a research topic exist some controversies (Flick et al., 2014; Johnson, Onwuegbuzie and Turner, 2007). While some scholars have seen mixed methods as a special case of triangulation, others understand mixed methods as a more pragmatic mix of methods and differentiate triangulation as a distinctive approach to link different research perspectives (Flick et al., 2014; Morgan, 2013).

Interpretation is very strongly based on subjectively construing content, connections, as well as rhetorical constructs and characteristics of a foreign language, because the interpretations of a researcher are not the only ways in which findings might be understood but leave room for other perspectives and understanding.

Since the research environment influenced the participants, their response might have been impacted. There were, for example, no means to influence the workshop locations for the AR interventions of this study or the scheduling since the entire study-weekend for all PT-MBA was organised through Aston Business School. Nevertheless, all assigned rooms were prepared before each workshop, by checking all the technical and teaching equipment necessary for the workshop. Furthermore, it was observable that a workshop on a Sunday for commuting part-time student had an impact on the number of participants, which limits the comparison between pre- and post-intervention to a certain degree. To counter this effect, all leaving attendees of the workshop were asked to participate at the post-intervention survey remotely and send responses to a neutral email address. No attendee returned the survey, which led to a lower sample size in the post-intervention survey.

The sample rates for this study are high ($n_{pre}=92$; $n_{post}=73$), nevertheless, the number of participants could have been higher to support better generalization. Also, the low diversity of origin of the participants limits the transferability, since the majority of participants (pre=87.0%; post=84.9%) of came from across the United Kingdom. Due to the admission requirements for the PT-MBA programme, participants are older (36-40 yrs.= 26.0%; 40+ yrs.= 38.4%), which limits comparison with other age groups.

A great advantage of surveys is that they allow to generate a large sample quickly. However, the lack of control over the research environment, as described above, may have had an impact on the quality of the sample, as it was unknown whether the participants were, for instance, under stress or just skimming over questions. Surveys sometimes observe the phenomenon of lack of honesty of the respondents. Thus, it could be that participants in this study did not answer some questions completely honestly, which was addressed during the briefing on the informed consent.

Qualitative and quantitative methods are characterised by certain advantage and disadvantage, which are balanced with the choice of a mixed methods approach in this study. This balance depended on parameters for the planned interventions for this study, such as sample size, and this was the challenge in selecting a target group of very different potential sample sizes (FT-MBA, on-campus versus PT-MBA, off-campus), which either demanded to sacrifice optional qualitative data collection methods (Focus-groups and/or interviews). Nevertheless, after weighing up the advantages and disadvantages, this study decided in favour of the larger PT-MBA group for retrieving more, potentially shorter qualitative responses and a favourable number of quantitative responses for more significant data base.

3.11 Methodology Summary

The underlying methodological assumptions for this research were based on pragmatism for a purposeful approach to research challenges and changing circumstances. Iteratively, a comprehensive literature review identified a range of relevant topics in the large learning domain, several key aspects of motivational influences of technology and HE policy.

The two main rationales for a mixed methods research design were balancing the need for proper research results with practicability. Furthermore, the prospect of a higher perceived objectivity is an additional benefit when collecting quantitative and qualitative data and combining the strengths of qualitative and quantitative research.

Adopting a mixed exploratory and explanatory survey design was the rationale for a mixed survey methodology. These features include design flexibility, understanding the student’s learning preferences and their influenceability, developing contextual understanding, facilitating interactivity between researcher and students, and adopting an interpretive stance. Two surveys were sequentially employed at two stages of the AR intervention that included quantitative and qualitative questions as well as Felder’s ILS.

This process was essential for the elaboration of specific findings emerging from statistical differences among the pre- and post-stage data, and from the results of analysing the participant's own words and f perceptions of AR in learning and teaching.

This study collected the necessary data from part-time MBA students who attended a mandatory workshop. Using a purposive sampling method, a total potential study population of 94 participants. From this total number of 92 students participated in the pre-intervention survey (n_{pre}=92; n_{female} = 35; n_{male} = 57) and 73 students (n_{post}=73; n_{female} = 28; n_{male} = 45) in the post-intervention survey. The students completed the surveys in the classroom using a paper and pencil format.

The research design followed seven sequential stages, starting with the identification of topics and a literature review. Succeeding the formal qualifying report and the proposal defence an application for the mandatory ethical approval followed, after which the surveys and the intervention detailed further. A required briefing of the participants took place in advance of the study weekend in close collaboration with the university. Furthermore, the students received a description of the study, the intervention, and an informed consent document. Each workshop started with an introduction and reiteration of the informed consent for this research, and subsequently asking all attendees to voluntary fill the pre-intervention survey prior the workshop. The workshops were divided into two main sections. The first section provided a theoretical introduction, while the second section was the actual intervention, where the students created their personal digital AR story. Subsequently, each workshop closed by asking the participants to complete the post-intervention survey. The impressions of the observations during each intervention were recorded after each day.

The analysis included two phases: data processing and theme finding, including collecting data in a meaningful way, reduce the volume of information, identify significant patterns, and create a framework for the analysis. Further preparation required to digitise, back-up, and transfer the data to spreadsheets. A native speaking academic transcribed difficult to identify anonymised responses. Next, the data was prepared for different analysis tools to cope with certain advantages and availability of statistical routines. The research design provided SPSS for Pearson-correlation and t-tests, as well Cronbach's test to verify the reliability of the post-intervention questionnaire and transferring the results to Excel for further processing. The results of the Likert scale questions were directly processed in Excel since SPPS did not offer a suitable Welch test. Next steps focused on demographic and ILS questionnaires data. The separately analysed scale-based questions of the post-intervention questionnaire were then related to the other demographic results in cross-reference tables. Creating visual representation in parallel to explore, make sense of, and communicate data was a final task.

Both ILS questionnaires were processed in MS Excel due to its dynamic data filtering that allowed instant flexible analysis and data visualization for demographic characteristics. Creating Felder ILS compliant graphs and tables supported comparing the results of this study with previous research. Despite not verifying the ILS, but relying on intensive previous studies, a further step was to import the numerical ILS results of each participant into SPSS to run cross-tabulation and Chi-Tests for each ILS domain against demographic data for later comparison. To reveal potential findings and explanations pre- and post-results were compared to identify interesting differences for further synthesis with the qualitative responses.

An AI-NLP based sentiment and emotion analysis attempts to consider the mood of participants on a topic. This data, the quantified sentiments and emotions, provided additional evidence for the triangulation. However, short responses were a challenge for the NLP to interpret and required manual verification to ensure the quality of the results. Diverging NLP results (tendencies) needed manual verification to identify interpretive deviations and errors of the AI-NLP. Furthermore, the study applied quantitative text analysis, such as hierarchical word cluster and multi-dimensional scaling correlations. The resulting graphs contributed to identifying themes within the responses. Field notes were an additional source and considered in relation to the AI-NLP results to reveal further findings and potential explanations. Similarly, the qualitative findings were finally related to Felder's definitions for LS domains.

This study considered the potential of participant expectations and study requirements on the praxis of research stakeholders that could lead to ethical issues. Ultimately, the study was evaluated and approved by the university's ethical committees, including a risk assessment, standardised questionnaire on study content, fields of potential danger, and data protection measures.

To enhance reliability and to ensure resulting data remained consistently comparable over time, this study applied great diligence in designing the research, creating the survey questions, and choosing an ILS. The study was not designed for any specific research environment that would have made re-use difficult or even impossible. In combination with quantitative methods, it was furthermore necessary to use an academically verified LS to achieved reliable and comparable results.

Interpretation is very strongly based on subjectively construing content, connections, as well as rhetorical constructs and characteristics of a foreign language. Despite using native speakers for specific conceptual clarifications this study cannot rule out that certain interpretations were lost in translation. The sheer variety of potential themes made it necessary to present only a selection of the research findings. A further limitation might be that due to the setup of the intervention and its timing on a weekend, this could have influenced student answers. Additionally, early leavers who did not return the questionnaire contributed to a smaller post-intervention sample size. As a general issue in survey research, the answers might not reflect the real perceptions of participant due to the phenomenon of lack of honesty and different interpretations about the questions.

4 Analysis, Interpretation, and Synthesis of Findings

This study revealed three main themes, based on the ILS results, the analysis of closed questions, and supporting comments and perceptions of participants. In reverse order of the research questions, the following sections lead incrementally towards the main outcomes of this study:

The first theme covers salient observed quantitative changes in learnings styles within Felder's four main learning style dimensions. Here the findings relating to the entire sample will be discussed first and are then supplemented by conspicuous changes in gender and age group sub-samples.

The second theme draws on the perceptions of the students towards AR as a learning method in a TEL environment and introduces three subjects identified in the analysis.

> The first subject is about the perceived favour of the students for a balanced mix of learning and teaching methods. This observation derived from the balanced response to a preference of AR over TEL or traditional learning and teaching methods. Furthermore, student comments on suitability of AR in TEL, their reported important learnings from the AR intervention, and their perceived preferences for AR in TEL and traditional methods contributed to this theme.
>
> Based on the quantitative measures of student satisfaction relating to creating their own digital AR enabled story and favourable qualitative references to student responses, the second suggested subject is about the perceived importance of the digital storytelling process.
>
> The third subject is based on the question of the expected value of the AR intervention for the students in their future. Repeated emphasis in respondent answers and demands during the interventions for further future relevant and specific business applications delivered answers to general question.

The third theme addresses several motivational effects that learning with AR had on the students and distinguishes three topics. The first topic discusses the aspect of Technology-Self-Efficacy [TSE], which emerged from reappearing patterns within different asked open questions and the field notes. These patterns describe how the AR enable TEL helped students to support student confidence in their tech skills and readiness for mastering technology when they created their own digital AR story. The second topic addresses the suitability of AR as a TEL method from the perspective of students after the AR intervention. The students were specifically asked to rate their perceived suitability of AR as method for TEL and were afterwards able to comment on this evaluation.

Based on the ARCS motivational model (Keller, 1999), the third motivational topic reports on four motivational conditions that impacted the perceived motivation level of the students after creating a digital AR story. The four motivational conditions considered in this study emerge from a perceived novelty and easiness to the perception of interactivity and engagement that all had influences on the overall motivation of the participating students.

> The first condition of perceived novelty connects the quantitative levels of prior experiences with AR in general and in a learning environment with frequent responses where students highlighted their perceived novelty of AR. The novelty condition interludes well to the next motivation condition, the perceived easiness of the AR learning method.
>
> The second condition of student perception of likelihood for success is one element for satisfaction in the ARCS model and builds inter alia on the perceived easiness of a learning method. This perceived easiness contributes to the overall motivational level of learners, especially in a TEL environment that made use of AR technology.
>
> The third condition draws on interactivity, which was an important aspect of the students after the AR intervention. The ARCS model supports this aspect since it regularly lists the degree of interactivity in a learning and teaching method as a condition for influencing the motivation level of students.
>
> The last motivational condition addresses the potentials of the AR intervention to influence the perceived level of engagement of AR as TEL method. The students in this study found the creation of a digital AR story as important for various reasons.

Before the presentation of the findings a brief overview of abbreviations and used scales is given.

4.1 Abbreviations and Scales

Active	ac
Sensing	sn
Visual	vs
Sequential	sq

Reflective	re
Intuitive	in
Verbal	vb
Global	gl

g_{ac}^{pre}

Participant Quote	p
e.g. Post questionnaire, Question 7, participant no. 33	

$p_{Q7(33)}^{post}$

Felder's Scale Interpretation[23]	
1-3	mild
5-7	moderate
9-11	strong

Likert Scales Reporting Values
All Likert scales used in this study correspond to a numeric range from 0 to 4, with 2 as neutral position. For example, a reported IQR of 2 would associate on the scale with a "quite well" rating.

4.2 Impact of AR on Student Learning Style Preferences

Learning can be described as the acquisition of new skills, knowledge, and behaviour. Every person has individual basic requirements for learning. While learning type theories, for example Vester's four learning types (1998), initially focused primarily on the input channels. These theories of learning styles, which have been developed in learning psychology since the 1970s, refer to preferred learning modalities of people. Since learning styles also influence learning strategies, one should be aware of the respective preferences, which led the research focus onto learning styles research.

This study adapted a learning style model, which was originally designed for the analysis of engineering students and successfully adapted for digital learning, was developed by Felder and Soloman who called it the Inventory of Learning Style [ILS]. In later research project the researchers simplified their learning style model by distinguishing between only four bipolar learning types, also called learning style dimensions: active - reflective, sensory - intuitive, visual - verbal and sequential – global (see section 2.2.5).

In connection to the third research question *"Does the experience of AR change student learning style preferences?"* (RQ_3) the participants were asked to fill Felder's ILS questionnaire. The ILS has been applied twice, before and after the AR intervention, to explore potential influences of AR enabled learning on the participant's learning styles, which were expressed through eight learning

[23] See ILS algorithm and report descriptions (Felder and Soloman, 1994)

style dimensions[24] paired in four learning continuums. This first section provides findings based on the complete sample (n_{pre}=92; n_{post}=65) of the pre- and post-ILS survey.

The literature on the ILS survey regularly reported the percentage of participants for each learning continuum and their average tendency for each side of the learning style continuum. Confusingly, studies often used the term Score for both units. To alleviate this condition this study used the term Score (s) for the percentage results and Grade (g) for the learning style tendencies. This study followed previous studies' convention of only reporting the first learning dimension (Active – Sensing – Visual - Sequential) of each learning style continuum.

This first theme section begins by looking at the four most prominent observed changes in the learning style dimension, which were sequential [SQL], visual [VSL], sensing [SNL], and active learning [ACL] style preferences. Appropriate comments of participants (p) were supplemented to support the findings.

4.2.1 Sequential Learning

One of the four learning style dimensions of Felder and Solomon (1988) includes the preferred form of learning structure when absorbing and processing new subject content, which are defined as sequential learning [SQL] and global learning [GBL] style. Here Felder and Silverman distinguish learners with a tendency to learn in a fixed, sequential sequence from those with a holistic, sometimes jumpy approach to new learning content. Sequential learners are students who prefer to proceed in a strictly logical and chronological order. It is generally believed that sequential learners gain the best understanding of a subject if they are taught the material in a structured, linear, and logical manner or sequence. For students with a predominant sequential learning style, the strength lies in a systematic and convergent way of working, in which they generally absorb content best when it becomes increasingly complex and difficult as the learning process progresses. This sequential learning style can result in learners being able to cover many different aspects in one area of knowledge, but sometimes this tends to combine aspects into a larger whole or transfer them to other problems or areas of knowledge (Felder, 1996; Felder and Brent, 2005; Provitera and Esendal, 2008; Seiler, 2011).

[24] see a description of learning style preference in the appendix, 7.3 - Learning Styles in Felder's ILS

This section reports on the high differences between the pre- and post-ILS result for the SQL preferences of the students. It is then looking at how these changes were reflected in the gender and age range samples, where the most interesting changes were suggested.

The graphs in Figure 6 and Figure 7 offer a combined overview of the overall grades and scores for all learning style dimensions pre and post the AR intervention.

Figure 6 - ILS Grades and Scores for Complete Sample - Pre

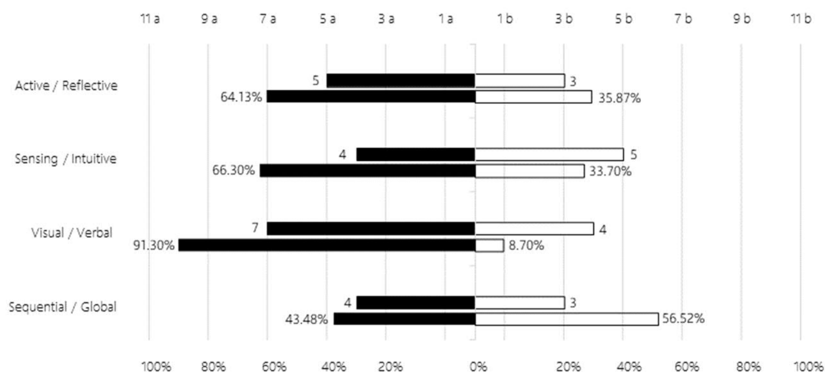
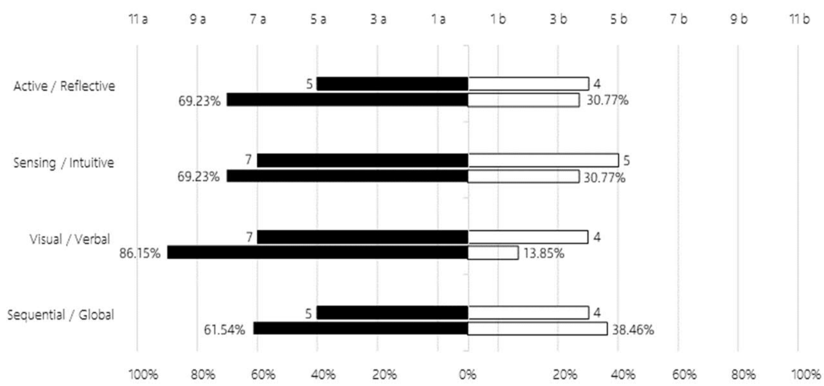


Figure 7 - ILS Grades and Scores for Complete Sample - Post



Furthermore, several researchers compiled and reported standardised ILS results of studies with participants from different fields in higher education (Felder and Spurlin, 2005; Heenaye, Gobin and Khan, 2012; O'Dwyer, 2009). The comparison with 42 results of the mentioned studies[25] and the two group intervention results of this study (Table 8) showed that the pre-intervention results look similar to the mean results of the collected studies across all four learning style dimensions. However, the post-intervention results in the active learning dimension deviated from the mean, which will be discussed later in 4.2.4.

[25] See the compiled results in appendix 7.6.4 to 7.6.8.

Table 8 - ILS Results of 42 Studies and the Results of this Study

	Active	Sensing	Visual	Sequential
M	61.88 %	65.76 %	81.47 %	56.39 %
σ	10.42 %	11.47 %	10.47 %	14.11 %

From the graphical presentations in Figure 6 and Figure 7 can be spotted that SQL reported the highest absolutely and relative change amongst all learning style dimensions in this study.

With 43.48% and respectively 61.54% the lowest number of MBA students preferred SQL pre ($M_{pre}=66.30\%$, $\sigma_{pre}=16.96\%$) and post ($M_{post}=71.54\%$, $\sigma_{post}=9.00\%$), nevertheless, compared to all other results[26] this dimension stands out reporting with 18.06% the highest increase of students preferring SQL after the AR intervention ($M_{\Delta}=5.23\%$, $\sigma_{\Delta}=8.33\%$) (Table 9). Interesting was also the comparison with previous research of 42 studies that reported a mean of 56.03% (σ=13.67%) that positioned the post results of this study into the upper half of the SQL comparison (see table of comparison in appendix 7.6.5).

Table 9 - SQL Dimension Scores (pre/post)

	Pre	Post	Δ
Sequential	43.48%	61.54%	18.06%
σ	16.96%	9.00%	8.33%
M	66.30%	71.54%	5.23%
MD	65.22%	69.23%	5.13%

There are three potential interrelated aspects that might help with interpreting the increased preferences for SQL methods and above average preference in comparison with other studies. The potential aspects are a cognitive overload, the novelty aspect from a content and skills perspective, and the sequential character of creative design.

The first aspect is found on the abstract nature of creating a digital story with AR and the required skills, which required the students to think in three dimensions and in content flows for the presentation of their AR story, and how to implement it with the provided tools. Thus, some students might have therefore been cognitively overloaded by various design options and possibilities to integrate those in their digital AR story. Other researchers found similarly potentials that AR might bear the risk of overloading students cognately (Cheng and Tsai, 2013; Dunleavy,

[26] See chapter 7.6.1 - ILS Results: Complete Sample in the appendix.

Mitchell and Dede, 2008). However, this needs to be further explored since the studies addressed only the consumption of prepared AR learning content, thus asks for extension to student created AR content for learning. Arguments for an assumed opposite reducing effect on cognition load could be found in an AR experiment of Bower et al. (2014), where visual art students who possessed a wide range of pre-knowledge with digital design tools actively created AR content themselves. As a result, the researchers emphasize that becoming a designer of AR content has the potential developing higher order thinking and reducing cognitive overload. From a passive usage of AR in learning perspective, Bressler and Bodzin (2013) assume a reduction of cognitive load with the limitation that the AR intervention needs to be designed well.

The cognitive load theory, developed by John Sweller (1988), suggests that the cognitive load in education is closely related required skills and a sequential build of perquisites help to establish schemas that extend the ability for students to understand and learn more difficult information. Build on this, a further potential explanation for a higher preference for SQL after the AR intervention could be interpreted in the novelty factor of required skills and knowledge for realizing the creation of a digital AR story. The creation of a digital AR story required certain technical understanding and skills to pursue the given task, which can be described as problem-solving digital skills.

An indication for a sequential interrelation of required digital skills comes from Laar (2019), who examined which skills are necessary for professions in the 21st century creative industry. Ultimately, her study found that digital skills are sequentially interrelated. For this study this could mean that student perception being more global learning style learners was relativized through the AR intervention and its new technical aspects. Therefore, it is possible that the novelty of digital storytelling with an AR tool for the majority of the students let many students ask for a step-by-step approach to gain the skills needed for the new technology enable learning method. This would finally allow the presumption that the students balanced their learning styles according to the novelty of the AR learning and teaching method.

Furthermore, this study assumes that some students perceived the possibilities and design process steps as potentially complex because most students did not make any experiences with digital AR storytelling before this study. The subsequent challenge of creating an AR story then let some students ask for a more sequential learning and teaching approach in order to manage the assigned tasks, substantiated by the decrease of global learning preferences after the AR intervention in favour for SQL. A cautioning explanation for this phenomenon comes from

Kalawsky et al. (2000) after researching the role of cognitive content processing in relation to AR. They explain that *"[...] a fundamental issue concerns the information processing demands placed on the human perceptual system by the technology. If such cognitive demands are too high, it is unlikely that AR will prove to be effective support to learning..."* (Kalawsky et al., 2000, p.40).

The creation of a digital AR story was a creative approach to utilise AR as learning and teaching method. Thus, a Design Thinking process might offer a further interpretational starting point for the increased SQL preferences of the students for SQL methods after the AR intervention. The design thinking theory is that the creative creating process requires a certain sequential, but often iterative, approach that helps to deal with complex design problems by sustaining in-depth learning processes on problem perception and diverse solution paths (Kröper et al., 2011).

A further potential explanation for the increased preferences for sequential learning methods approaches comes from another model, developed by Owen (1998), suggesting that a design process combines analytical and synthesising characteristics that require a sequential approach to build up new knowledge. A comment of a female student supports these characteristics as potential interpretation for the increased preferences for SQL after the AR, describing for her important characteristics of a sequential learning process, such as the logic, reflective, and iterative nature of her learning approach: *"Having to think on the spot. I usually need the to reflect and think of ideas. I do not class myself as very imaginative, so found difficult to think of suitable content."* ($p^{post}_{Q11(1)}$).

From this top view the following sections looks down on sub-results within the sample. First, the changes of the preference for both genders will be discussed, then the SQL preferences within the different age-ranges finalise the findings for SQL dimension.

The differences between male and female students for this increase were small (Table 10) and did not differ much from the previously reported overall change of 18.06%.

Table 10 - SQL Dimensions Score by Gender – Delta **Δ**

female	male	M	σ
15.43%	19.65%	17.54%	2.98%

These changes towards SQL after the AR intervention and the similarity with the overall results might allow the deduction that male and female students experienced the AR intervention very similarly and were facing the same challenges. A comparison with previous research in TEL and traditional learning and teaching approaches that applied Felder's ILS do not offer a definite trend for the SQL style preferences of both genders (Ivey and Lee, 2014). Similar to this study, previous research offer examples for a balanced preference for SQL (Dee et al., 2002; Gündüz and Özcan, 2010; Prajapati et al., 2011; Shuib and Azizan, 2015; Sopian, 2013; Teevan, L.I. and Schlesselman, 2011). However, often research found that female students prefer SQL approaches more than male students (Aliakbari and Soltani; Chen, Jones and Xu, 2018; Litzinger et al., 2005; Liu and Shi, 2015; Rosati, 1999). The later could be it alia explained through existing general differences between genders that Costa et al. (2001) found in their inter-cultural study exploring personality traits. The similar change in favour for sequential learning approaches seems to support the previous assumption that learners prefer clear sequential steps in approaching new materials, where the new content and required skills develop from easy to more challenging to comprehend and manage (Rosati, 1997).

Unfortunately, these studies have in common that their data present only an artefact derived from a snapshot before or after an intervention. Thus, it is difficult to relate the change in SQL in this study to a generalisable preference for sequential learning methods. Nevertheless, it could be concluded from the results of this study and the knowledge from previous studies that students adapt their learning style preference to the actual learning task and their existing pre-knowledge. This could be especially true for SQL because this dimension copes with the processing of new information, and therefore the students of both genders might have SQL perceived as a more favourable approach to reach the aim of planning and creating a digital AR story.

The next section looks at the changes found within the age groups towards their SQL preferences. As

Table 11 suggests there were two age ranges prominent in comparison to the average changes ($M_{\Delta}=10.97\%$, $\sigma_{\Delta}=15.72\%$). First, in the age range 40+ a salient number of 27.33% more students scored for SQL, which made it the highest increase rate overall ($M_{\Delta}=6.99\%$, $\sigma_{\Delta}=14.99\%$). This was followed by the age range of 31-35 with 24.29% more students preferring SQL after the AR intervention ($M_{\Delta}=7.29\%$, $\sigma_{\Delta}=13.32\%$).

Furthermore, it was noticeable that 66.67% students from the age range of 26-30 years preferred SQL ($M_{pre}=46.06\%$, $\sigma_{pre}=13.94\%$), which marked the highest score within the SQL dimension in the pre-ILS. However, after the AR intervention 9.52% less students scored for this dimension and

Table 11 indicates this result is the only score that decreased within SQL ($MD_{\Delta}=10.97\%$, $\sigma_{\Delta}=15.72\%$).

Table 11 - SQL Dimensions Score by Age Ranges – Delta **Δ**

	Active	Sensing	Visual	Sequential	M	σ
40+	3.44%	5.87%	-8.70%	27.33%	6.99%	14.99%
36-40	3.53%	-2.72%	-3.80%	12.77%	2.45%	7.60%
31-35	11.34%	-1.62%	-4.86%	24.29%	7.29%	13.32%
26-30	1.59%	4.76%	0.00%	-9.52%	-0.79%	6.15%
20-25	0.00%	33.33%	0.00%	0.00%	8.33%	16.67%
M	3.98%	7.92%	-3.47%	10.97%		
σ	4.37%	14.70%	3.66%	15.72%		

The impact of the AR intervention on the perceived importance of SQL for the students is discussed next. Overall, was the increased number of students preferring SQL accompanied by only a slight increase (F_{Welch} $(1, 77.138)= 1.606$, $p=0.209$) from $g_{sq}^{pre} = 4$ ($MD_{pre}=4.5$, $IQR_{pre}=1.5$) to a moderate preference of $g_{sq}^{post} = 5$ for SQL ($MD_{post}=6.0$, $IQR_{post}=2.0$). After the AR intervention female ($n_{pre}=35$; $n_{post}=25$) students kept their perceived importance for ILS stable on a moderate grade of 5, but male students ($n_{pre}=57$; $n_{post}=40$) changed their mild tendency from 3 to a moderate grade of 5, which compensated the differences between the genders[27].

This compensation could also be observed among the age range samples, where the pre-ILS showed a more scattered distribution ($MD_{pre}=4.0$, $IQR_{pre}=2.0$) for the student preferences for SQL, which got compacted after the AR intervention ($MD_{post}=4.0$, $IQR_{post}=1.0$). In the overall age range sample, a slight increase between the preferences in the pre-ILS ($MD_{pre}=2.0$, $IQR_{pre}=1.0$) and the post-ILS ($MD_{post}=4.0$, $IQR_{post}=1.0$) could be found.

However, the results identified the 31-35 old students as having the strongest preference for SQL pre as well post the AR intervention, which furthermore increased to a stronger moderate preference for SQL ($g_{sq(31-35)}^{pre} = 5$; $g_{sq(31-35)}^{post} = 7$).

Interestingly, among all age range groups only in the sample for the 26-30 old students less students favoured SQL[28]. The results showed that after the AR intervention 9.52% less students of

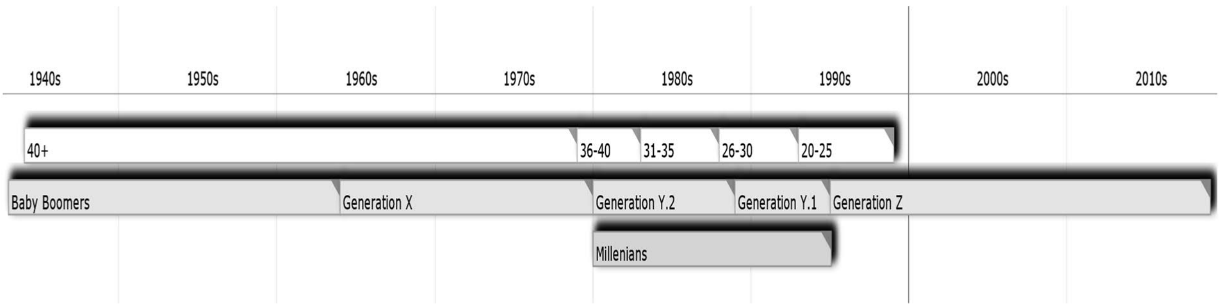
[27] See Figure 31 - ILS Overall Scores (Pre/Post) in the appendix.

[28] See Figure 43 and Table 70 in the appendix.

this age preferred SLQ ($M_\Delta = 10.97\%$, $\sigma_\Delta = 12.77\%$). However, their preferences for SQL increased from a mild preference by two grades to a moderate preference at the same time ($g^{pre}_{sq(26-30)} = 2$; $g^{post}_{sq(26-30)} = 4$).

As the demographic data[29] show, the age of the participating students of this study spread mainly between 30 and 40-year-old students. Literature regularly assigns those age ranges, more precisely ranges of concrete years of birth, to a Generation classifier, such as Generation-X. Unfortunately, the publications do not offer a universally agreed categorisation for these Generations. Thus, this study suggests in Figure 8 a timeline that allocates each age group of this study to an averaged common Generation category based on a selection of sources (Bickham et al., 2008; Kasasa, 2019; Schofield and Honoré, 2009; WJSchroer, 2020).

Figure 8 - Generation XYZ Association to this Study Age Ranges



From this association it is safe to assume that the mentioned 30 to 40-year-old students belong to the so-called Generation-Y and Generation-X, which simplifies and helps to draw comparisons with previous studies that made use of these categories of Generations in all succeeding sections.

In relation to SQL preferences, Schofield et al. (2009) attest the Generation-Y being directed to nonlinear and non-sequential learning. Furthermore, in a longitudinal comparison between 1993 and 2010 Eubank and Pitts (2011) found a 62% decrease in Kolb's Assimilator[30] learning style dimension, which also describes sequential learning preferences. These results do not explain but are even contradicting the result of this study, which reported a prominent preference changes

[29] See the tables and graphs for the age distributions pre and post the AR intervention in section 7.5.2.

[30] Kolb's assimilator learning style dimension includes the preference for organising information into logical and concise forms, which correlates with Felder's learning dimension for preferring sequential learning methods (Felder and Spurlin, 2005; Kolb, 1974).

in favour for sequential learning for the majority of students of the Generation-Y.2 and Generation-X.

A potential explanation could be found in the previously discussed novelty of the AR technology as learning and teaching method for the students, specifically the new technical aspects. The different Generations were surrounded by various technology advances in their time and required specific approach to new and increasingly mor sophisticated technology. Especially the contact in early formative years of children, as Dede (2009, p.15.1) argues, might have influenced their approaches to learning with technology.

So, even when the majority of students of all ages perceived to be more global learner prior the AR intervention the new, probably as more sophisticated and abstract perceived, AR technology led a large proportion of students realize that a sequential learning approach would guaranty a higher chance to master the task of creating a digital AR story. Additionally, the sequential nature of a digital storytelling process might have forced the students to revise their degree of SQL preference after the AR intervention. The observed adaption of the Generation-X and Generation-Y.2 students preferences raise the question of how constant this SQL preference would be for a different learning and teaching setups? This question becomes even more interesting since the Generation-Y.1 (26-30 years) students constituted an exception of this countertrend. Differently from the two other groups the Generation-Y.1 students showed a decreased preference for SQL, which finds support in the thesis of Schofield et al. (2009) that this Generation-Y.1. as part of a Generation Y, prefers global learning and teaching methods.

Overall, it can be concluded that most students perceived to favour global learning styles prior to the AR intervention. After creating a digital AR story, however, considerably more students changed their preferences towards methods that support sequential learning styles.

The perceived SQL importance did not change to the same extend as the number of students preferring SQL after the AR intervention. The age range samples reported a mixed result with the 40+ old as leading group, while both genders followed the general trend.

The results allow the assumption that the student in this study adopted their learning style preference to the characteristics of the requirements for creating a digital story with AR. The novelty of the AR technology might have caused cognitive stress to some students, which let them switch from a global, less organised, to a sequential and more ordered learning mode to make sense of what they were doing with this new learning technology.

Answers to other questions in this study students provided some evidence to their need for a sequential structure of AR intervention. Some students seem to have been overwhelmed by the perceived complexity. For example, one student wished for a *"more detailed breakdown of the steps"* ($p^{post}_{Q13(2)}$), while another student stated that he needed *"understanding exactly what was required. [Thus, for me] the training needs more structure."* ($p^{post}_{Q11(33)}$).

This reported preference for a sequential structure is rooted in the basic human behaviour of organizing things and activities serially (Lashley, 1951). A preference for serialisation is omnipresent since according to Giles and Sun (2001), most of our daily activities involve a sequence of actions to achieve a desired goal, especially when learning new skills and facts. Furthermore. it has often been observed that learners are more attentive and sequential when acquiring a skill in the initial phase. But after repeated practice, for example with the acquisition of experience, the skill is applied almost automatically (Bapi, Pammi and Miyapuram, 2005; Fitts, 1964) and, in terms of the learning style dimension, it is applied globally.

From this universal preference for sequential approach to tackle a given task and assuming that according to Felder learning style preferences are not static values and the confrontation of the majority of students with a new AR learning method that required the acquisition of new knowledge and skills, it becomes clear that many students have adapted to this situation. Thus, the perception of the students being global learners may be due to the fact that they have used past experiences and knowledge as a benchmark, without including the new learning situation with digital storytelling with AR.

The later might have also been influenced by the attributed generation of the students and their approach to master the task with the new AR technology, based on their familiarity with technology they acquired in younger years. The results for the Generation-Y.1 students seem to support the assumption of some researchers of preferring more global learning methods rather than sequential learning approaches.

The following list provides a brief summary for SQL preferences after the AR intervention:

- The highest change rate of all learning style dimension.
- More students preferred SQL.
- More students from both genders preferred SQL.
- Overall, strong preference grades for SQL.
- Considerably more 40+ old preferred SQL.

- Outstanding increase to a strong preference for SQL in age range 31-35.
- Moderately decreased number in the 26-30 age range, while grades increased by 2.
- Many students adapted a sequential learning approach to master the new and challenging task of creating a digital story with AR. The intervention had mixed influences on the members of different generations.

Next, the study presents insights to strong preferences found for visual learning based on the ILS results and supporting comments of the participants.

4.2.2 Visual Learning

Unlike the sequential learning dimension discussed in the previous section, the Felder's visual learning dimension accounts for a channel on how to receive new information by the learner. Since the visual learning type [VSL] primarily receives information through the eyes, this type of learner can achieve the best learning outcomes by, for example, reading books and writings, using graphics, and experiments or demonstrations. These preferences for visual presentation of information were also shown by the results of this study in the high number of students who preferred this learning type, which was associated with an ILS preference. Nevertheless, after the AR intervention the visual learning dimension decreased in favour for other ILS dimensions.

In this study the recognisable highest number of students expressed their primary preferences for VSL before the AR intervention ($s_{vs}^{pre} = 91.30\%$, $M_{pre}=66.30\%$, $\sigma_{pre}=16.96\%$), which was followed by a slight decrease of 5.15% afterwards ($M_{\Delta}=5.23\%$, $\sigma_{\Delta}=8.33\%$).

Despite this decrease visual learning remained the salient preference among all learning style dimensions ($s_{vs}^{post} = 86.15\%$, $M_{post}=71.543\%$, $\sigma_{post}=9.00\%$). Furthermore, these results were supported by a strong and stable ($F_{Welch}(1, 106.287) = 0.344$, $p=0.559$) preference for visual learning ($g_{vs}^{pre} = 7$; $g_{vs}^{post} = 7$)[31].

A comparison with 42 studies that applied Felder's ILS reported a high mean of 82.26% ($\sigma=10.17$) of all asked students prefer visual learning and teaching methods. The student in this study led the comparison with the results prior the AR intervention and the decreased preference for VSL left the results of this study in the first third (see table of comparison in appendix 7.6.6). The

[31] see Table 57 in appendix 7.6.1.

comparison of studies shows strong preferences of the participants for VSL but does not allow an interpretation for longitudinal trend for VSL. However, in one longitudinal study that applied Kolb's Learning Style Inventory [LSI], Eubank and Pitts (2011) found that the number of students perceiving themselves as divergers and assimilators, which both include the visual learning preference, increased between 1993 and 2010 substantially. A recent 4-year study, using the VARK to identify learning preferences, found also an increase of visual learning preferences of student (Marwaha et al., 2019).

These discoveries leave the question as to why the student preferences for VSL decreased after the AR intervention in this study? Several studies found that the learning style dimensions are interrelated within each of the four dimensions but also between, thus, might change over time and depending on subject matters (Felder, Felder and Dietz, 1998; Graf, Viola and Leo, 2007). Therefore, the previous section on SQL might provide one potential explanation, the potential of AR enabled learning to cognitively overload students.

Humans rely by nature very much on their visual sense to gather information, consciously as well unconsciously, about our environment or a specific object of interest. Processing visual information is said to be a resource intensive operation and pairing these efforts with additional inputs such as remembering sequences of tasks and operations may overload the intake capacity of a person (Hendee and Wells, 1997, pp.33–35; MIT Research, 1996). Applied to this study, some student might have experienced an issue with absorbing and processing all information provided by the digital storytelling and AR creation process. Augmented Reality in its current state is predominantly a visually immersing reality that uses visual components for navigating and presenting, as well, as the creation process makes use of visual tools (Arth et al., 2015). This complexity of the required activities frequently overstretched the abilities of some student, which led to a visual cognitive overload (Benford and Fahlén, 1993; Dunleavy, 2014; Radu, 2014).

Interestingly, when looking at the gender results in this study and comparing it with the other learning style dimensions, VSL dimension was the only dimension that showed a reverse scoring behaviour for male and female students (Table 12).

Table 12 - VSL Dimensions Score by Gender - Delta

	Active	Sensing	Visual	Sequential	M	σ	MD
female	2.29%	3.43%	2.29%	15.43%	5.86%	6.40%	2.86%
male	6.84%	2.59%	-9.74%	19.65%	4.84%	12.12%	4.71%
M	4.56%	3.01%	-3.73%	17.54%			
σ	3.22%	0.59%	8.50%	2.98%			

The male students followed the overall trend with a moderate decrease of 9.74% to $s_{vs(m)}^{post} = 85.00\%$, whereas slightly more female participants ($s_{vs(f)}^{pre} = 85.71\%$; $s_{vs(f)}^{post} = 88.00\%$) preferred visual learning (M_{Δ}=-3.73%, σ_{Δ}=8.5%).

Table 13 - VSL - Gender Scores – Pre / Post

	Pre	Post
female	85.71%	88.00%
male	94.74%	85.00%
M	90.23%	86.50%
σ	6.38%	2.12%

Beside the reverse scoring, after the AR intervention the difference between both genders decreased considerably, which allows to assume that the AR intervention influenced female and male students in the same way due to the primary visual character of the AR intervention. Nevertheless, the visual component was not seen as an isolated attribute by some students, similar as said in the previous section on SQL, which was supported by a female student suggesting that *"... [AR] makes the learning content more interactive and visual, which helps to better understand and memorise the concepts"* ($p_{Q1(9)}^{post}$), whereas a male student relativized his view stating *"yes, [AR] can be very engaging and visual. However, [it] would suit some subjects more than others"* ($p_{Q12(39)}^{post}$). The opinion of the male student offered a potential indication for the decreased preference of the male student as they might related it specific learning content and context. With regards to many previous studies reporting that male students usually prefer VSL more than female students (Hernández-Torrano, Ali and Chan, 2017; Rosati, 1999; Teevan, L.I. and Schlesselman, 2011), it is interesting that that the AR intervention let this preference decrease. The characteristics of creating an AR story and the preferences for other LS methods of female students, who often prefer other LS dimensions over VSL, might be a reason for the change effect in VSL. For example, in addition to previously mentioned studies some studies found that female students favouring active learning methods to a higher extent than VLS (Dee et al., 2002; Liu and Shi, 2015). The digital AR storytelling intervention supported the demand for both LS dimension by providing both in dense format – creating and presenting visual information that are then *hands-on* experiences (Kowsalya and Dominic, 2016). Besides the differences in the preference for VSL in this study both genders reported pre and post the AR intervention their major preference for VSL methods. This study underpinned these findings with showing that the level of importance for VSL did not change after the AR intervention for the female (F_{Welch} $(1,\ 40.60)= 0.249,\ p=0.620$) and male ($F_{Welch}$ $(1,\ 62.11)=\ 0.201,\ p=0.888$) sample, but left both genders preferences on a strong grade of 7. Explanations and support for this strong tendency for visual learning were explained by two students. The first student described his perceived visual preference as *"personally, I am a visual learner. I like to see objects, graphs, pictures, etc. to learn more than plain written facts on paper"* ($p^{post}_{Q7(32)}$), while the other student articulated learning better visually aided by claiming *"that I can remember visual things more the written word"* ($p^{post}_{Q10(10)}$).

While the results here cannot be directly compared with all earlier studies, there are some studies that conducted learning style preferences in connection with technology in educational setups, which evidence this general trend of visual orientation of students. For example, Adkins and Brown-Syed (2002) found in a study with students of Literature and Information Science [LIS] programs their participating students markedly preferred visual learning and attributed this to the transformational character of the supporting technology. Another study in a TEL setup utilizing hypermedia instructions reported a comparable strong preference of 8 for visual learning of the participating students (Waalen and Zywno, 2001), and this group improved above average through the enhancement of the classroom with hypermedia. Relating these findings back to the AR intervention of this study suggests that story telling with AR fostered the for the student important visual learning approaches and seemed to balance the preferences and importance for VSL between the genders.

There are, however, previous studies that presented deviating results. Some studies reported reversed and very mixed learning preferences for VSL, which allow the assumption that there are additional factors that influence both gender's preferences for certain learning styles, such as the cultural environment and the educational systems both experienced (Liu and Shi, 2015; Naik and Girish, 2012; Vaseghi, Ramezani and Gholami, 2012).

With the small sub-sample sizes[32] in mind, the change data within the age ranges left a twofold picture (see above

Table 11, p. 113). The two youngest ranges, 20-25 and 26-30, remained unchanged with a 100% of the students preferring visual learning, whereas in the other three ranges, 31 to 40+, the number of students preferring VSL decreased (M_{Δ}=-3.47%, σ_{Δ}=3.66%). The preference for VSL mildly increased for the majority of age ranges to a strong preference for VSL (see Table 14), except the age ranges 31-35 and 20-25 years, who decreased their preference slightly to a remaining strong preference (MD_{post}=8.0, IQR_{post}=1.0).

Table 14 - ILS Visual Grades by Age Ranges

	Pre	Post	Δ
40+	6	7	1
36-40	7	8	1
31-35	8	7	-1
26-30	7	8	1
20-25	10	8	-2
σ	1.5	0.55	1.41
MD	7.0	8.0	1.0
IQR	1.0	1.0	2.0

The decrease of number of students and the simultaneous increase of the preferences of three of the five age range samples might indicate a redistribution of learning style preferences after the AR intervention. Probably, some students perceived the visual components in the AR intervention as too strong, which led to a decreasing number of students preferring VSL. But at the same time, visual learning methods became even more important (Table 14) for the majority of students. Despite these changes the visual learning style preference were still the most prominent ILS dimension after the AR intervention. For the Generation-Y[33], the literature provides some evidence that these students strongly prefer visual learning methods of other. Researchers connected this preference to the omnipresent visual impressions this generation was and is confronted every day. This generation was the first that did not know a time without Internet and all its mainly visual offerings, such graphics, video content and VR games, and is also regarded as being technology savvy (Bickham et al., 2008; Fesol et al., 2016). This visual conditioning could

[32] See Figure 40 and Table 67 in the appendix in chapter 7.6.3.

[33] See the association of the age range to the Generation classifications in Figure 1 on page 108.

explain the high importance for VSL methods pre and post the creation of a digital AR story, within a certain level of saturation that the students perceived as being comfortable and favourable for their learning.

The 40+ old students (Generation-X) perceived themselves in this study prior the AR intervention as strong visual learner, which declined after the intervention in favour for SQL[34] dimension. This might be linked with the environment these students grew up, for example, a dominant influence in daily live were television sets.

Previous studies therefore described Generation-X students as very visual and technical literal due to living in the advent of email and first social networks (Baker, 2013; Bickham et al., 2008; Cambiano, Vore and Harvey, 2001; Fong, 2001). Nevertheless, sophisticated technology was less developed and accessible as for younger generations, which needed them to approach learning differently. Conversely, students of the Generation-X were also attested to be more tactile learners who prefer learning by doing (Fong, 2001). In summary, the results of this study for the other ILS dimensions confirm these views for the 40+ old students, which can be attributed to the creative hands-on and highly visual attributes of creating a digital AR story.

These findings may surprise since many researchers report a strong preference for visual learning styles, using Felder's ILS and other metric tools for measuring learning style preferences that offer a visual category such as mentioned VARK or Grasha-Riechmann. Nonetheless, the overall and detailed insights of the results in this study allow to conclude that the digital AR story telling intervention supported the visual learning style preferences of the students based on the perceived constant importance of the students pre and post the intervention. It should be noted that the creation of a digital AR story had a moderately negative impact on the number of male students preferring VSL, which influenced the overall number of students preferring VSL. The AR intervention, conversely, let more female students prefer VSL afterwards, which is a sign that AR storytelling supported the generally reported strong preference for VSL. Within the age ranges the AR intervention had a moderate negative effect on the preferences for VSL of the 40+ old students (Generation-X), while little fewer younger students of the Generation-Y.2 favoured VSL.

[34] See the overall comparison of LS results for all age ranges in the appendix 7.6.3, especially the delta results in Figure 45 and Table 72.

On the Generation-Y.1 and presumably the Generation-Z[35] the AR intervention had no influence on their degree VSL style preferences.

It can be concluded that the creation of a digital story with AR influenced the VSL learning style preferences differently on macro and micro perspective. Overall, the visual learning styles preferences accounted for the most prominent learning style dimension pre and post the AR intervention. Nevertheless, a view less students preferred it after creating the AR story, while at the same time the importance remained on the same strong grade, possibly due to cognitive overload triggered by the complexity and novelty of the creation process of the digital AR story. Furthermore, the AR storytelling caused a certain dynamic in terms of numbers of students preferring VSL and their preference grades for VSL within the different age range groups. Despite a high importance of the visual attributes of the AR intervention it affected some age groups VSL preferences only marginally.

The following list summarizes the main results for VSL preferences after the AR intervention:

- The highest number of students scored for VSL.
- Slightly decreased number of students after the intervention.
- All students between 20 and 30 scored for VSL pre and post the intervention.
- Majority of age ranges increased their preferences, except 31-35 and 20-25.
- All sample groups reported an unchanged strong preference for VSL.

The sensing learning style dimension is subject of the next section. It offers insights to the overall significantly increased preferences for sensing learning and supporting comments of the students.

4.2.3 Sensing Learning

The sensing learning style [SNL] dimension reflects the type of information that students preferentially perceive. In Felder's ILS, this information reception is categorized according to perception with the poles sensory and intuitive learning styles. With regard to the perception of new subject content, sensory learners prefer facts, data and experiments and value proven, systematic structures. Student with SNL preferences can work in great detail, but are easily irritated by surprises or complications, which may be reflected in a slower procedure.

[35] Please note that the sample size for Generation Z students were very low and thus their results need to be interpreted with caution.

Furthermore, sensing learnings learn best when content is tied to specific examples and procedures. Therefore, these students often prefer, for example, brainstorming in group about practical applications and how to apply concepts in real-world scenarios. By creating their own AR stories, the study addressed some sensory characteristics, such as converting text content into interactive, animated content, because AR technology allowed students to create and apply own meaningful content in an interactive application.

As illustrated in Figure 6 and Figure 7 the AR intervention in this study influenced the perception of the student sensing learning style preference. The analysis identified SNL as the only dimension that reported significant changes of preferences of the students pre and post the AR intervention. In comparison with the other learning style dimensions the sensing learning style is the only that reported a significant increase by three grades (F_{Welch} (1, 87.286)= 13.939, $p < 0.000$), which demonstrated the student preference for SNL ($g_{sn}^{pre}=4$; $g_{sn}^{post}=7$). Remarkable is that at the same time the overall difference accounted for only 2.93% more students scored for SNL (s_{sn}^{pre} = 66.30%; s_{sn}^{post} = 69.23%, M_{Δ}=5.23%, σ_{Δ}=8.33%), which made this learning style preference the one with the smallest difference between pre- and post-results within all ILS dimensions. Also, the comparison with prior studies left the result of preference an AR intervention slightly above the mean of all compared results (M=66.04%, σ=10.84%) and corresponds to the little observed change in SNL preferences (see table of comparison in appendix 7.6.7).

Table 15 - Welch Test on ILS Sensing Dimension

	Female	Male	20-25*	26-30	31-35	36-40	40+
α	0.05	0.05	0.05	0.05	0.05	0.05	0.05
F-stat	1.939	5.209	0.000	3.600	5.209	11.335	4.811
df1	1	1	1.000	1.000	1.000	1.000	1.000
df2	28.201	14.072	2.000	7.692	14.072	19.615	34.426
p-value	0.175	0.039	1.000	0.096	0.039	0.003	0.035
sig	no	yes	no	no	yes	yes	yes

*The age range 20-25 did not offer required amount of data for calculating a reliable Welch's test!
A minimum of four to five observations is recommended for this test.

After the AR intervention some MBA students highlighted especially the relevance to business repeatably, saying that they would have preferred *"more examples of how AR is being applied in business/case studies"* ($p_{Q13(5)}^{post}$) and *"relevant practical application"* ($p_{Q13(51)}^{post}$), or more specifically asking for *"exploration of trading, etc."* ($p_{Q13(61)}^{post}$). These statements support the mentioned importance for learners with a sensing learning style preference for meaningful applications of new learning content.

Two characteristics of a learning intervention that allowed students to create an AR story can be connected to the increased preferences of the students for SNL in this study. Research suggests that creating digital stories with AR addresses favourably the demands of students with sensory learning styles (Lynch, 2007; Mahmoudi, Badie and Valipour, 2015). In a recent study on learning with AR compared to traditional media, Nimkoompai et al. (2019) found that with AR the sensing dimension acquired larger improvement that with traditional media, which is connected to the experimental but structured approach of AR storytelling and demand that the AR intervention should be connected to real-life scenarios (Makina and Salam, 2011).

The definitions of Felder (2016) for general characteristics of sensing and intuitive learners conclude that students with sensory preference are more likely to dislike innovations, complication and surprises and rather prefer well-established learning methods for learning fact-based content. On the other hand, the definitions assume that students with SNL preferences are additionally attracted by hands-on work. Projecting these characteristics on the creation of a digital story with AR, the intervention was an innovative learning method for most of the students and let the students go through iterations caused by, for example unexpected behaviour or issues of the AR creation tool and modification of the underlying ideas for their digital story.

For the overall group in can be concludes that it is not clear which characteristic of the AR intervention contributed to increase of SNL preference for an almost stable number of students before and after the intervention. However, the active creation of a digital AR story influenced the student preferences for SNL in three main attributes, the experimental approach of the AR intervention, the relation of the learning content to immediate practice application, and innovative level of AR as learning method for the students.

Looking at the results in different age ranges, which were related to general generation definitions above, the Welch test (Table 15) confirmed a significant trend furthermore for 36-40 old sample group ($g^{pre}_{sq(36-40)} = 4; g^{post}_{sq(36-40)} = 7$, p_{Welch}=0.003). Not all sub-samples followed this general tendency and as Table 15 also shows less significant changes were found also for students within the 40+ (p_{Welch}=0.035) and 31-35 age range, which reported the same significance value of p_{Welch}=0.039. For the other groups the Welch test did not report significant changes. An exception within the SNL results were the students of age 20-25 years, who reported an unchanged and only very mild preference for sensing learning styles ($g^{pre}_{sn(20-25)} = 1; g^{post}_{sn(20-25)} = 1$) in favour for an unchanged strong intuitive learning style preference ($g^{pre}_{in(20-25)} = 5; g^{post}_{in(20-25)} = 5$). Despite a reported significance (Table 15), all other age ranges and the group of female students supported this strong tendency for SNL with only a moderate increased preference by two grades[36].

In summary, the Generation-Y.2 and Generation-X showed significant changes in SNL, as well as the female students after creating a digital AR story. Nevertheless, the AR intervention had negligibly small impact on younger students of the Generation-Y.1 and Generation-Z, as well as the male students. Researcher regularly conducted that Generation-X and Generation-Y (1 and 2) are sharing similarities in their learning as they both grew up using technology in one form or another, thus both generations usually respond well to technology based learning with AR that addresses sensory learning preferences (Baker, 2013; Bickham et al., 2008; Bova and Kroth, 2001; Cambiano, Vore and Harvey, 2001; Fesol et al., 2016; Fong, 2001). Interesting in this study is the grouping of the Generation results (X & Y.2 and Y.1 and Z) that indicates a transition of learning preferences between neighbouring generations, which is reflected in a similar number of students favouring SNL. However, the Generation-Z students showed a strong unchanged intuitive after the AR intervention, which suggest their attribution to innovative learning methods, especially immersive technologies such as AR, that supports their fast and variable access to knowledge (Azhar, Kim and Salman, 2018; Fedock, Young and Butcher, 2013). Furthermore, the creation of a digital AR story corroborates the assumed characteristics of the Generation-Z to learn by playing and following a non-linear approach to solving tasks and gaining knowledge (Veen, 2007).

The significant differences between both genders has been found in many previous studies reporting male students with a higher preference for SNL than female students (Hosford and Siders, 2010; Naik and Girish, 2012; Rosati, 1999; Teevan, L.I. and Schlesselman, 2011). Unfortunately, this seems not to be a general trend since other studies could not find significant difference between both gender in the SNL dimension (Hernández-Torrano, Ali and Chan, 2017; Ivey and Lee, 2014; Prajapati et al., 2011) as well female students preferring SNL more than male students (Alumran, 2008). The exemplary cited studies for both outcomes show a heterogeneous mix of characteristics of the observed students and suggest that that the reported preferences for SNL are linked, for example, to the cultural environment and field of study of the students.

The following summarises the impact on SNL preferences after the AR intervention:

- Significantly increased preference overall, for the male and 36-40 old students.

[36] See section 7.6.2 - ILS Results: Gender Pre / Post and 7.6.3 - ILS Results: Age Range Pre / Post in the appendix.

- Moderate increased preference for female and age ranges 26-35, and 40+.
- Only age range 20-25 reported an unchanged very mild preference for SNL.
- Overall, very stable and only slightly more students favoured for SNL.

The results showed that the creation of a digital AR story influenced the SNL preferences of the students significantly, although exposing stark differences between both genders and within the age groups. The AR intervention influenced the preferences of the students for SNL significantly, especially in the male and 35 to 40-year-old sample. The other sample groups reported only a minor increase and a stable preference for favouring SNL.

The following section covers active learning preferences of the students, which were found as the second highest but moderately increased preference.

4.2.4 Active Learning

According to Felder & Silverman (1988), the process of information processing includes the experience of how new learning material manifests itself while processed. This processing dimension is divided into the poles active and reflective learning styles. Active learners generally learn by doing something with the new information. They often discuss what they have learned and benefit greatly from group work. Typically, active learners prefer group activities in which members explain topics to each other and finding ways to apply or use the information actively. A typical sentence from active learners would be: *"Let's try it out and see if and/or how it works?"* (Felder, 2016, p.1). In contrast, reflective learners show more intrinsic characteristics, as such, they are more inclined to think through topics and write summaries for themselves in individual work. Everyone is sometimes active and sometimes reflective since according to the Felder-Silverman model. As well as valid for all other learning style dimensions, people sometimes phase between preferring active learning and reflective learning. However, most people trend more toward one learning style than the other styles (Felder, 1996; Felder and Brent, 2005).

The next section reports on the increased preferences of the MBA students for active learning methods after the AR intervention and how students perceived that AR might have influenced their learning preferences.

Interestingly in comparison with the previously introduced learning style dimensions is that ACL reported exactly the same number of students as SNL did, but with a slightly higher increase rate Table 17. However, as Table 17 suggests, students raised their preferences overall moderately for active learning by 5.10% ($M_{\Delta}=5.23\%$, $\sigma_{\Delta}=8.33\%$), which was the second highest increase of student numbers for one learning style dimension ($s_{ac}^{pre} = 64.13\%$; $s_{ac}^{post} = 69.23\%$). Interestingly, this post result was identical to SNL, furthermore it put this dimension together with SNL as the second highest score learning style after the AR intervention. A comparison with prior result allows to see these post results as a high level for ACT level (see table of comparison appendix 7.6.8).

In contrast to the previously reported changes in numbers of students, Table 16 below shows that the average preferences for ACL remained unchanged within the whole sample, similar to VSL, on a moderate level ($g_{ac}^{pre} = 5$; $g_{ac}^{post} = 5$).

Table 16 - ILS Overall Pre/Post Grades

	Pre	Post	Δ	IQR	MD
Active	5	5	0	0.00	5
Sensing	4	7	3	1.50	6
Visual	7	7	0	0.00	7
Sequential	4	5	1	0.50	5
σ	1.2	1.0	1.2		
MD	4.5	6.0	0.5		
IQR	1.5	2.0	1.5		

Previous research found that learning with technology and AR support the active learning preferences of students. The studies argue that it lays in the nature of creating a digital story with AR that this method endorses the ACL, especially because this creative method engages students in manipulating and monitoring the learning content students (Brown et al., 2009; Chen and Chen, 2018; Koutromanos, Sofos and Avraamidou, 2015). These attributes reinforce the resulting increase of the overall student's preferences for AC in this study but might also explain the stable attractiveness of digital AR storytelling as active learning as active learning and teaching method.

Table 17 - ILS Overall Pre/Post Scores

	Pre	Post	Δ
Active	64.13%	69.23%	5.10%
Sensing	66.30%	69.23%	2.93%
Visual	91.30%	86.15%	-5.15%
Sequential	43.48%	61.54%	18.06%
σ	16.96%	9.00%	8.33%
M	66.30%	71.54%	5.23%
MD	65.22%	69.23%	5.13%

Two sub-samples stood out in relation to learning style changes. Slightly higher than the overall score, a moderate 6.84% more male students tended to ACL. However, 11.34% more students of the age group 31-35 preferred ACL, which constituted more than twice the overall change and made it the 3rd highest increase within all ILS dimension within all age ranges (see

Table 11, p. 113). Several student responses suggest that the AR intervention influenced their perception of 'active' AR as a learning method and the engaging effects of AR on learning and active applications. The high numbers of students performing ACL underpinned by perceptions and opinions that coordinated with the characteristics of ACL, such as *"[AR is] much more interesting and interactive way of learning. It seems to engage the student much more thoroughly"* ($p^{post}_{Q1(70)}$) or respectively *"everyone remembers interactive learning above reading in my opinion"* ($p^{post}_{Q1(10)}$). One student expressed with references to future useful application that the AR intervention supported him in *"developing a tool to market a product and / or pass a message to inform the decision makers at a firm or organisation"* ($p^{post}_{Q12(8)}$), which underlines the importance of active learners for applying the elaborated learning content actively.

Despite that the complete sample reported a constant level of ACL preference pre and post the AR intervention, in detail the two youngest age range groups of 20-25 and 26-30 old students stood out of the results. While 26-30 old students decreased their preferences for ACL by two grades from a moderate to a mild preference ($g^{pre}_{ac(26-30)} = 5$; $g^{post}_{ac(26-30)} = 3$), the age range 20-25 conversely increased their already very strong preference even further by two grades ($g^{pre}_{in(20-25)} = 8$; $g^{post}_{in(20-25)} = 10$). A summary of the preferences and its changes for each age range can be found in Table 18 below.

Table 18 - ILS Active Grades by Age Ranges

	Pre	Post	Δ
40+	5	6	1
36-40	4	5	1
31-35	5	5	0
26-30	5	3	-2
20-25	8	10	2
σ	1.52	2.59	1.50
MD	5.0	5.0	1.0
IQR	0.0	1.0	1.0

The active creation of a digital AR had positive effect on the active learning preferences for the majority of the students from Generation-X to Generation-Z. There numerous studies that confirm the positive impact of AR enabled learning on the active learning preferences of student, but usually these studies adopted 'passive' predefined AR learning content (Bower et al., 2014), as also described above. A view studies made use of active-creative approaches of AR in education, thus, providing less comparison to this study. For example, Wei et al. (2015, p.223) think the practical experience of creating an AR story supports the *"[...] desire to express their creativity and improve creative thinking [...]"*. This perceived lack of creative 'hands-on' experiences where students have the opportunity to try things and to make mistakes has been often systematically suppressed in formal education. Robinson (2006, time: 06:15) goes even further and claiming that many education systems are educating students *"[...] out of creativity"*. The offered iterative creative and active learning approach through creating a digital story with AR could address was a welcomed substitution of usually more passive learning approaches. This positive impulse of the creating a digital AR story is also reflected in the high ranking in the comparison with previous research[37]. Interesting would be to know, picking up Robinson's claims, if these students would 're-learn' being more creative if the preferences for active learning would consequently increase even more? Such active participation would make the students to active prosumers of learning content in a positive sense, other than the economically defined version prosumers of Ritzer (1992, p.15 pp.).

The Generation-Y is described by Schofield et al. (2009, p.29) as understanding gaining new knowledge as an *"active creation process"*. This generations values social learning with new technology, which are exploited to design their work environment, contribute to their knowledge, and sharing their ideas to a community (Reinmann-Rothmeier, Mandl and Prenzel, 1994; Schofield and Honoré, 2009). So, it is insofar not surprising that the increased and very strong ACL preferences for the youngest student group in this study show the highest preference grades after the AR intervention. Theses preference for active and interactive learning and teaching methods makes the creation of digital AR stories an ideal method for students of the Generation-Z, in this study the 20 to 25-year-old students.

Summary for active learning style preferences after the AR intervention:

- Second highest but moderately increased preference overall.
- Moderately more male students than the average.
- Highest increase within 31-35 range by more than twice the average.
- Unchanged moderate preference grade overall.

[37] See appendix 7.6.8 - Meta Table of ILS Results of 42 Studies by ACL

- The only decrease within the 26-30 to a mild preference grade.
- Very strong higher preferences within the 20-25.

The active learning style dimension reported, together with VSL, the second highest preference with a moderate increase after the AR intervention. The AR intervention let only a view more male students to prefer ACL methods. Simultaneously, the students did not change their level of preferences for ACL, but the details in the age ranges delivered converse trend for the two youngest sample groups. The youngest students were more attracted by the active creation process of the AR intervention than the others. Nevertheless, creating a digital AR story was attractive enough to raise the preferences for ACL for the majority of student generations. Overall, it was observed that the creation of a digital AR story showed more distinguishable impacts between the different age ranges in this study, which often went in line with the general attribution of previous research that describe the different learning preference of Generation-X to Generation-Z.

4.2.5 Summary for AR Storytelling Impacts on Learning Style Preferences

The comparison of the results for Felder's ILS before and after the students created their digital story with AR left a mixed impression of the impact of the adoption of AR as an active creative learning method. The increased preferences for SQL after the AR storytelling intervention suggest a large proportion of the students realized that a sequential learning approach would guarantee a higher chance to master the task of creating a digital AR story. The VLS was the most prominent learning style dimension pre and post the AR intervention, but this dimension decreased in prominence after creating the AR story, while remaining strong. A possible explanation could be a potential cognitive overload of the students due to the amount of newly acquired skills and knowledge, as well as the limitless possibilities of creating a digital story with AR. The SNL dimension was significantly influenced by the AR intervention. Furthermore, the study exposed in this learning dimension stark differences between genders as well as generation effects which could be attributed to the experimental but structured approach of AR storytelling and connection to real-life scenarios the students defined themselves. The ACL dimension was the second highest preference, which moderately more students preferred after the AR intervention but with a stable preference. The results also suggest that male and the younger students were more attracted by the active creation process of the AR intervention than the other sub-sample groups.

The previous four sections focused mainly on the quantitative findings of how AR impacted student learning style preferences within the Felder's LS. The forthcoming chapters and sections will reverse this previous approach and address the further findings primarily from a qualitative perspective, while linking them to the quantitative results. The next chapter will cover themes of how the students perceived AR storytelling in this study. Within this main theme this study suggests three findings: a preference of the students for a balanced mix of learning methods, a perceived importance of digital storytelling, and the ability of AR storytelling to address diverse student perceptions.

4.3 Student Perception on AR in Learning

This chapter sets out themes that emerged in the analysis of student perceptions of creating digital AR stories. To create a positive perception of a learning task in terms of usefulness and meaningfulness a learning and teaching method needs to address the personal learning needs and preferences of students, their personal interests and a connection to their life (→ 4.2.4 Active Learning) (Keller, 2009 pp. 109).

The first section of this chapter starts by suggesting the preference of the MBA students for a balanced mix of learning and teaching methods as the student answers indicate a pragmatic view linked to their preferences, interests and learning content. The study revealed that a number of students expressed the perceived importance of digital storytelling with AR in terms of the potential benefits for their learning and application of new skills.

The final finding in this chapter addresses the ability of AR to address the very diverse perceptions and expectations of the students in this study.

4.3.1 Preferences for Balanced Mix of Learning and Teaching Methods

The second research question addressed in this study examines student preferences towards AR enabled e-Learning. For this the participants were asked after the AR intervention if they would prefer an AR intervention over other technology enabled or traditional[38] learning and teaching (RQ_3). This section suggests that the students in this study articulated a preference for a balanced mix of learning and teaching methods. An applied AI based interpretation of the student answers supported this perception through positive sentiment and emotion indications toward AR as superior learning and teaching method.

After the AR intervention the students reported a balanced opinion (see below), whereas the majority of participants agreed with 41.18% (Q_{Q12}^{post}) that they would quite well prefer AR over other methods. Interestingly, the two extreme perceptions, 'not at all' and 'absolutely', were almost equally distributed (Figure 9).

Overall, there was a slightly more positive trend towards an AR preference, which summed up to 73.53% positive mentions ($M=20.0\%$, $\sigma=13.8\%$). To reinforce this positive trend some students suggested, comparable to earlier discussed preferences for active learning, that *"[AR is] easier to remember, interactive, catches the audience's attention much better than traditional learning methods"* ($p_{Q12(9)}^{post}$) and that *"interactive learning is better than traditional learning!"* ($p_{Q12(49)}^{post}$).

Unfortunately, the student answers in this study did not elaborate an understanding of their definitions of interactive learning and teaching methods. With the help of the answers by two students $p_{Q12(13)}^{post}$ and $p_{Q12(18)}^{post}$, which point to recorded online lectures for part-time MBA students, this study adopts two terms coined in the Dot-Com era, namely Consumer and Prosumer[39]

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[38] In a puristic view, traditional teaching and learning methods can be described as regularly being teacher-oriented, related to a common lecture style approach, and often considered as inflexible. Usually, in lectures teacher teach by introducing skills using blackboard-like presentation media, including some technical devices, which is accompanied by a verbal explanation or lecture. Practical work for students comes in form of preparation work, assigned tasks during the lectures or in complementing materials, which is ideally followed by feedback from the lecturer. Traditional learning methods point more to the paper-and-pen methods, such as note-taking, reading paper-based materials, writing and exercising tasks and examples. Strictly speaking, this learning methods do not include electronics substitutes or advanced learning option, such as simulations. However, the boundaries between new and traditional learning becoming fuzzy due to the acceptance and the matters of course how new technologies and methods are adopted to learning and teaching (see student quote $p_{Q12(13)}^{post}$ below).

[39] Ritzer is probably the most prominent scholar that coined the term 'prosumer' in his research around globalisation of today's societies and systems (Ritzer, 2018, 1992; Ritzer, Dean and Jurgenson, 2012). Here he and his colleagues use the term to describe a transformational change of consuming and producing customer (continuum) in an economy (Ritzer, 2014), whereas Hayes and Wynyard (2016) relate these modes especially to ongoing changes in higher education. Furthermore, in his discussion Ritzer (2014) attributes a certain level of exploitation to the term prosumer. This study uses the term prosumer in a more positive way to describe the creative integration of the students in the learning and teaching process, by choosing subject, planning the development, creating the AR story and presenting the results.

(Giurgiu and Barsan, 2008). A substantial difference is that traditional learning methods might often only be attributed to a consuming character of participation of students, while interactive TEL methods could offer students to consume (audience participation) and produce learning artefacts simultaneously. In the light of Web 2.0 technology, for instance digital social networks, which addresses such prosumer activities AR enabled learning could fall into both character categories.

In relation to this study, students could just consume prepared AR content, where the AR intervention requires a certain level of interactivity when consuming the learning content. But student participation that integrates active creation of content could blur the line between consumption and production activities when students create their own digital AR story (Giurgiu and Barsan, 2008; Ha and Yun, 2014; Ivashkevich, 2015), thus transforming students into prosumers.

Furthermore, an AI sentiment analysis (Table 19) supported the previously reported tendency by accounting a very similar result of 68.09% positive answers, whereas 21.28% resulted in a neutral sentiment ($M=33.33\%$, $\sigma=30.8\%$). The later neutral tendency found its exact reflection in the emotional analysis of the answers in which also 21.28% of the participants formulated their answers indifferently ($M=14.29\%$, $\sigma=18.00\%$).

Figure 9 - $Q12_{post}$: "Would you prefer an AR intervention over other methods of technology enabled or traditional learning and teaching?"

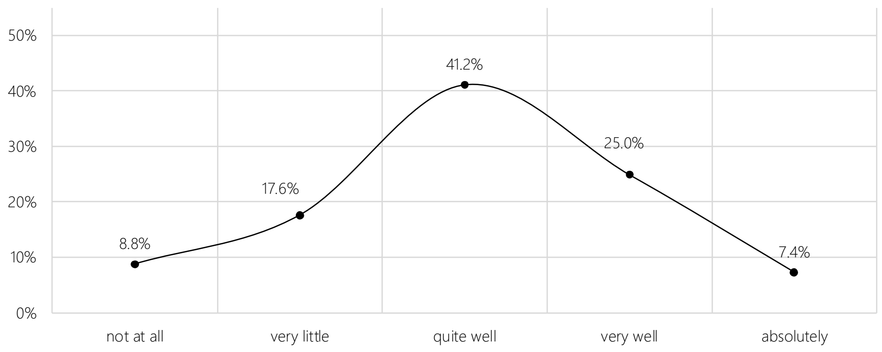


Table 19 - $Q12_{post}$: AI Sentiment and Emotion Analysis Results for Preferences TEL vs. Traditional Methods

	AI Sentiment	
	n	%
positive	32	68.09%
neutral	10	21.28%
negative	5	10.64%
	M	33.33%
	σ	30.56%

	AI Emotion	
	n	%
Excited	10	21.28%
Happy	23	48.94%
Indifferent	10	21.28%
Bored	0	0.00%
Sad	4	8.51%
Angry	0	0.00%
Fear	0	0.00%
	M	14.29%
	σ	18.00%

Despite this positive trend, more students have repeatedly expressed a preference for a balanced mix of AR enabled and traditional learning methods. Despite that the students did not define the two terms it could be implied that they interpreted as part-time students recorded lectures as traditional and the AR intervention in this study as interactive learning methods. Furthermore, it was interesting, that only two participants mentioned alternative eLearning methods, such as comparing the AR intervention with online lectures saying that *"[it is] more interesting than recorded lectures that I have seen"* ($p^{post}_{Q12(13)}$) and that *"the 'practical' feel is better than simple lectures online"* ($p^{post}_{Q12(18)}$). However, two other students compare the AR intervention with traditional learning and teaching methods. One student perceived that *"interactive learning is better than traditional learning!"* ($p^{post}_{Q12(49)}$), while the second student prefers AR learning methods but confined this view saying *"yes, but in combination with traditional [learning]"* ($p^{post}_{Q12(36)}$). A cluster of synonyms[40], such as combination – variety – mix – compliment – combination, characterised the student preferences for a balance between AR enabled and traditional learning and teaching methods.

These exemplary comments indicate that the students in this study define learning and teaching methods differently, and thus evaluate the AR intervention according to their personal leaning preferences. The previous ILS section mentioned the issue of potential cognitive overload through the use of AR methods in learning and teaching, which could let the students strive for a compensation of such overload. It would be conceivable that the students might want to prevent to fall into a saturation of motivation for one or the other learning and teaching method. In other words, many students might to avoid boredom as mentioned explicitly in some Generation attributes in the previous chapter on ILS. Furthermore, the challenging reconciling of the part-time MBA course, family, and professional life might stimulate the desire for a certain variety of learning and teaching methods. As well the values for part-time MBA students seem to be prioritized. For example, Rouyendegh and Erkan (2011, p.774) noticed that they are *"working in companies, therefore, time is invaluable for them"*. Other studies suggest that cultural environment might add additional complexity to the student priorities, motivations and thus preferences for a certain learning and teaching method, or a balanced mix of it, in order to align private and academic challenges a part-time MBA program involves (Kibelloh and Bao, 2014; Ronnie and Wakeling, 2015).

Further confirmation for a balanced approach comes from a student who suggested that *"combining different method of taking in information. That way everyone would find something they are interested in"* ($p^{post}_{Q10(62)}$), thus addressing the differences in learning styles and learning situations. This situational thinking was additionally expressed through the perception that different learning and teaching methods *"are useful in their own way"* ($p^{post}_{Q12(14)}$), and that AR enabled learning was *"one of many ways to learn"* ($p^{post}_{Q12(31)}$) and should be offered *"in combination with traditional [learning and teaching methods]"* ($p^{post}_{Q12(36)}$). One female student added the aspect of future application to her balanced preference, claiming that it was *"for us a part of a mix of learning and teaching methods. Also depends on the sector. It worked well in the welding example"* ($p^{post}_{Q1(27)}$). Another student saw the favour for a balanced offer of AR enabled and

[40] See appendix 7.7.1 for an excerpt of student answers and extracted synonyms.

traditional methods more critically by arguing that an AR enabled learning method *"complements other learning. Doesn't necessarily replace it"* ($p^{post}_{Q12(21)}$). This perception pointed to a dissatisfaction for solitary applied learning and teaching methods. The last comment confirms what previous studies, but often from a teacher's perspective, concluded: TEL or specifically AR enabled learning and teaching can supplement but probably not replace traditional approaches entirely, rather enhance them. In an construction course Fauzi et al. (2019) found that the students were sceptical towards AR in the programme, nevertheless it could be an effective method to enhance student learning. Such relativizing perception of student towards AR enabled learning and teaching might be influenced by, inter alia, the overall quality of an AR intervention, including technical and content related matters. Some studies in educational environments highlighted user acceptance, usefulness, ease of use, enjoyment, and attitudes towards AR enabled learning and teaching, have an impact on the status of AR from a student perspective (Cabero-Almenara, Fernández-Batanero and Barroso-Osuna, 2019; Chen and Wang, 2018; Dalim et al., 2017).

Focusing on online-classes for business school students rather than AR enabled interventions, van der Rhee et al. (2007) found that these students preferred mixed classes over pure online-classes. The study assumes that the prior choice of the students for a specific program mode at a traditional university shapes these preferences for a mixed approach.

From the perspective of self-regulated learning in TEL environments, such as the AR storytelling intervention in this study, it seems to be favourable to establish a balance between (more) structured traditional learning methods and offering students to learn self-regulated. Carneiro et al. (2007) relate this to the need of a balance between a perceived guidance and freedom in learning environments, potential cognitive overload through TEL methods, and the pragmatic stances of students. Especially, the later pragmatic stance, also often called goal-orientation, of business students has been found repeatedly by a number of researchers (Prince et al., 2015; Manai and Holmlund, 2015; Murphy and Yetmar, 2010; DiBenedetto and Bembenutty, 2011)

Nevertheless, such preference for a balance of teaching and learning method or AR enabled methods might also be influenced by the field and subject, for example, where learning objects could be virtually visualized through AR and students find it support to gain deeper understating of the material to learn (Peterson and Mlynarczyk, 2016).

In this study the majority students expressed neutral preference for AR enabled over traditional learning and teaching methods (see Figure 9 above). The AI analysis of a given answers showed that the absolute majority of the students trended towards a positive sentiment (see Table 19 above), which was also reflected in the student answers which expressed felicitous emotions towards AR enabled learning. Despite these positive perceptions, the responses in this study suggest that a large number of students prefers a balanced mix of traditional and technology enabled learning and teaching methods for their own learning. The AR enabled learning was seen as a welcomed but complementary method to existing traditional methods. Nevertheless, despite a few hinting answers no clear indication could be found for what students perceived as traditional, modern, alternative or TEL learning and teaching methods.

Nevertheless, the concept of digital story telling seemed to be remarkably important to the participating students in this study and allows the assumption that the creation of a digital AR story might be a welcome diversion for their learning process. The next section is picking up this perceived importance of digital storytelling with AT and reports on some gains from creating aa digital story with AR that students perceived as favourable for their learning and future career.

4.3.2 AR Supports Skill Building and Personal Learning

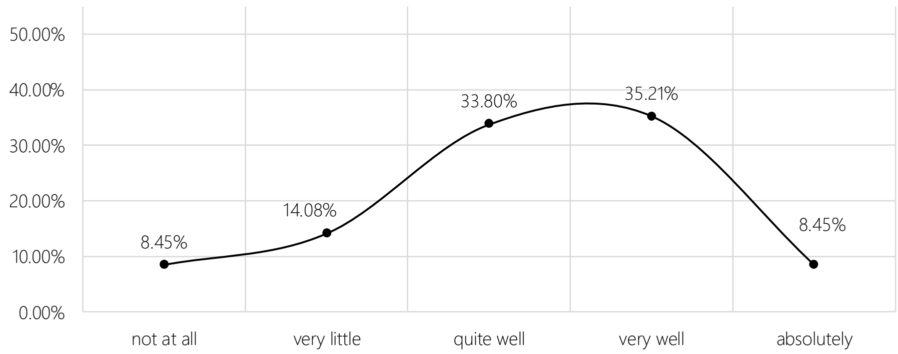
In the intervention for this study the participating students were asked to create a digital AR enabled story, which had the concept of digital story telling[41] integrated. Comparable to the ADDIE model the students traversed the storytelling process from ideation, structuring, sourcing to the final creation of the AR enabled story (McNeil and Robin, 2012). This study found that a number of students perceived the concept of digital storytelling as important because the students esteemed AR, in relation to the research question two (RQ_2), as supporting their learning process and honing a skill set students could benefit from in their future careers.

As seen in the previous section on AR helping to reinforce students TSE, the majority of students perceived that AR supported their personal learning quite well (see graph in Figure 13). After the AR intervention the students were asked to which extent, they enjoyed the creation of an AR enabled story. As Figure 10 shows, overall 35.21% and 33.80% of the students ($M=20.0\%$, $\sigma=13.5\%$) claimed to have enjoyed very well, respectively quite well ($MD=2$, $IQR=1$), creating their own digital AR story, which supported additionally the perceived importance of the concept

[41] Storytelling can be defined as a method in which information is conveyed through the use of stories. These stories have been passed on through analogue media since ancient times. Digital storytelling can be seen as a modernized form of storytelling where digital media complement traditional forms. For digital storytelling digital images, films and sound can be woven into the stories, which can be transported through different channels. Here can be mentioned more or less interactive applications such as hypertext technologies or virtual and augmented reality enabled environment for storytelling (Alterio and McDrury, 2003; Information Age Education (IAE)).

of digital storytelling for the students. These data points and the small spread (IQR=1) suggested that the students assumed a mostly positive stance on creating their own AR enabled digital story.

Figure 10 - Results: $Q4_{post}$ "Did you enjoy creating your own AR story as a learning option?"



Furthermore, the text analysis of the student responses for the post-intervention survey questions Q_7, Q_{10} and Q_{12} revealed a favourable mentioning of the storytelling process[42]. This was undergirded by the earlier highlighted strong preference grade of 5 for sequential learning as reported in chapter 4.2.1. In accordance with Felder's (2016) characteristics for sequential learner the study identified that learners preferred logical steps to tackle a task, and active learning that deals with the processing of information material such as active problem solving activities.

When asked for their most important learning from the AR intervention two students reckoned on the potential of the AR technology for the digital storytelling and storytelling per se. One participant ($p^{post}_{Q10(68)}$) shared that *"to me [it is this] new technology to bring storytelling into live"* and another participant emphasised literally *"the importance of storytelling"* ($p^{post}_{Q10(39)}$).

Furthermore, digital storytelling with AR seemed to enhance the personal learning experience of students since *"thinking in terms of themes and creating a story is a great way to expand the way I approach information presentation"* ($p^{post}_{Q7(18)}$), as one participant explicated. This has been elaborated in relation to potential preferences of AR based over traditional learning as one

[42] Q_7: Do you think the AR experience supported your personal learning process?

Q_{10}: What is the most important thing you learned personally?

Q_{12}: Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?

participant, for example, attested AR epigrammatically being a method for *"easy story telling"* ($p^{post}_{Q12(29)}$).

The concept of storytelling has additionally been perceived as a beneficial skill set for future career because *"there's a new way for storytelling which I've found really interesting and very useful for business purposes at all levels, from reports presentation to training"* ($p^{post}_{Q10(9)}$), as one student commented. This perceived importance of the students for potentially gaining benefits from AR enabled learning and teaching will be further discussed in section 4.4.4 - Importance and Benefits for a Future Career.

The field notes for all three interventions left the impression of a vivid participation in all stages of the digital storytelling process. It seemed that the majority of students enjoyed discussing ideas, developing and creating a digital AR story. Nevertheless, it could be observed that some groups had issues in working as a team on one common story and expressed that the time constraints were an issue for some of them to come up with 'good' ideas and a 'perfect' story. As a result, these field impressions left the perception that a prototyping quality approach was too progressive for some students and did not met their set expectations.

In educational environments personal judgement of one's self-efficacy relates to performance capabilities expectations of students to accomplish a task set in comparison to their co-students (Zimmerman, 2000). Following this thesis, in this study the student rated their certainty according to the perceived level of difficulty to create a high-quality digital story with AR, rather than comparing the outcome with their co-students. These high expectations might in turn be rooted in an unfamiliar learning situation, where the students have to plan and create a story with the AR technology in a non-linear process,

which was new and probably intimidating complex for some student. To overcome such barriers pedagogically teachers and lecturers could intervene early to enhance the student self-efficacy vocally in small sprint-sessions[43] and during the whole intervention.

The previously cited comments of the students, however, did not stress the technical part of the storytelling as the hindrance, rather highlighted than that some students perceived themselves

[43] The term sprint-session origins from the agile project management concept Scrum (2020), which could be adopted pedagogically in a modified form for educational settings with students. In these mini-meetings students explain and discuss ideas of students, while the teacher as a "Scrum-Master" offers support in timing, planning and confirmation of the student abilities to solve the task.

as not being creative enough to accomplish the creative task of creating a digital story with AR. This perception of not being creative, which should not be confused with being arty, might be caused in what the students experienced, and which habits they adopted in their previous educational career. And according to Robinson these experiences and (un-)learned habits are systemic because he claims that educational systems are often aligned and compared to the requirements of industrial productions lines. Such industrialized and serialized alignment of education sets learning targets and the ways to reach them, which leaves no room for creativity in education (Hill, Cromartie and McGinnis, 2016; Robinson, 2008, time: 06:45 - 07:37). For various organisational and political reasons, many educational systems for, especially further education[44], systematically unlearn student their previous abilities of being creative. In a longitudinal study, which tested imaginative thinking, Land et al. (2011, time: 05:27) found that in the group of 4-5 year old children 98% produced original creative ideas and that this ability decreased to 12% until they became 15 years old.

However, at the same test for adults of an average age of 31, which correspond well to the average age of students in this study, only 2% of the participants could come up original creative ideas[45]. When exploring possible cause Land et al. (2000; 2011) found that current teaching system force children to apply two contradicting ways of thinking, divergent and convergent, at the same time, which they argue leads to an un-learning of divergent thinking that produce creative imaginations. Similar results come from Eshet (2002), who concluded an un-learning process is caused by old teaching approaches that limit the fostering of lateral thinking skills.

Similarly, Robinson (2006, from 13:30) agrees to this loss of creative capacity and claims that educational systems *"educate people out if their creative capacities"*, which he ties also to the industrial orientation of educational system that foster the suppression of divergent (creative and value-free) in favour of convergent (immediately judging) thinking. This way of thinking habits is the opposite of Design Thinking with the basic idea of creativity as a process that favours divergent thinking, nevertheless, included judgments and iterations in order to reach the aim of solving problems, such as creating a new design, solving a technical problem, and creating a

[44] Referring here to all schools and institutions post primary education.

[45] Results for 4-5 yrs. = 98%, 10 yrs. = 30%, 15 yrs. = 12% (n=1600); Adults (avg. 31 yrs., n>1 million) = 2%

digital story with AR (Noweski et al., 2012; Robinson, 2011, ch. 3 and ch. 6; Wang and Hannafin, 2005).

As mentioned before, most creative tasks follow structured approaches such as the creation of a digital story made use of a staged and iterative process to construct a digital story. The students perceived digital storytelling with AR and its underlying process steps as favourable skills, which found support in the previously reported preferences for sequential learning. Furthermore, the students enjoyed the creation of the AR story relatively well, which could be reasoned with some supporting potentials of the new AR technology for digital storytelling (Abas and Zaman, 2010; Schrier, 2006; Yilmaz and Goktas, 2017).

This section reported on the abilities of digital storytelling with AR to support diverse skill building and the personal learning of the students. Nevertheless, the different preconditions, perceptions and expectations exposed for a view student deficit in self-efficacy regarding the abilities to create unique and creative ideas for a digital story. This seems not connected to AR technology by students per se, rather related to a general perception of not being creative. It seems that the students perceived the ideation stage, which requires lateral thinking skills, of the AR storytelling interventions a challenging. However, the students enjoyed the implementation stages, when they had set a plan that could be followed sequentially. This allows the assumptions that the sample of this study are less lateral (agile or global) thinkers and learners. According to Kamal and Radhakrishnan (2019) is e-Learning environments not all students are agile thinkers, which relates to the personality types[46] and the goals setting of the students. Another study from a teacher's perspective, reported contradicting results. The teachers perceived the students as more global learners and thinkers than sequential (Kurilovas, Kurilova and Dvareckiene, 2017). Probably, these were perceptions influenced by wishful thinking, as it was assumed during the conception phase of this study for the specific sample of MBA students. This was driven by the ideas of business requirements for managers in working environments where exponential more new, sometimes disruptive, technology innovations disturb linear process thinking and require lateral thinking for adopting to new situations and environments. These findings should therefore have consequence on the design of AR enabled interventions, in the way that a balance of methods needs to be

[46] Personality straits as defined by tests such as the MTBI versus Learning Style preferences (e.g. in Coffield, 2004).

implemented that serves both learning and thinking types, as well to provide targeted support to foster lateral thinking skills.

The previous findings and the results from the ILS section revealed that the students in this study showed diverse opinions, perceptions, and expectations toward learning and skills development, with and without AR. The next section will connect these diverse perspectives and will draw on the ability of digital AR storytelling to address the diversity of students in HE.

4.3.3 AR Helps to Address the Diversity of Students

The starting sections of the findings of this study reported on student learning style preferences, individual preferences, and their perception of importance of digital storytelling with AR. The student responses offer a broad spectrum of opinions, views, experiences and expectations for an AR enabled learning environment. Previous studies in diverse educational settings, regularly confirm highly diverse student groups. However, in recent years educational researchers, practitioners and other professionals observed increased and more complex differentiation amongst students (Correa and Tulbert, 1991; El-Khawas, 2003; Ford and Whiting, 2007; Grubb et al., 2011; Happ et al., 2016; Jabbar et al., 2020; Powell et al., 2019)[47].

These differences of students are often associated with the term 'student diversity'. Commonly, this term stands for differencing or relating to attributes, such as, gender, age, and heritage, especially in anglophone countries (Markic and Abels, 2014; Sliwka, 2010, p.211 pp.; Spelsberg, 2013). In academic literature and in recent public discussions[48], these attributes are often subject for a so-called gap-discussions, for example, in educational environments on gender-gaps or equality efforts. Nevertheless, in educational context diversity is often seen more integrative, where *"[...] diversity as a systemic paradigm perceives difference as an asset"* (Sliwka, 2010, p.213).

[47] The literature examples compile publications that address diversity and heterogeneity of students. A differentiation of these two terms follows later in this section.

[48] A small exemplary cross-sectional selection of recent (academic) discussions, movements, and organisations addressing various perspectives of diversity:

Black Life Matters (BLM, 2020), Diversity in an Anti-Immigration Era: Theories, Controversies, Principles (Parvin, 2020), PISA: How are School-Choice Policies Related to Social Diversity In Schools? (OECD - PISA, 2019), The Policy of STEM Diversity: Diversifying STEM Programs In Higher Education (Briggs, 2017), The Holy Grail of Gender Equality: Toward Gender Equality at Work (Benschop and van den Brink, 2018), Diversity In The Work–Life Interface (Beauregard et al., 2020)

Robinson (2017b, para. 8) extends this by claiming that *"the real principle that governs human ability is diversity. Diversity is what makes us human. Diversity of talents and backgrounds and experiences and disposition"*.

There exist a lot of academic work on the subjects within a diversity discussion in areas of social life, for instance, addressing issues in organisations, societies, and educational environments. Nevertheless, people worldwide do not understand, define, and interpret the term diversity in the same manner. In the field of organisational diversity research, Loden and Rosener (1990) introduced the Diversity Wheel as one approach to define diversity from several perspectives in a holistic way[49]. Other researchers, for example Gardenswartz and Rowe (2010), adopted models to other fields, such as education, to accommodate special settings.

The diversity wheel below classifies diversity into five rings, each conflating personal, organisational, and sociological and global attributes of potential diversity issues.

Figure 11 - Diversity Wheel adopted from Loden and Rosener (1990)

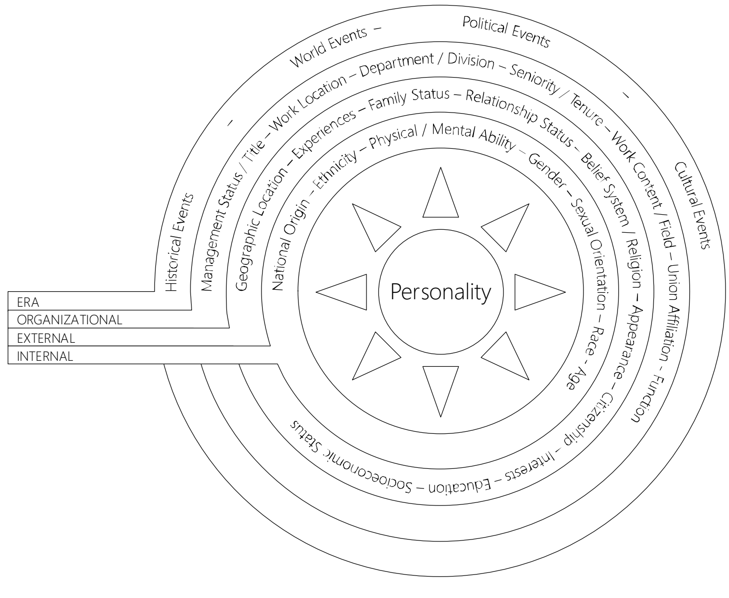
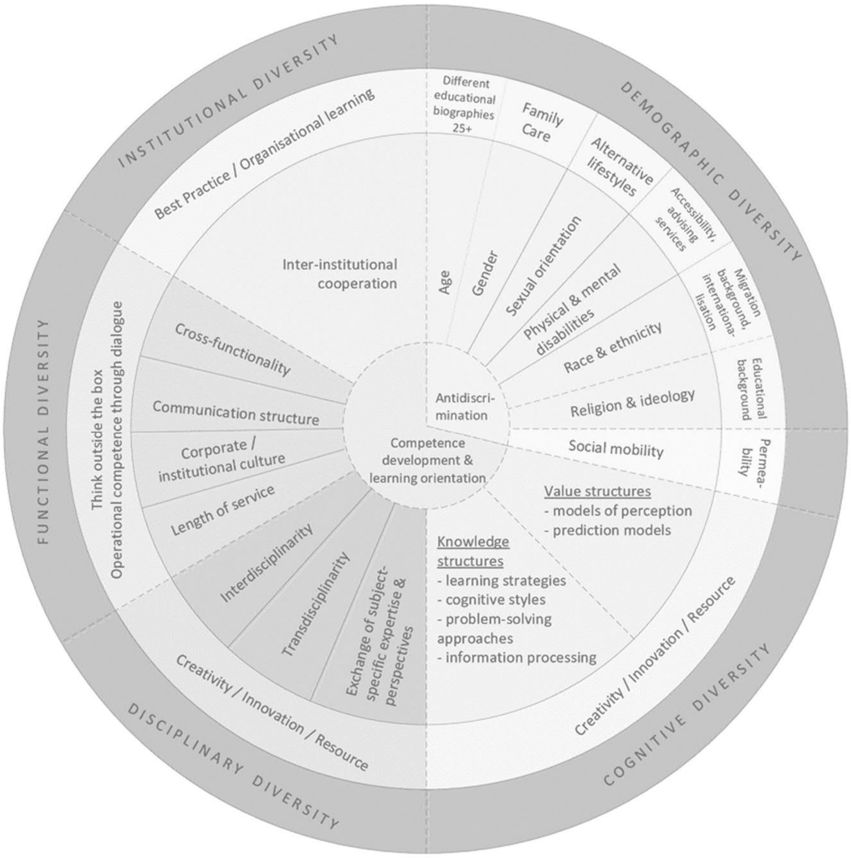


Figure 11 offers a useful basic model for describing and understanding especially more mature students, such as the MBA in this research. However, this model has its roots in diversity management, looking at workforce diversity aligned to map social characteristics of personal identity, without taking account of any specific HE demands and opportunities. Gaisch et al. (2019)

[49] The original version of Loden and Rosener's diversity wheel is of interest because it introduces an important attribute for students who interact with AR enabled learning and teaching approaches. It puts the position of the students in a time frame (era), which influences the access, literacy, importance, and acceptance of, for example, new technology in learning and teaching.

claims that this model furthermore neglected requirements of student population and challenges of managing increasingly diverse students. To reflect the specific challenges that diversity causes HE institutions Aichinger and Gaisch (2016) developed a model that is tailored for higher education awareness for diversity - the HEAD wheel model.

Figure 12 - HEAD diversity model for HE, adopted from Aichinger and Gaisch (2016)



The HEAD model includes learning and teaching relevant attributes, such as learning orientation and strategies, cognitive styles, dives educational biographies, while addressing teaching as well students' perspectives. The global knowledge economy revealed new challenges of unprecedented complexity, which has added further challenges and obstacles on HE. As discussed in section 2.4, the duress for innovation and a nation's educational level progressively became a synonym for economic growth and competitiveness, which led to a paradigm shift towards competence portfolios which go beyond pure factual knowledge and are increasingly impacting HE (Maassen and Stensaker, 2011; Braun et al., 2020; Gaebel et al., 2014; Boahene, 2006).

The ability to navigate in our globalized and digitalized world has become a critical asset and needs reflective thinkers. To address these purposes Gaisch (2019) argues for more holistic concepts, such as the HEAD wheel. This model has the potential to help subduing diversity-related biases and achieving more informed decisions about diversity-sensitive and contextualized situations cause, for instance, by the digitalisation of people's environments. Responding to the diverse needs of students to teach new skills can lead to students perceiving new learning contents as beneficial for their future careers (see 4.4.4 - Importance and Benefits for a Future Career).

Due to their maturity these students are potentially more diverse students because they collected experiences, impressions, learned new things, have different interests and expectation compared to many younger students. A further interesting feature of the above diversity wheels is the all-embracing Era circle, which influences almost every other diversity. This is particularly important for this study, which took place in a technology driven environment. The recent flux of digital technologies in people's life, such as AR in learning and teaching, is influencing students in many ways (Gaisch, 2019). Nevertheless, this alone cannot explain all perceptions of students towards AR in this study, rather important in which environment the students lived before re-entering an academic education. The era of their time formed their access, approach, and the use to technology. As mentioned previously in this study, several older students reported a less perceived confidence in dealing with learning technology[50], while younger students seem to see and approach technology in general as a naturalness[51].

The previous findings revealed some difference in gender regarding the perception of AR in learning and teaching, and at the level of their implementation of the digital story with AR. Additionally, the existence of often stereotyped gender role models in different eras might have influence on the perceptions of students towards AR. However, the gender differences in this study appear marginal, where the learning style findings presented some salient difference quantitatively and several student answers offered no clear tendency. Reason for this could be a perceived higher openness of female students discussing issues than male students. Several previous studies, for example, on gender differences found differences between male and female students in terms of learning preferences, styles and abilities, rather than one group is better than the other (Dünser et al., 2006; González-Gómez et al., 2012; Hyde, 2005; Vedadi et al., 2017). These differences, however, seem often to be influenced, inter alia, by personal interests and

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[50] See following section 4.4.1 -AR Fostered Technology-Self-Efficacy.

[51] This naturalness for younger students in this study manifest in the quantitative results of the novelty (familiarity) (Table 28) and the perceived easiness (Table 32) of AR in learning and teaching. The following chapter discusses both attributions.

social environment of the students. In relation to the studied students, previous research suggests that the type of MBA program (part-time, full-time, distance, etc.) influence how students perceive AR enabled learning and teaching approaches. These influences are associated with the challenges, boundaries, expectations, and perceived benefits that students are facing in a selected course (Arbaugh, 2000; DiBenedetto and Bembenutty, 2011; Simpson et al., 2005).

Some researchers claim that such views, projected onto learning environments and students, would be too narrow from a mode perspective. They argue that some attributes in the diversity wheel are pre-defined and usually not modifiable over time. Rather, there are attributes that might change, and some might supervene over time. One way to substantiate such change in a student is Dewey's pedagogic idea of scaffolding knowledge, where students gain knowledge through an iterative process based on previous experiences, their social context, and the time flux, which influences student perspectives (Dewey, 1938 Ch. 3 & 4)[52].

Subsequently, these iterative learning processes might gradually change influence and change student interests, expectations and aims. Thus, instead of subsuming all student attributes into the controversially discussed singularity of the term diversity, some research proposes heterogeneity as an additional classification of attributes (Happ et al., 2016; Markic and Abels, 2014; Shavit, Kolumbus and Ellison, 2016). This additional classification would measure up to mutable characteristics of the variety of students.

Previous research suggests furthermore that heterogeneity is fundamentally value-neutral while diversity connects to values, which it would allow to better understand student learning by separating diversity-based causalities and heterogeneity-based traits (Sliwka, 2010; Spelsberg, 2013). Unfortunately, in the educational field exist many publications that do not define their understanding of either term and often use both terms interchangeable, which makes a clear distinction more difficult (Markic and Abels, 2014).

Nevertheless, the previous discussion allows to assume that diversity and heterogeneity attributes do not form a strict dualism, rather inherit interdependently.

In this study measured, correlated, and analysed attributes were gender and age. As the previous findings show there are quantifiable differences in the responses of the students. Nevertheless,

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[52] The Diversity Wheel offers several heterogeneity attributes on different levels that might change due to learning, experience, and change in the social environment of a person: Family Status, Experiences, Seniority, Physical / Mental Abilities, etc.

the responses could not conclusively connect to the mentioned attributes. It rather seems that the students found it more important to emphasis their personal learning with AR is linked to, for example, the possibility to apply AR to their current work environment or future business opportunities[53]. Furthermore, the results did not confirm major diversity-based preferences in favour or against AR enabled learning but seem to be related to personal influences, such as previous experiences with AR learning and perceived technology-self-efficacy. As mentioned before, it cannot be excluded that, for instance, the gender and age of the students has not influenced previous experiences and perceived abilities. These are often determined by the cultural and sociological background, such as school forms (e.g. mixed, boys/girls only, technical, etc.), influences of family or friends, nowadays omnipresent social-media, to name a view course (Arbaugh, 2000; DiBenedetto and Bembenutty, 2011; Simpson et al., 2005).

The previous finding sections in this study also revealed that differences in opinions were not guaranteed to be steady, which limits the interference of the results from one question to the next. As reported, the answers of female students could be interpreted as an openness towards AR enabled learning as leaning and teaching method and enabler for future business opportunities. Answers of male students, however, allow to assume a more pragmatic view on AR enabled learning, which Yau and Cheng (2012) suggest might be explained through their often different and deeper previous technical knowledge and the approach to it.

Four main perspectives could be subsumed for the responses in this study and for the pedagogical space the AR intervention was placed: teaching, learning, expectations, and influences.

Teaching and learning are closely connected, and student perceptions and opinion are very diverse. There might be several reasons for this variety. As discussed earlier, one root cause might be the heterogenic personal interests and level of knowledge in the field the AR intervention covered in this study. Another reason might be the effects of previous styles of teaching and thus learning approaches the students were exposed in their educational career. Most of the students of this study grew up in a time, where teaching and learning concepts were in place that fostered, for instance, sequential rather than global (holistic) knowledge transfer and learning (Baker and Schmidt, 2014; Bova and Kroth, 2001; Ivanova and Ivanova, 2009; Schofield and Honoré, 2009).

[53] See section 4.4.4 - Importance and Benefits for a Future Career for examples of student responses and further discussion.

As the era saw the advent of new internet based and more sophisticated digital technology, school could not keep up or integrate them into the curriculum[54]. Previous research found a variety of factors that influenced the educational environment of the student at that era. Researchers repeatedly mentioned, for example, the impact of national as well educational policy on the level of technology in teaching and learning. This in turn is influenced, inter alia, by the perceptions of educational organisations of their role in education and the assessment of skills that are potentially needed for the future careers of the pupils and students, especially in terms of future technology (Barnett, 2000; Hayes, 2019, pp.1-12;64; 98ff; Hayes and Bartholomew, 2015; Niemi and Multisilta, 2016; Noweski et al., 2012; Redecker et al., 2010; Schrier, 2006; Singh and Singh, 2017).

Table 20 summarizes some examples of the heterogeneity of perceptions, opinions and experience towards AR enabled learning and teaching of the students in this study. However, this study intentionally avoids any assessment of the responses since the statements are a selection of personal perceptions, which might not reflect other student's opinions. The table rather categorises seemingly contrary perceptions.

Table 20 - Heterogeneity of Student Perceptions, Abstracted Responses

	Teaching	Learning
A	• Right pace • Something new • Supplements other methods • Right amount • Could be more	• Coherent • New perspectives • Trying something new • Enhancing technology self-efficacy • Holistic / project approach
B	• Too slow / fast • Too "techy" • Used to previous teaching styles • Too much content	• Too abstract • Serial learning favoured • Future use of AR

This study further found that their personal expectations and preferences besides the AR method that influenced the learning experiences with AR. One example emphasised by students are their different of ideas of approaches and expectations towards group work, which was necessary for the AR learning but influenced their overall learning experience. Some students required, for example, *"longer time for a project to submit as coursework"* ($p^{post}_{Q1(60)}$) more time for group work, while another student gave a hint for the previous and highlighting different perspectives of students by saying that there are *"larger group with conflicting ideas. Needed to manage our*

[54] See previous section 4.3.1 - Preferences for Balanced Mix of Learning and Teaching Methods that discussed the technology imprint of the different generations represented in this study.

differing ideas & expectations" ($p^{post}_{Q11(28)}$). The impressions of the AR storytelling workshop, on the other hand, reflected a rather positive attituded towards group work with no obvious tensions. Table 21 below supports quantitatively a bipolar preference for learning in a group versus learning alone, which shows the heterogeneity of student perceptions in this study.

Table 21 - Pre/Post LS Preferences for Study Mode (Q_{21}, Group vs. Alone)

	n_{pre}	n_{post}	Pre %	Post %	Δ	σ	M
∑	92	65	100.00%	100.00%			
a: … in a study group	43	32	46.74%	49.23%	2.49%	1.76%	47.98%
b: … alone	49	33	53.26%	50.77%	2.49%	1.76%	52.02%
σ			4.61%	1.09%			
M			50.00%	50.00%			

Additionally, despite the common nationality the heritage and thus the impact of the social environment of the students might have added an additional layer to the variety of the students in this study. Overall, it could be observed that the AR Storytelling intervention could address many of the diverse perceptions, expectations, and approaches of the MBA students in this study.

Nevertheless, the heterogeneity of student perception is the starting point for the particularly salient aspect of motivational effects of learning and teaching with AR on student perceptions. Motivational aspects of students in learning and teaching are surely items of special importance and the entire following section is devoted to four main themes:

How AR fostered technology-self-efficacy, why students perceive the active AR intervention as suitable TEL method, how the AR intervention impacted the students motivational, and how the students perceive the importance of benefits for their career.

4.4 Experiences of Learning with AR

This chapter addresses several motivational aspects related to learning with AR had on the students, which addresses the question how students perceive digital AR storytelling, as one technology enabled learning method, supports their learning process (RQ_1). In principle, AR enabled learning and teaching allows the digital expansion of learning and teaching materials or even entire rooms, and numerous empirical studies show that learning with AR can have a positive effect on the interest and motivation of students (Antonioli, Blake and Sparks, 2014; Bacca, Baldiris and Ramon Fabregat, 2018; Di Serio, Ibáñez and Kloos, 2013; Li et al., 2015).

Although many students have grown up as digital natives in a world full of technology, some of them are sometimes so-called digital immigrants, who often need to catch up in acquiring technical skills and knowledge, which is needed to handle new technology with self-confidence (Gui and Argentin, 2011; Prensky, 2001).

The first section of this chapter draws on the previous chapters and reports the finding that creating a digital story with AR can have a positive impact on the development of personal technology-self-efficacy.

First, a brief definition of motivation in TEL is needed. The literature offers many definitions, which try to broaden or narrow a definition of motivation in student learning. A concise definition is provided by Di Serio et al. (2013), who say that in an educational context, motivation is the wish of students to engage in a given learning and teaching environment. Furthermore, in a TEL environment the level of student motivation is influenced by the perceived suitability of an adopted technology from a student perspective.

The second section in this chapter refers to the suitability of the active creation of AR for personal learning, which was particularly emphasized and highly rated by the students. Technologies embedded in learning and teaching offer the possibility to create meaningful learning experiences. Educators and researchers point out the potential of technologies, including AR, to increase the motivation and commitment of learners, to respond to different learning styles and to improve learning outcomes. Thus, finding the appropriate technology that appeals to the majority of students is crucial to the motivational perception of learning technologies (Cabero and Barroso, 2016; Cabero-Almenara, Fernández-Batanero and Barroso-Osuna, 2019; Garzón and Acevedo, 2019; Pamungkas, Dirhami and Asfarian, 2018).

This study found that this perceived suitability is applicable for an AR intervention in a learning and teaching environment, since the students in this study appeared to be convinced of the suitability of actively creating a digital story as a TEL method.

The previous two sections in this chapter presented two motivational effects of AR enabled learning and teaching, and all provided certain intersections between each other. In the third section of this chapter, this study proposes four additional motivational conditions, which were distinctively suggesting an impact on the student motivation while creating a digital AR story. The found conditions of interest, which relate to Keller's proposed ARCS model of motivation, were the by the students reported novelty of the applied AR enabled learning method, the comprehended easiness of the applied AR learning method, the implied favourable interactivity through the creation of an AR story by the students, and the amplifying influence on the perceived engagement level of the students.

The final section draws on the motivational influence of the AR storytelling intervention on perceived value for the future career of the students in this study. This section is strongly related to the application of the newly learned skills mentioned before, such a storytelling process, creative ideation, and technical realization of the AR story. Based on student responses after the AR intervention this study suggests that the students saw different skills gained the AR intervention as very beneficial for their future careers.

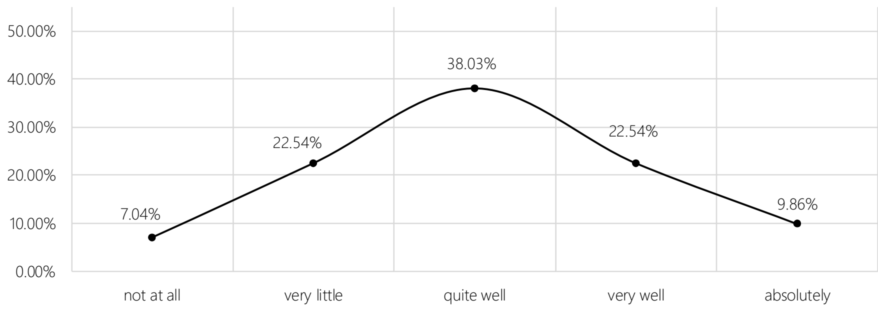
4.4.1 AR Fostered Technology-Self-Efficacy

The first research question of this study asked: *"Does creating an AR experience support the student's learning process and what features do they consider the most useful?"* (RQ_1) to discover factors in a broad field that contribute causally to potential benefits for personal learning of the students. Technology in a learning environment, more specifically in a sense of conquering potential insecurities when using technology, can be one factor that contributes to a favourable learning process (Juutinen, Huovinen and Yalaho, 2011).

The general term self-efficacy has been coined and defined by Banduara (1997, p.3) as *"perceived self-efficacy refers to beliefs in one's capabilities [...] required to produce given attainments"*. However, self-efficacy can be influenced by several factors, such as previous education, personal interests, or social impacts. Probably the most prominent factor is the successful mastery experience if related to technology enabled learning methods. This study utilised a sophisticated AR technology, which makes it necessary to make specifically use of the term technology-self-efficacy [TSE]. Related to this study students need to have or to build up self-confidence using the technology and might need to over-come a probably existing anxiety related to technology, so that they consider themselves to be able to manage the provided technology environment to accomplish the task of creating a digital story with AR (Bandura, 1997; Li, 2007; Selim, 2007; Stafford, 2005; van der Rhee et al., 2007). This study found that a digital AR storytelling intervention can help students to reinforce their level of technology-self-efficacy[55] while mastering new AR technology in their learning process.

With the post-intervention survey question Q_7 the study addressed the first research question RQ_1 directly by asking if the students think that the AR enabled learning experience supported their personal learning process in general. With 38.03% most of the students ($M=20.0\%$, $\sigma=12.3\%$) responded that the AR intervention supported their learning 'quite well' ($MD=2$, $IQR=2$), while the other student responses approximated a normal distribution (Figure 13). As the graph illustrate the responses for 'very little' and 'very well' were identical, whereas between the two extremes slightly more students (2.82%) perceived that the AR intervention 'absolutely' supported their learning process.

Figure 13 - Results: $Q7_{post}$ "Do you think the AR experience supported your personal learning process?"



Interesting here was the gender perspective, where the female students responded with a trend towards a very supporting characteristic of the AR intervention ($M=2$, $IQR=1$), while the male showed a neutral position with a wider spread of opinions ($M=2$, $IQR=2$) (Table 23).

Table 22 - $Q7_{post}$: "Do you think the AR experience supported your personal learning process?" by Gender

	not at all	very little	quite well	very well	absolutely
female	7.4%	18.5%	29.6%	37.0%	7.4%
male	6.8%	25.0%	43.2%	13.6%	11.4%

The AI sentiment analysis of the written responses for the same question Q_7 showed that the corresponding question was predominantly answered with positive comments (58.70%,

[55] Not to be confused with the general meaning of self-efficacy. TSE is a specific version of the broader and more general construct of self-efficacy and can be defined as the self-confidence in one's ability to successfully perform a technologically challenging new task or project (Bandura, 1997; McDonald and Siegall, 1992).

M=33.33%, σ=22.63%). However, the emotional content analysis revealed a mixed, predominantly positive result with a considerable proportion of responses expressing a perceived negative (sad) confidence or readiness towards learning technology (Table 23).

Table 23 - AI Sentiment and Emotion Analysis Results (Q_7)

Sentiment			Emotion		
n	46		n	46	
positive	27	58.70%	Excited	12	26.09%
neutral	12	26.09%	Happy	16	34.78%
negative	7	15.22%	Indifferent	11	23.91%
M		33.33%	Bored	1	2.17%
σ		22.63%	Sad	6	13.04%
			Angry	0	0.00%
			Fear	0	0.00%
			M		14.29%
			σ		14.19%

One older male student expressed his anxiety towards technology with a short and strong statement *"I struggle with technology!"* ($p^{post}_{Q7(49)}$). A longitudinal change revealed the retrospective statement of a female student who explained *"I have a mental barrier towards technology innovation and IT as I feel I am very weak! I'm actually not"* ($p^{post}_{Q7(53)}$), which implied a stronger anxiety toward technology at the beginning but also that the AR invention had the potential to strengthen her confidence in mastering technology and thus suggesting to support her learning process. The same student later underlined this newly gained TSE of mastering the technology with the slogan *"I can do it!"* ($p^{post}_{Q10(53)}$). Another question (Q_{10}) that offered students responses that contributed to the first research question revealed a changing perception of TSE. For example, a male student replied on the question what he learned most during the AR intervention was, *"that I can do it and shouldn't be scared to try new technology (...)"* ($p^{post}_{Q10(63)}$), supporting a relief effect of the AR intervention in term of access to technology.

A more sceptical view addressed the wariness towards the novelty of AR technology as learning method by explaining that *"AR is a new concept to me - I need more time to get to grips with it [...]"* and *"[...] then I can reassess it"* ($p^{post}_{Q7(47)}$), suggesting the revaluation of the potential supported of her learning process through AR enabled learning.

Several previous studies investigated negative attitudes of students towards learning with technology. Looking at an e-Learning environment Juutinen et al. (2011) suggest that a fear towards technology in general and in learning and teaching context is rooted in past experiences of students with technology and computing. Additionally, they found the less digital literate the more negative perceptions of the students are, which could also be applied to further aspects of their life. In a comparative study Da Silva Santana and Leeson (2015) found that the duration and starting point in life of using technology has a decisive influence on perceptions of people towards technology, especially the more mature people are. Regarding AR enabled learning environments Chang et al. (2011) highlighted that familiarity with AR technology influences the level of self-efficacy in applying AR, which finds support by Huang et al. (2020) for an articulated level of general technology-self-efficacy when student are confronted with computer technology. Similar to this study Fauzi et al. (2019) reported view students that were sceptical towards AR enabled learning, nevertheless, the majority were attracted by the AR and was ready to confront themselves with this new technology. Several recent examples of AR enabled learning and teaching approaches suggest that AR as the potential to promote key and transversal competencies in students, such as digital skills and the approach to new technologies, which then can foster the perceived level of technology-self-efficacy of students (Astuti et al., 2020; Huang et al., 2020; Meletiou-Mavrotheris, Charalambous and Mavrou, 2020).

More protruding, however, were the frequent questions during the interventions about possible effects of making mistakes and uncertainties with the technology used, both the offered AR platform and the own computer systems. One group showed this insecurity with technology repeatedly, claiming not being good in dealing with computers and the software, and feared after a mishap to fade the whole project and not to present a finished product. However, the team took up the challenge together, overcame this blockage, and proudly to presented one of the best perceived digital stories.

However, from a teacher perspective and based on the frequent requests for support during the AR storytelling intervention left the impression that a larger, but distributed over all age range and gender, number of students did not have the level of technology-self-efficacy that was expected by the researcher before this study. There are recent studies that confirm the perception deficits in digital skills among students in HE inter-culturally, which in turn could explain a perceived lower level of technology-self-efficacy and potential abilities (Gómez-Trigueros, Ruiz-Bañuls and Ortega-Sánchez, 2019; Jaseena and Moosa, 2020; Khasanah and Rahmawati, 2019). The experiences from this study show that an enhanced pedagogical approach of the teacher through additional enactive support and feedback can foster the perceived self-efficacy and help the students to overcome such obstacles (Hattie, Hodis and Kang, 2020; Zimmerman, 2000).

In quantitative terms, the students' opinion of whether learning with AR technology supports their learning processes indicated a balanced, normally distributed picture. Cumulated, the trend is slightly more affirmative. In terms of gender, female students showed a clearer positive influence of the AR enabled learning method on the learning process than male students. Yet, the text responses of the students were more revealing, indicating that some of them pronounced a low level of TSE at the beginning of the intervention. However, the expressed student experiences also indicate that AR-enabled learning has the potential to reduce fear of contact with AR technology and thus strengthen the personal TSE.

The next section covers the theme that actively creating a digital AR story contributed positively to student motivation since the AR intervention was perceived as a suitable method in TEL by the students.

4.4.2 Active AR Creation as Suitable Method in TEL

General principles that have the potential to foster student motivation were summarized by Fry et al. (2009, p.35 pp). They state that personally meaningful and suitable content and materials in connection with stimulating and engaging tasks and activities contribute to an increasing interest and motivation of students. For technical environment, this perceived suitability is often linked to user acceptance, which usually address the perceived degree of access to a technology and the appropriateness to solve or assist certain tasks. This perceived suitability was another perspective from which this study inquired AR enabled learning. The second research question asked, *"How do students perceive AR as a technology enabled learning method?"* (RQ_2), which the post-intervention survey directly addressed to the students. The following results derived from a scaled question in connection with the possibility for open responses, where two main characteristics of AR were important to the students.

As Table 24 suggests, the majority of participants tended to rate AR positively with 37.50% as 'very well' and 18.06% as 'absolutely suitable' ($M=20.00\%$, $\sigma=14.65\%$), while none of the students rated the AR enabled intervention as not at all suitable as a TEL method. Interestingly, the female sample saw the suitability of AR more positively than the male sample. For example, the rating for very well suitable was significantly higher ($Q1^{post}_{very\ well\ (f)} = 46.43\%$; $Q1^{post}_{very\ well(m)} = 31.82\%$) and for very little suitability less than half of the male ratings ($Q1^{post}_{very\ little\ (f)} = 7.14\%$; $Q1^{post}_{very\ little(m)} = 18.18\%$).

Table 24 - $Q1_{post}$: AR Perceived as Suitable TEL Method by Gender

	not at all₀	very little₁	quite well₂	very well₃	Absolutely₄	M	σ	MD	IQR
female	0.00%	7.14%	25.00%	46.43%	21.43%	20.00%	17.96%	3.0	1.0
male	0.00%	18.18%	34.09%	31.82%	15.91%	20.00%	13.77%	2.5	1.0

The study consolidated the qualitative responses for these perceptions into three main themes. These themes derived from student perceptions that AR is a suitable TEL method because it offered impulses for personal learning experience, it had impact on the student's engagement level, and it was a novel technology. In relation to these categories the interactive character of the AR intervention appeared more frequently in the student responses, while using different synonym descriptions for interactivity of the AR intervention. The learning impulses from the perceived interactivity were expressed by students stating that AR *"gives learners different method to learn"* in the way that *"you can make the learning more interactive for those who learn that way"* ($p^{post}_{Q1(31)}$) because *"it combines images with plain written facts, creating an interesting visual learning tool"* ($p^{post}_{Q1(32)}$). These exemplary expression of student perceptions recursively support the findings from previous sections, where students attested a strong favour for active and visual learning, but also their demand for a mix of traditional learning and teaching methods. Furthermore, the alternative learning and teaching approach made AR a useful method for students who perceived it as *"an interesting format to allow you to experience the content in a different way..."* ($p^{post}_{Q1(13)}$) and because AR *"is interesting, easy to use, and AR create[s] a multi-faceted experience"* ($p^{post}_{Q1(68)}$). One student highlighted the suitability of AR as TEL methods by claiming AR is a *"future method to help with learnings"* ($p^{post}_{Q1(37)}$).

The Spatial Contiguity Effect in Mayer's multimedia theory claims that students learn better if different presentation methods are closely together offered, whereas the Temporal Contiguity Effect fosters student learning when presented timely (Mayer and Moreno, 2003). These are characteristics of digital storytelling with AR as in this study, which went even further to set the students in the situation of prosuming students who create their own interactive learning content pro-actively. Compared to pre-created AR learning interventions, which puts the student into an interactive consuming learner, digital storytelling with AR seems to enhance all necessary characteristics of a set of learning and teaching methods to address the diverse expectations of students towards more interactive learning experiences (Lynch, 2007; Radu, 2014; Wu et al., 2013).

Regards to a perceived suitability of AR in learning and teaching environments, unfortunately, most studies reflected on suitability more from an organisational and teacher perspective by highlighting specific fields of learning, content delivery capabilities, integration into curricula, costs, and improvement of outcomes (Dalim et al., 2017; Diegmann et al., 2015; Kurilovas, Kurilova and Dvareckiene, 2017; Radu, 2014; Radu et al., 2010).

There are view studies that rather look at AR from a student perspective that confirm the positive effects of AR on student perception of suitability and interactivity in learning with TEL. For instance, Karagozlu and Ozdamli (2017) identified eight themes that were important to students, who highlighted their importance of the perceived learning support of AR enabled learning. Similarly, in another study the student found AR more interesting to learn with and attested that AR can attract students as a new learning tool (Majid, Mohammed and Sulaiman, 2015). Interpreted from a more general learning and teaching perspective different researcher suggest that a positive stance towards learning is promoted by involving students actively in learning (Bransford, Brown and Cocking, 2000, p.206 ff.; Driscoll, 2002). This is often referred as Active Learning where students are involved in planning and creating their learning that results regularly in positive learning attitudes and outcomes (Benek-Rivera and Mathews, 2004; Bonwell and Eison, 1991; Jin, Wen and Gough, 2010; Kubota et al., 2017; Watkins, 2005).

Further support came from the AI based opinion mining of question $Q_{post1,}$ reporting a substantial positive sentiment that classified 69.49% of the student responses as positive perceptions, which suggested that a high number of students found the AR intervention as suitable as a TEL method or had a positive opinion of creating a digital AR story as learning method. This AI sentiment interpretation was possibly driven by the frequent occurrence of words that underline the impact of AR enabled TEL on the engagement of the students. Students expressed concisely a positive attitude towards AR as learning method as they perceived the learning with AR as *"interacting, engaging, fun media"* ($p^{post}_{Q1(30)}$) and it was *"yes, very interesting and keeps it interesting"* ($p^{post}_{Q1(64)}$). Two other students provided attempts to explain the suitability of AR enabled learning and teaching from their perspective by positing that *"[AR] seems to engage the student much more thoroughly"* ($p^{post}_{Q1(70)}$) through its *"...visual memory plus impact - more kinaesthetic impact"* ($p^{post}_{Q1(14)}$). It seemed that the students had heterogenous perceptions of favourable characteristics that made AR enabled learning suitable for them. Nevertheless, the study found three subthemes that seemed to be particularly important to the students: new technology, mastering digital skills, engaging and interactive approach.

The following statements were representative for the indicated subthemes. Some students related their perception of the suitability of AR as TEL method to the technology by noting, for example, that *"technology is the core of Augmented Reality therefore making it very well suited"* ($p^{post}_{Q1(3)}$) and that the intervention enabled them *"learning new technology"* ($p^{post}_{Q1(54)}$). Like other students, one participant connected a potential suitability of AR as learning method to successful mastering required digital skills, by indicating that *"once familiar with this technique it could be good"* ($p^{post}_{Q1(65)}$). Statements like the previous were consistent with the previously mentioned support some students needed before they could make use of the full potentials of the AR learning environment. Overall, the suitability of AR as TEL methods had been positively received, emphasised by one female student summarising this perception trend by claiming that AR is *"engaging, interactive, suited to the digital age we're in"* ($p^{post}_{Q1(1)}$).

This study showed indications that many students perceived the creation of digital AR story as a suitable method in TEL and digital Zeitgeist. The students composed their perception of suitability with set of characteristics, while combining the aspect of interactivity with a different approach to learning and the perceived engaging character of creating and experiencing a digital AR story. Nevertheless, there were students who expressed the need that a set of digital skills was required to fully become suitable for learning with technology.

The previously discussed subthemes play a decisively role in influencing the motivation of student in learning and teaching environments. The next section reports on four major motivational impacts of creating a digital AR story. In this study the student motivation was influenced by the positively perceived easiness of the storytelling process with AR, the high level of interactivity that the intervention demanded, and how the AR storytelling fostered the student engagement. Nevertheless, the next section starts with looking at a more intermediate effect on motivation, which is the novelty of AR in learning and teaching for many students.

4.4.3 Motivational Impact of Creating a Digital AR Story

Vallerand et al. (1992) claim that one of the most important elements for learning and teaching environments is motivation. Motivation of learners depend much on the selected medium, which was in this study divided in a passive consuming introduction phase and an interactive prosumer intervention where the students created their own digital AR story. The medium is not the sole condition that relates to an assumed level of student motivation but supplemented by performance, persistence, learning and curiosity. As introduced earlier[56], Keller's ARCS model for motivation in educational settings describes those motivational conditions in a very similar manner and has been applied to several TEL based studies (Keller, 1999).

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[56] See chapter 2.3.2 - ARCS Model for Motivational Design.

This study addressed motivational conditions in relation to AR enabled learning and teaching with the research questions RQ_1 and RQ_2 (see section 1.5). Based on the ARCS model four motivational conditions were suggested for the analysis of the motivational perceptions of the participating students towards the AR enabled learning intervention. Some motivational conditions have already been presented in previous findings. Additionally, this the study analysed scaled question from pre-and post-intervention surveys, as well, closed question from post AR intervention survey that can further supplement ARCS conditions, which are suggested in Table 25:

Table 25 - Motivational Conditions adopted to ARCS Model

	Attention	Relevance	Confidence	Satisfaction
In this section	➢ Novelty			➢ Easiness ➢ Level of Interactivity ➢ Perceived Engagement
Covered		Practical benefits: Future business applications Personal learning → 4.4.4	Technology Self-Efficacy → 4.4.1	Perceived suitability → 4.4.2

4.4.3.1 Novelty

The results of this study seem to support the definition of intrinsic motivation by Ryan and Deci (2000a), in which people tend to go in search of novelty and challenges to expand, explore and learn. This effect is widely known as the Hawthorne-Effect (Schulmeister, 1995, p.95 pp.) In particular, the novelty of AR Technology in the learning environment was highlighted by students as a very motivating factor. Nevertheless, the motivational condition of novelty is usually influenced by the previous knowledge of learners. The next section reports on the level of familiarity of AR and experiences with AR in learning environments of the students before the AR intervention, and how the students articulated the novelty of digital AR storytelling a motivational factor.

To get an indication of the novelty rate of AR in learning and teaching environments the students were asked prior the AR intervention to rate two questions.

The first question asked the students how familiar they were with the term AR prior the AR enabled intervention. As Table 26 suggests, the majority of students reported a limited familiarity with AR and the largest group, with 32%, answered to be slightly familiar with the general term of AR ($M=20.0\%$, $\sigma=12.1\%$).

Table 26 - $Q1_{pre}$: Familiarity with AR

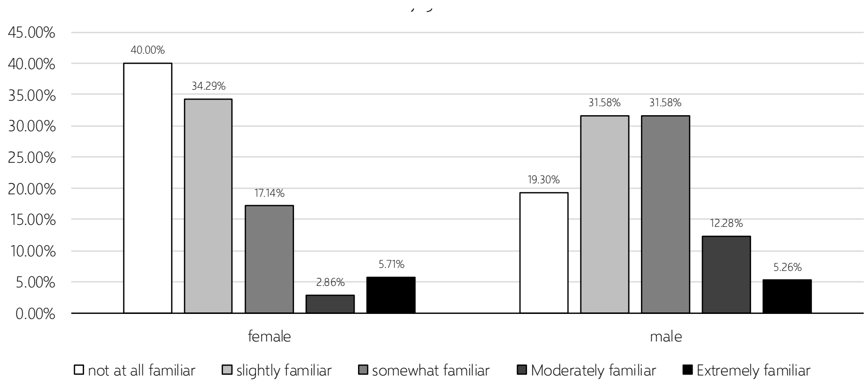
not at all familiar	*slightly familiar*	*somewhat familiar*	*Moderately familiar*	*Extremely familiar*	M	σ
27.2%	32.6%	26.1%	8.7%	5.4%	20.0%	12.1%

When considering the gender, the study found that the female students with 40% reported the largest number of students being not at all familiar with AR prior the intervention (Table 27), which underlined the overall unfamiliarity of AR in this group (M=20.00%, σ=16.66%; MD=1.0, IQR=1.5), nevertheless with a wider spread. The male sample showed a more balanced familiarity that grouped around being somewhat familiar with AR (M=20.00%, σ=11.68%; MD=1.0, IQR=1.0).

Table 27 - $Q1_{pre}$: Familiarity with AR by Gender

	not at all familiar	slightly familiar	somewhat familiar	Moderately familiar	Extremely familiar	M	σ	MD	IQR
female	40.00%	34.29%	17.14%	2.86%	5.71%	20.00%	16.66%	1.0	1.5
male	19.30%	31.58%	31.58%	12.28%	5.26%	20.00%	11.68%	1.0	1.0

Figure 14 - $Q1_{pre}$: Familiarity with AR by Gender

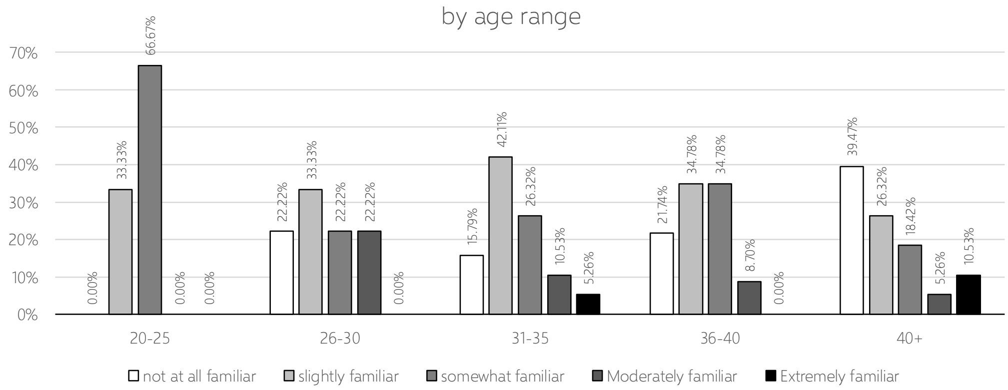


As Table 28 reveals, the age ranges reported a mainly twofold picture. The 26-30 and 36-40 reported a balanced familiarity similar to the male sample, while the 31-35 and especially the 40+ old students (IQR=2.0) followed the tendency of unfamiliarity of the female sample (compare above and Figure 15). Interestingly, at the same time the 40+ old students reported the highest familiarity with AR before the intervention (Table 28).

Table 28 - Q1$_{pre}$: Familiarity with AR by Age Range

	not at all familiar	slightly familiar	somewhat familiar	Moderately familiar	Extremely familiar	M	σ	MD	IQR
20-25	0.00%	33.33%	66.67%	0.00%	0.00%	25.0%	31.9%	2.0	0.5
26-30	22.22%	33.33%	22.22%	22.22%	0.00%	19.4%	14.0%	1.0	1.0
31-35	15.79%	42.11%	26.32%	10.53%	5.26%	21.1%	16.6%	1.0	1.0
36-40	21.74%	34.78%	34.78%	8.70%	0.00%	19.6%	17.9%	1.0	1.0
40+	39.47%	26.32%	18.42%	5.26%	10.53%	15.1%	9.2%	1.0	2.0

Figure 15 - Q1$_{pre}$: Familiarity with AR by Age Range



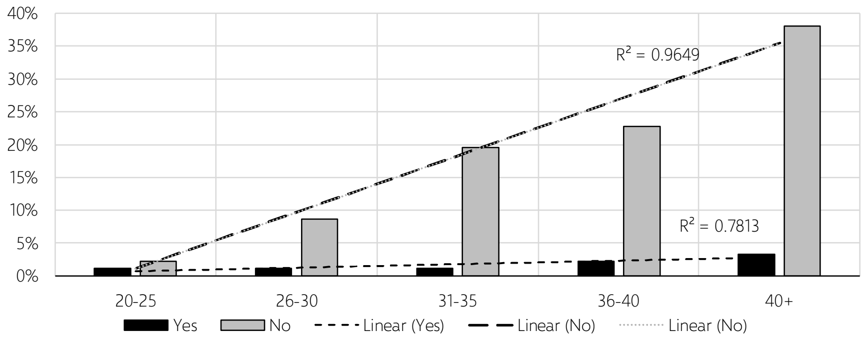
Related to the previous, a second question asked specifically if the students made already experiences with AR in a learning and teaching environment. The results show a clear majority of 91.30% did not made any previous experience.

Interesting were the results by age range. The juxtaposition of Table 29 and Figure 16 suggests, that the responses of the students for both answers were very linear distributed ($R^2_{yes}=0.964$; $R^2_{no}=0.781$) in direction towards the 40+ old students, of which 38.04% negated prior AR experiences in learning and teaching environments (M=18.26%, σ=13.82%). These results also showed that the 40+ old students reported the highest rates for having and not having made experiences with AR in learning prior the AR intervention.

Table 29 - Q2$_{pre}$: Prior AR Experience in Learning & Teaching

	Yes	No
20-25	1.09%	2.17%
26-30	1.09%	8.70%
31-35	1.09%	19.57%
36-40	2.17%	22.83%
40+	3.26%	38.04%
M	1.74%	18.26%
σ	0.97%	13.82%

Figure 16 - $Q2_{pre}$: Prior AR Experience in Learning & Teaching by Age Range



The reported deficits of making experiences with AR in general and in an learning environment could imply that the creation of a digital AR story constituted a novelty in their learning experience. This study found two main subjects on which students commented their perception of novelty. The first related to the perceived future career benefits and potential opportunities to apply what was learned during the AR intervention, which was presented in section 4.4.4, but students were additionally highlighting the novelty that sparked these perceptions. One student commented that creating a digital AR story was *"something new, able to adopt as new way of presenting informative engaging stories"* ($p^{post}_{Q7(1)}$), while another student saw the AR intervention as a new opportunity for a more specific applications and perceived AR storytelling as *"there's a new way for storytelling which I've found really interesting and very useful for business purposes at all levels, from reports presentation to training"* ($p^{post}_{Q10(4)}$). Other student responses implied that the novelty of AR enabled learning allowed them to gain new knowledge, stating *"I had little or no knowledge about the possibilities or practicalities of AR before today's session"* ($p^{post}_{Q10(70)}$). In connection with the novelty condition two students quoted briefly on the new competencies they gained, suggesting that they *"learnt something new!"* ($p^{post}_{Q14(37)}$) and the digital AR intervention was offering *"something new, new skills"* ($p^{post}_{Q10(1)}$).

The majority of students in this study reported a low familiarity with AR in general, while female students showed distinctively lower degree of familiarity with AR. With 91.30% the students clearly showed a deficit with experiences in a learning context prior the AR intervention. Interestingly, this deficit was linearly distributed towards the 40+ students, who made the least prior experiences with AR in TEL. Based on this missing prior experience it could be constituted that AR enabled learning and teaching was a novelty for the student learning experience. This was supported by student responses who saw potential benefits in this novel AR enabled learning for their personal future, but also the students highlighted the novelty factor of AR as a spark for a higher perceived motivation in their learning.

The following section will draw on a motivational condition that is especially important when confronting people with technology, which is the perceived easiness of access and handling a new technology. Easiness of a new technology in a learning environment contributes as a factor to a potential success of the students, which on its part impact the student motivation.

4.4.3.2 Ease

In addition to a motivational effect of potentially new learning and teaching technology the combination of perceived and experienced easiness of a chosen technology contributes to the learning motivation of students. With regard to the ARCS model satisfaction is conditioned by the student perception of likelihood for succeeding in a task such as the creation of digital story with AR (Bacca, Baldiris and Ramon Fabregat, 2018). In consequence, a high level of perceived easiness might foster satisfaction through accomplishing a task, which can positively impact student learning motivation, while the opposite might impact the learning motivation of students adversely. This study applied AR to a digital storytelling as TEL method and according to Sun et al. (2008) the perceived easiness of the chosen AR environment contributes substantially to the overall motivational level of learners.

The perceived easiness of creating a digital story with AR can contribute to a perception of the motivational impact of AR on student motivation. Hence, with the dedicated question $Q3_{post}$ the study asked the students after the AR intervention for their perception on how easy the AR tool was to use. The median response was a neutral perception (MD=2.0, IQR=1.0) of easiness of the AR tool but as table suggest the cumulated majority found the AR tool easy and very to use (Table 30).

Table 30 - $Q3_{post}$: Easiness of the AR tool

very difficult	difficult	neutral	easy	very easy	M	σ	MD	IQR
5.6%	15.5%	38.0%	31.0%	9.9%	20.0%	13.9%	2.0	1.0

The results in Table 31 showed that within the gender the female students had a very neutral perception (MD=2.0, IQR=1.3) of easiness of the AR tool, while more male students were tending to find the AR tool easy to use (MD=2.5, IQR=1.0).

Table 31 - $Q3_{post}$: Easiness of the AR Tool by Gender

	very difficult	difficult	neutral	easy	very easy	M	σ	MD	IQR
female	7.4%	22.2%	44.4%	22.2%	3.7%	20.0%	16.06%	2.0	1.3
male	4.5%	11.4%	34.1%	36.4%	13.6%	20.0%	14.32	2.5	1.0

From an age perspective the results showed two main straits. The younger students, age 25 to 35, found the AR tool easy to use (MD=3.0, IQR=1.0), while the older students, 36 to 40+, had a neutral option (MD=2.0, IQR=1) of the easiness of the AR tool (Table 32).

Table 32 - $Q3_{post}$: Ease of Use of the AR Tool by Age Range (Combined View)

	Very Difficult	Difficult	Neutral	Easy	Very Easy	Median	IQR
20-25	0.0%	0.0%	33.3%	33.3%	33.3%	3.0	1.0
26-30	0.0%	14.3%	28.6%	42.9%	14.3%	3.0	1.0
31-35	0.0%	6.7%	33.3%	46.7%	13.3%	3.0	1.0
36-40	10.5%	15.8%	36.8%	31.6%	5.3%	2.0	1.0
40+	7.4%	22.2%	44.4%	18.5%	7.4%	2.0	1.0

Additionally, the study asked the students what they think could be improved in future AR enabled interventions. Repeatedly, the students mentioned that a perceived easiness was important for their motivation to learn with AR. Students suggested that AR needs to offer an easy access to enable them to engage with the AR intervention. For example, one student supported a general requirement of *"ease of use"* ($p^{post}_{Q13(53)}$) of the AR tool, which another student extended that it needs to be in the way that *"[the used AR tool] has to be easy to engage with"* ($p^{post}_{Q13(4)}$). A second characteristic mentioned by students were technical related requests stated in relation where students tried to transfer their ideas into the AR tool. Students expressed that the AR environment needs to be *"easier to use - from development angle"* ($p^{post}_{Q13(26)}$), and more specific highlighting detailed functionality such as that *"[it needs to be] easier to do effects on a page"* ($p^{post}_{Q13(31)}$) and that *"the AR website to have an easier way to import photos and videos [...]"* ($p^{post}_{Q13(8)}$).

As previous findings highlighted, students reported different previous knowledge on AR in general or in a learning environment and showed various learning style traits. These differences and personal viewpoints were also reflected in opposite opinions on the easiness of the AR intervention that again expressed their motivational levels. Representatively, the following table (Table 33) shows four examples for opposite perceptions of some students:

Table 33 - Perceptions of Easiness of the AR intervention

Negative	Positive
That this technology exists, and it is a growing industry with many applications but is extremely difficult to use & navigate in such a short time - very frustrating. ($p^{post}_{Q10(65)}$)	It's interesting, easy to use, and AR create a multi-faceted experience. ($p^{post}_{Q1(68)}$)
Using the technology - complicated, long, poorly explained. ($p^{post}_{Q11(19)}$)	It was a great to learn, fun and well explained. ($p^{post}_{Q13(8)}$)

The results show balanced perception of easiness of the AR technology. In terms of gender, the male students found the AR environment slightly easier to use. This might be related to the experiences, discussed in section 4.4.3.1 on the effects of novelty of AR on student motivation, that male students already made experience with AR prior the digital storytelling with AR intervention. In relation to general learning with technology many studies found students reporting that knowing certain basic concept of technology prior a task supports and engages them to achieve a set goal and thus can help them to influence learning motivation positively (Al Kurdi, Alshurideh and Salloum, 2020; Alexander, 2001; Fredericksen et al., 2019; Joncour, Sinclair and Bailey, 1994; Shih, Muñoz and Sánchez, 2006).

For the age ranges this study can conclude that the older the student are the less comfortable they were with the AR environment. This goes in line with the discussions and results in chapter 4.2, which inter alia compared generational differences of approaches and habits towards technology of participants belonging to the Generation-X to Generation-Z. In short, the student previous experiences with technology seem to influence the perceived easiness of accomplishing the task of creating a digital story with AR, which can impact the level of learning motivation of the students.

Interestingly, the female students were more balanced in their perception of easiness of the AR environment, however, literature on gender differences specifically on AR enabled learning does not offer a clear explanation for this phenomenon (Cheng, 2018; Dünser et al., 2006; Vedadi et al., 2017). Taking in account that the vast majority of the students in this study have mostly a non-technical background might allow to assume a diverse level of previous knowledge of technology and technology-self-efficacy[57], which in turn this study could confirm with the reported levels of

[57] See discussion in chapter 4.4.1 - AR Fostered Technology-Self-Efficacy.

previous experience with AR enabled learning and teaching methods[58]. However, in relation to general learning with technology Yau and Cheng (2012) summarised that female students tend to have less positive attitudes towards technology enabled learning and teaching methods, which supports the results of this study. According to Gonzales (2012), this might be influenced by a significant different prioritisation of aspects of female students regards learning and teaching with technology.

The next section draws on the fundamental interactive characteristic of AR and how it can impact the learning motivation of students.

4.4.3.3 Interactivity

Interactivity is a fundamental aspect of AR in general. In this study two different modes of interactivity were present because the student created in an iterative and interactive process a digital story with AR, which again lead to an interactive interaction by the student exploring the created AR stories. Several researchers concluded that interactivity in learning and teaching influences the degree of satisfaction and thus the motivational levels of students (Cheng, 2018; Di Serio, Ibáñez and Kloos, 2013; Rodgers and Withrow-Thorton, 2005). Due to the interactive nature of AR recent research could endorse this positive effect student learning motivation, specifically for learning and teaching with AR enabled methods (Akçayır and Akçayır, 2017; Hsu, Lin and Yang, 2017; Khan, Johnston and Ophoff, 2019; Liu et al., 2017; Santos et al., 2016; Shiue et al., 2019).

This study found within three open questions about 13% of the answers suggested that interactivity was an important motivational condition for the students (Table 34).

Table 34 - Occurrence of Perception of Interactivity

	Q1	Q10	Q12	M
Occurrence of "interactive" in % of answers	15.25%	9.76%	14.89%	13.30%

[58] See appendix - 7.5.5 - Previous Experience with AR in Learning

Interestingly, students related the interactive creation approach of the AR intervention mostly to their learning experience. The following table presents examples[59] where students related terms of interactivity to creation of an AR story in a learning context:

Table 35 - Example of Perception of Interactivity in Learning with AR

Responses	Participant	Post-intervention survey Question
Engaging, interactive, suited to the digital age we're in.	1	Q1: Do you perceive AR as suitable as a technology enabled learning method
It makes the learning content more interactive and visual, which helps to better understand and memorise the concepts.	9	
Everyone remembers interactive learning above reading in my opinion.	10	
Interacting, engaging, fun media.	30	
You can make the learning more interactive for those who learn that way.	31	
Allows users an interactive experience using lots of different types of material which they can use.	41	
The interactivity promotes learning.	49	
A different dimension of learning, where you can make perceived dull content very interactive.	32	Q10: What is the most important thing you learned personally?
A more interactive way to learn. Linking story boards	55	
That I can do it and shouldn't be scared to try new technology. I would enjoy interactive learning as I like pictures and sound together.	63	
useful & interactive	4	Q12: Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?
Easier to remember, interactive, catches the audience's attention much better than traditional learning methods.	9	
Could make learning more interactive.	23	
Interactive and visually engaging as a teaching & learning tool.	40	
Interactive learning is better than traditional learning!	49	
I enjoyed interacting with it.	61	
The interaction makes it more engaging.	71	

Only one participant reported that the interactive creation (prosumer) approach did not suit the personal preferences by explaining that "*ready-made AR's were useful to engage with but didn't get much out of actually making one.*" ($p^{post}_{Q7(14)}$).

The study could illustrate that the interactive attributes of the creating a digital story with AR positively impacted the learning motivation of many participating students. The combination of Consuming and Prosuming aspects[60] of interactivity of the creation process of the digital AR story might have fostered these effects. However, further research might be interesting to explore the prosuming aspect of the interactive creation of AR environment by students. The next section connects closely to the motivational effects of interactive creation process with AR by looking at the motivational impacts of digital AR storytelling on the perceived engagement from a student perspective.

[59] Some of the examples in the table were already cited in a previous section but have been considered to offer a more complete overview of the students' perceptions towards "interactivity" in learning and teaching.

[60] See chapter 2.3.4 - Students as Consumer and Prosumer of TEL Environments.

4.4.3.4 Perceived Engagement

As one of several functions, new media, such as AR in Learning, are attributed the function of motivating learners (Schulmeister, 1995, pp.401, 404). Thus, learning technologies should, for example, encourage learners to deal with a subject area of their own interest with the aim of creating intrinsic motivation in the students. Various researchers offer research results on motivational aspects of multimedia systems, including the use of interactive computer games and Augmented Reality in learning environments (Bicen and Bal, 2016; Eskisehir and Sural, 2018; Gopalan, Zulkifli and Bakar, 2016). The studies found that attractiveness is stimulated by the creation of an emotional context and the arousal of curiosity for a novel technology, which has been discussed in the sections before. Augmented Reality allows to present known learning contents in a new form and new ways. Images can become animations, 2D transposes into 3D, static text content, as in the AR intervention of this study, can turn into an interactive experience. The creation of own AR content and the natural interaction with this content has the potential to increase the motivation of students and thus could have a positive impact on educational success of the students (Deimann, 2002; Di Serio, Ibáñez and Kloos, 2013; Radu et al., 2010).

Supporting the previously said, this study found that the creation of a digital AR story indicates a higher importance for the student in terms of their perceived level of engagement, which contributes to the satisfaction condition of Keller's ARCS model of motivation.

Due to their relation to perceptions of engagement and satisfaction the question Q_1 [61] and Q_{12} [62] of the post-intervention survey reported the most occurrences of identifiable synonyms for engagement or satisfaction expressions in this study. The analysis found these direct mentioning in question Q_1 in 22.03% and in question Q_{12} in 14.89% of the student answers[63]. The results for an AI analysis of the responses on emotional levels, which can be seen as degrees of satisfaction, suggested an even higher engaging and satisfactory characteristics of the AR enabled intervention.

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[61] Q_1: "Do you perceive AR as suitable as a technology enabled learning method?"

[62] Q_{12}: " Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?"

[63] see appendix 7.7.2 - Question 1: Response, Tagging, and AI Text Analysis & 7.7.3 - Question 12: Response, Tagging, and AI Text Analysis.

Asked for the suitability of AR in TEL in question Q_1 the corresponding AI analysis reported that 49.15% of the student answers indicated excitement and 30.51% being happy with the suitability of AR for TEL (Table 36). Together, these two highest ratings (M=14.29%, σ=18.49%) made the majority of all participant answers for this question.

Table 36 - AI Emotion Analysis on Q_1

Do you perceive AR as suitable as a technology enabled learning method	
AI Emotion Analysis	
Excited	49.15%
Happy	30.51%
Indifferent	8.47%
Bored	3.39%
Sad	6.78%
Angry	0.00%
Fear	1.69%
M	14.29%
σ	18.49%
N	59

Table 37 - AI Emotion Analysis on Q_{12}

Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?	
AI Emotion Analysis	
Excited	21.28%
Happy	48.94%
Indifferent	21.28%
Bored	0.00%
Sad	8.51%
Angry	0.00%
Fear	0.00%
M	14.29%
σ	18.00%
N	47

Additionally, question Q_{12} asked the students if they would prefer AR over other TEL or traditional learning methods. The analysis revealed a shift to an indifferent, here meaning a neutral position, which corresponds with the preferences for a balanced mix of methods reported in section 4.3.1. Nevertheless, the AI analysis showed that a majority (70.22%) of students were engaged through the AR intervention and reported satisfaction (see Table 37 above).

Furthermore, the students commented on their perceived engagement in general in relatively short answers. The students, however, perceived that AR as a technology enabled learning method *"has potential to be very engaging"* ($p^{post}_{Q1(39)}$) and might be *"more engaging for students"* ($p^{post}_{Q1(58)}$). Some student attached attributes more specifically to their perception of AR enabled learning, stating that AR enabled learning is *"visually engaging"* ($p^{post}_{Q1(40)}$), *"intuitive, different, engaging"* ($p^{post}_{Q12(52)}$), and *"[...] futuristic"* ($p^{post}_{Q12(53)}$), which made the AR intervention *"more interesting and engaging"* ($p^{post}_{Q12(70)}$). The frequency in the previous selection of answers of terms describing engagement were protruding and support the earlier mentioned engaging potentials of AR as learning method, especially the digital AR story creation in this study.

Many students used synonyms that described a certain degree of perceived engagement in their written answers. The AR base text analysis reported an even higher level of perceived engagement in a sentiment and emotion analysis, where the majority of student answers expressed excitement and happiness with the AR intervention.

A protruding number of synonyms for describing engagement indicated that creating their own digital AR story had a positive influence on the student motivation, which suggest that AR enabled learning and teaching can enhance the student motivation in a learning environment.

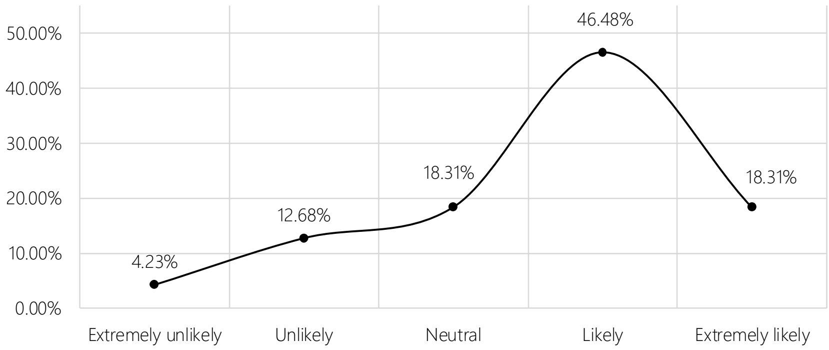
This last section on motivational impacts of digital storytelling with AR concludes that this teaching and learning methods influenced the majority student engagement positively. The next section introduces the important benefits that the students perceive the intervention of creating a digital story with AR could have for their future career.

4.4.4 Importance and Benefits for a Future Career

In view of the fact that students have for years been demanding that higher education provides more practical relevance and skills that can benefit their career. Studies regularly show that student worldwide feel sufficiently qualified or prepared for the job by academic study alone (Burbidge, 1994; Dämon, 2015; Frankfurter Allgemeine Zeitung, 2014; Kandiko and Mawer, 2013; Yu and Churyk, 2013). Many of those questioned students would like to see more intensive teaching of key professional qualifications, especially oral communication, problem-solving skills, and more practical case studies in the courses (Fish and Fish, 2010; van der Meer, Skalicky and Speed, 2019). In relation to the first research questions, which asked *"Does creating an AR experience support the student's learning process and what features do they consider the most useful?"* (RQ_1), this study found that part-time MBA students were very interested in content that could be beneficial for their career or enable new opportunities for the future. This section reports on the student perceptions of personal future benefits regards the skills and knowledge building offered by the AR enabled storytelling intervention of this study. It will draw on the general usefulness of the AR intervention, the request for business related examples for application, value creation and the application of the AR storytelling concept in business environments and tasks.

This study suggested the usefulness of the AR intervention for future careers of the students as important feature, and thus has asked the students explicitly for their opinions and perceptions. A majority of students considered creating a digital Story with AR as being valuable for their future ($Q6^{post}_{likely} = 46.48\%$; $Q6^{post}_{Extremely\ likely} = 18.31\%$), while a moderate number of 18.31% of students took a neutral position ($M=20.00\%$, $\sigma=15.88\%$; $MD=3$, $IQR=1$).

Figure 17 - Q6$_{post}$: "Do you consider what you learned from this AR intervention to be value for your future?"



For the same Likert-scale items (Table 38), it is worth noting that the female students perceived considerably more value ($Q6^{post(f)}_{likely} = 51.85\%$; $Q6^{post(f)}_{Extremely\ likely} = 25.93\%$) in the AR learning content for their future than the male students ($Q6^{post(m)}_{likely} = 43.18\%$; $Q6^{post(m)}_{Extremely\ likely} = 13.64\%$).

Table 38 - Q6$_{post}$: Future value of AR intervention for future by Gender

	Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely	M	σ	MD	IQR
female	0.00%	14.81%	7.41%	51.85%	25.93%	20.00%	20.22%	3.0	0.3
male	6.82%	11.36%	25.00%	43.18%	13.64%	20.00%	14.59%	3.0	1.0

A high number of student responses supported a dominant tendency for business relevant benefits, rather than expressing future learning benefits of AR enabled TEL. In all relevant responses several themes could be identified, such as generating potential future value in general and specific businesses, as well as enabling better storytelling within business tasks. Two of these themes were predominant in the student perceptions of future benefits of digital AR storytelling. The first and strongest perceived benefit was the ability to adopt AR technology and storytelling skills to communicate with potential customers and business stakeholders. One student contributed to these perceptions with his wish for *"more examples of how AR is being applied in business/case studies"* ($p^{post}_{Q13(2)}$), the field notes concurred with a demand for more business related examples of potential future applications of AR for training, storytelling and other business purposes.

According to a study of a business study a majority of business leader predict that companies will face disruptive change driven by digital technologies and claim that the organizations lack of then necessary skills to adopt to this new situation. The study estimates that, for example, software engineers as well as Professionals in marketing, sales, manufacturing, law, accounting, and finance, will face a demand to redevelop their skills on an average all 15 months. From this they claim a change in learning modes and content through new teaching and learning approaches, such as delivering continuous learning digitally (Pelster, Stempel and van der Vyver, 2017). This is not a new perception, since Hussein (2009) similarly found in an e-Learning study that engineering students perceived that an alternative creative e-learning approach would offer them benefits in their future career, as the new approach adds favourable knowledge gains to their skill portfolio. Furthermore, studies from a student perspective highlight that learning with various technology could beneficially support and sustain the future career of students (Baruah, Ward and Brereton, 2017; Concannon, Flynn and Campbell, 2005).

One student reflected that AR *"opened my mind to what is possible and got me thinking about value added applications in my workplace"* ($p^{post}_{Q7(59)}$), which goes in line with another voice on general future value that said *"[...] I know what augmented reality is now and have ideas about its potential for use in our company or industry"* ($p^{post}_{Q7(64)}$). More specifically one student expected that AR *"[...] will be very useful at work for recruitment"* ($p^{post}_{Q7(61)}$) and might be useful for future "*exploration of trading, etc.*" ($p^{post}_{Q14(61)}$), while another student highlighted the potential *"advertising benefit of AR"* ($p^{post}_{Q10(10)}$). Several students explained some of the perceived beneficial features of digital story telling with AR more comprehensibly. One comment addressed the internal communication, stating that *"I can use AR in explaining to work colleagues and learning colleagues about an idea or product information. It also helps in passing knowledge to others"* ($p^{post}_{Q7(8)}$). Another one extended the perception of future benefits of AR as business communication method by claiming that *"Augmented Reality is a great tool to explain to customers, engineers and other individuals require learning to have a feel and knowledge about a product or idea or service that is available in the market"* ($p^{post}_{Q1(8)}$). Two students further highlighted, almost identically, additional storytelling qualities of AR. The first student argued that AR *"brings a brand or topic or subject to life and interacts with its potential user, buyer or client"* ($p^{post}_{Q1(4)}$), while the second related potential benefits to her field, since *"[she] work[s] in marketing and business management environment. This [AR] would bring the presentation to life."* ($p^{post}_{Q7(62)}$). Nevertheless, the conclusion that AR *"[is] not applicable to my current role, in positions I engage in my future career. Maybe more interesting than ... For me. Perhaps more in other sectors or roles"* ($p^{post}_{Q7(28)}$) documented the also existing neutral perception of benefits from AR enabled TEL.

The second, by far less pronounced, benefit addressed personal future gains of the newly learned skills. There were rare cases in which students related to potential personal future benefits of AR skills for their personal learning, possibly also within TEL. Exemplary, one student revealed that he *"will use this [learned / AR] going forward"* ($p^{post}_{Q7(31)}$), while a second shared that she is *"planning* *on branching out and this could be used in new venture!"* ($p^{post}_{Q7(12)}$). Recent unique and meta-analysis research draws primarily on reflective benefits of future relevance of applied AR learning and teaching in terms of influencing grades, user (student) acceptance from a technical perspective, rather for the experienced learning with AR and its perceived influence on future learning of students (Cabero-Almenara, Fernández-Batanero and Barroso-Osuna, 2019; Dalim et al., 2017; Garzón and Acevedo, 2019; Hantono, Nugroho and Santosa, 2018; Munnerley et al., 2017), which leaves questions open for further specific research from a student perspective.

A clear majority of students saw the AR intervention as useful for their professional future, with female students being much more positive about the potential benefits. The MBA students continued to attach great importance to the inclusion of sample applications of AR technology with very concrete practical relevance and potential new business ideas. Furthermore, the students perceived the concept of AR supported storytelling as a communication tool as important for strengthening their future communication skills with customers and other stakeholders. However, some students seemed to have very concrete ideas for the application of the AR skills they had learned and wanted to put them into practice.

The following final section provides a summary of the findings of this study.

4.5 Findings Summary

4.5.1 Learning Style Preference

This first section focuses on observed changes in *learning style preferences* of students after the intervention creating a digital storytelling with AR.

A clear finding was the significant increase in student preferences for SQL, which made it the highest change rate of all learning style dimensions. Within the sample considerably more students aged 40+ preferred SQL, while at the same time the number of students for the group 25-30 year old students decreased moderately. The latter group showed a strong SQL preference grades prior the AR intervention, which increased after the AR intervention. The students overall reported strong preference grades, while the results for the 31-35 old students stand out by an increase to a strong preference.

The VSL is the dimension for which the greatest number of students scored for, pre as well post the AR intervention. After the intervention, the number of students in favour of VSL decreased slightly. Nevertheless, a very strong overall preference for VSL remained unchanged. This balance was caused by decreased preference by the 31-35 old students, whereas all remaining sample groups increased their preferences for VSL slightly.

Additionally, the study revealed a significantly increased preference overall for the SNL dimension. Male and 36-40 year old students followed this strong trend, whereas the female and the 26 to 40+ year old students increased their preference only moderately. However, students aged 20-25 years reported an unchanged very low preference for SNL. Overall, only slightly more students favoured SNL.

The ACL dimension gained the second highest score and moderately increased following the intervention. Compared to the average increase moderately more male were in favour of ACL following the intervention, whereas the number of 31-35 year old students increased their preference by more than twice the average of all students. The AR intervention left an unchanged moderate preference grades overall, except for the very strong higher preferences within those age 20-25 years.

4.5.2 Student Perceptions

The following section summarises the findings of this study in relation to *student perceptions* of learning with AR.

The study found that students reported a preference for a *balanced mix of learning* and teaching methods, even when the majority preferred AR over other methods. Despite this positive perception, more students repeatedly expressed a preference for a balanced mix of AR enabled and traditional learning methods. Students saw a balanced mix of methods as a preferred way to address different learning style preferences and specific learning situations. Furthermore, the participants believed that AR might be a useful addition but not a substitute for traditional learning and teaching methods.

In terms of the *perceived importance* of AR in learning the study found that a large number of students perceived the concept of digital storytelling to be important for supporting their learning process and honing a beneficial skill set. The majority found creating a digital AR story as a very enjoyable TEL option. Student responses additionally revealed a favourable mentioning of the storytelling process, supported by a vivid participation in all stages of the creation of the digital AR story. Field notes also left the impression that the majority of students enjoyed discussing ideas, developing and creating a digital story. However, there were teamwork issues that sometimes interfered with the creation process.

The study revealed that creating a digital story with AR has the potential to *address the diversity* of students in terms of expectations, interests, previous knowledge, experiences, and skills. However, the results do not confirm major diversity-based preferences either in favour of, or against, AR enabled learning but seem to be related to personal influences, such as previous experiences with AR learning and perceived technology self-efficacy. An overall observation was that the digital AR Storytelling intervention could address many of the diverse perceptions, expectations, and approaches of the MBA students by offering varied learning impulses. Nevertheless, the heterogeneity of student perceptions indicated that diverse motivational effects of learning and teaching with AR had impact on their perceptions.

4.5.3 Motivational Effects

The study found that an AR intervention can help students to reinforce their *technology-self-efficacy* in their learning process. The starting point for this finding was the student perception that AR enabled TEL can support personal learning quite well. The students supported this with predominantly positive answers. Nevertheless, there was a considerable proportion of responses expressing anxiety towards technology, which was endorsed by field observations. Students claimed that they met the challenges of the digital AR story creation, alone and in teams, because AR enabled TEL offered them a safe space to try out new things. Overall, the students positively perceived the active creation of a digital story with AR as a *suitable TEL method*. A majority of students agreed that they would prefer an AR intervention over other technology enabled or traditional learning and teaching. Students argued that AR was a suitable TEL method because it offered the opportunity for learning by addressing different ways and styles of learning. Furthermore, it impacted their engagement level by offering an interactive and kinaesthetic intervention, and many students saw AR as a novel approach that could enhance technology enabled learning and teaching. Finally, participants strongly favoured active and visual learning styles supporting the suitability of AR as method for TEL.

The study found that the creation of a digital AR story *impacts motivational conditions*, and suggests four motivational conditions that the students perceived as important in reflecting on the creation of a digital story with AR.

Novelty is affected by previous experiences and knowledge and the vast majority of students reported being unfamiliar with the term AR. Male students reported a slightly higher level of familiarity than female students. The age range showed an undifferentiated overall result, where those aged 40+ reported both the least and greatest familiarity at the same time. In terms of previous experience with AR in a learning and teaching context a clear majority of 91.30% did not have any experience prior this study. The analysis by age range revealed a clear decreasing linear trend in experience of AR learning, which was found to be supported by the student comments that highlighted the novelty of AR in TEL.

The perceived *easiness* of a method in learning and teaching, especially TEL, contributes to the overall motivational level of learners. Students commented on this motivational condition mostly from a general perspective, but some mentioned specific technical requirements that might contribute to a perceived easiness. In this context it became evident that student might have very opposite perception of one and the same intervention.

Interactivity is assumed to influence the degree of satisfaction and thus the motivational levels of students. This study found in two main questionnaire items that students reported interactivity as important, which suggests an influence on their motivation towards the creation of a digital AR story, which supports the suggested role of students as prosumers in educational settings.

The level of *perceived engagement* contributes to the satisfaction condition. Two AI based analyses demonstrated that the majority of students were excited and happy with the AR intervention. The student comments stood out in terms of the frequent use of engagement attributes.

The final section drew on the question of the perceived *benefits of digital storytelling with AR for the future careers* of students. The study found that a majority of participants considered that learning AR skills and knowledge was valuable for their future. It is worth noting that the female students perceived significantly more value for potential business-related applications than the male students. Overall, the study found a dominant tendency for perceived business relevant benefits supported by a high number of student responses. These responses identified three main themes. The students expressed that AR enabled TEL has the potentials to generate future value in general business communication with stakeholders, in applications in specific businesses fields, as well as in enabling them to become better storytellers within economic sectors tasks, and potentially new opportunities for new business ideas.

Drawing on the findings presented in this chapter the next chapter returns to the original research questions and discusses the implications of this research. After a summary of the boundaries of this study the chapter concludes with as set of proposed recommendation for technical applications, professional practice, and further research.

5 Conclusions and Recommendation

This final chapter considers the findings in relation to the research question, considers the significance of the findings and discusses some of the limitations of this study. The chapter closes with recommendation for learning and teaching approaches with AR, as well as some potential ideas for further research.

5.1 Findings of the Study

The third research question considered changes in learning style preferences across four dimensions and the findings of this study seem to build in particular on previous research (see 2.2.5 and 4.2). Many of these studies investigated learning style preference in e-Learning environments and confirmed similar tendencies within all learning style dimensions (Huang, Lin and Huang, 2012; Waalen and Zywno, 2001; Laar, 2019; Kurilovas, Kurilova and Dvareckiene, 2017; Makina and Salam, 2011). However, in the context of this study digital storytelling with AR seems to have an extraordinary impact on the visual domain, and additionally following the intervention substantially more students preferred a sequential learning approach.

Investigating the perceptions of students towards AR enabled learning was one the aims of the second research question. It was striking that students favoured a sequential approach to learning when creating a digital story with AR, as discussed in chapter section 4.2.1. Several researchers claimed that many contemporary students are not agile (non-lateral) thinkers but rather normal students (Kamal and Radhakrishnan, 2019), who prefer sequential approaches to learning and teaching. This preference derives from education systems that fosters non-lateral thinking and approaches to learning, which resulted in systemic influenced habits of students (Hill, Cromartie and McGinnis, 2016; Robinson, 2008, time: 06:45 - 07:37).

The findings that AR storytelling potentially supports skills acquisition and personal learning (see 4.3.2) suggests in particular that the students perceive many features of creating a digital story with AR as beneficial for their personal learning. This is consistent with findings from the research literature on tangible AR interventions, while often stressing the influence of the interactive immersion of the students with existing educational AR content (Abas and Zaman, 2010; Schrier, 2006; Yilmaz and Goktas, 2017).

The findings in section 0 on the experiences of students with digital storytelling with AR revealed that AR as a learning and teaching method can foster technology self-efficacy among students with limited previous experiences. Furthermore, the study found that the students perceived that the characteristics of actively creating a digital AR story were a suitable TEL method. This extends finding of previous educational AR studies of the benefit of considering students as creative prosumers (Charlton et al., 2018; Menorath and Antonczak, 2017; Yilmaz and Goktas, 2017). Further findings related to the motivational impacts of AR storytelling, which revealed four main dimensions that the students perceived as important. The novelty of AR as TEL method was especially motivating for students in this study, as well as the interactive aspect of the approach. However, the perceived ease in the use of AR tools was also an important motivational factor. Previous studies examining TEL methods and specifically user acceptability have consistently reported this requirement (Sun et al., 2008; Cheng, 2018; Dünser et al., 2006; Vedadi et al., 2017). Overall, this study found that students perceived digital storytelling with AR as a potentially engaging and beneficial TEL method.

The second research question furthermore related to the learning preferences of students towards AR enabled learning. The study found overall a neutral preference for AR enabled teaching methods, while at the same time an absolute majority of students expressed a positive sentiment and stronger emotions towards creating a digital story with AR. This is consistent with the emphasis in previous research where students consistently rated AR interventions as engaging (Deimann, 2002; Di Serio, Ibáñez and Kloos, 2013; Radu et al., 2010). Despite these positive perceptions, the main finding was students expressing a preference for a mix of traditional and technology enabled learning and teaching methods. The literature suggests that social factors, demand for variety, and the pragmatic goal orientation of students regards learning shape their preferences (Cabero-Almenara, Fernández-Batanero and Barroso-Osuna, 2019; Dalim et al., 2017; Garzón and Acevedo, 2019; Hantono, Nugroho and Santosa, 2018; Munnerley et al., 2017). A further support for the findings in this study was that a large number of students perceived digital storytelling with AR as a welcome but complementary method. Interestingly, the investigation of this research question disclosed that students had no clear definition of the distinction between traditional and modern TEL methods. The research literature offers definitions that consider e-learning methods rather than AR enabled learning as traditional methods. However, this distinction is drawn by researchers, instructors, and organisations rather than students (Karanezi, Rapti and Halimi, 2015; Richards, 2006; Darder, 2015).

The first research question considered how creating an AR enabled story could support student's learning process and lead to two main findings. First, this study found that AR supports skills acquisition and the personal learning of the students. The students perceived the creative process of digital storytelling with AR as a favourable skill and knowledge contribution, which they saw as beneficial for both, their future career and personal learning. Participants communicated their enjoyment of storytelling with AR and explicitly supported this approach and considered it to have a positive effect on their learning. The study furthermore found that students regarded the storytelling skills as highly valuable. Research on design process theory confirms this perception as a helpful aid for creative problem solving, which enables students to create new ideas, solutions and strategies: attributes typically valued and demanded by MBA students (Kröper et al., 2011; Beckman and Barry, 2007). But the literature also suggests that storytelling skills particularly in connection with immersive technology such as AR, support traditional learning tasks such as paper writing and creating presentations. AR therefore has an additional role in promoting the application of new media, thinking in new spheres, and including a third dimension through immersion (Frey, Fisher and Everlove, 2009; McNeil and Robin, 2012; Moon, 2004). However, student preference for serial learning style also has implications. Not all students are agile thinkers but rather 'normal' thinking learners. Some educational researchers believe that the main reasons might be systemic in the way that rigid and inflexible school systems let students unlearn their creative and agile thinking and learning abilities students (Hill, Cromartie and McGinnis, 2016; Robinson, 2008, time: 06:45 - 07:37; Kamal and Radhakrishnan, 2019). This may have consequences for the instructional design which responds to this preferential learning style and at the same time promotes creative and lateral thinking again.

Recent literature stresses the increasing heterogeneity of students due to underlying complex socio, cultural, and technology influences (Correa and Tulbert, 1991; El-Khawas, 2003; Ford and Whiting, 2007; Grubb et al., 2011; Happ et al., 2016; Jabbar et al., 2020; Powell et al., 2019). This leads to the second finding relating to how AR enabled learning and teaching supports student learning as this study found that AR can support learning by addressing the diversity of the students in terms of expectations, interests, previous knowledge, experiences, and skills. This diversity was especially prominent within the more mature and experienced MBA students in this study. However, the study did not find major diversity-based preferences in favour or against AR enabled learning rather the perceived support for AR seemed to be related to personal influences, such as previous experiences with AR learning and perceived level of technology self-efficacy. Previous studies confirm that the student learning processes can benefit if instructional design is aware of, and addresses, student diversity which might contributing key success factors for successful learning processes support (Happ et al., 2016; Kuzmanovic et al., 2013).

The first research question asked consequently, in relation to the learning process impacts, what features of AR the students considered the most useful. Research on business students often claims that these students are usually pragmatic and goal oriented (Prince et al., 2015; Manai and

Holmlund, 2015; Murphy and Yetmar, 2010; DiBenedetto and Bembenutty, 2011). This reinforces the findings in this study where a majority of the students viewed digital storytelling with AR as offering potential benefits for their future, in terms of acquiring communication and technical skills. Additionally, the students felt supported through the development and presentation of business-related AR examples, which they perceived as very important for potential applications to real life scenarios. Many studies that made use of both, traditional and TEL, methods support this relationship to the perceived importance of students towards future potential applications of learning content students (Baruah, Ward and Brereton, 2017; Concannon, Flynn and Campbell, 2005). This finding of perceived future benefits was further substantiated by students who saw very specific relevance to business and invoked concrete future plans for the application of digital storytelling with AR. Interestingly female students were more positive towards the future potential business-related benefits of AR storytelling than their male colleagues.

5.2 Contribution to Knowledge

There are different things that are knowable in research projects, and a researcher is expected to process them in order to create some evidence, which might become an original contribution to knowledge. The following presents five sources that contributed to the body of knowledge within educational research on applied AR in HE.

INFORMATION - Transforming data into meaning is the creation of information for different audiences, the researcher himself and other interested people. The specific rearrangement approach of facts in this study enabled new interpretations which can be a significant contribution to knowledge. A perceived major contribution is that this study uses a unique combination of AR aided coding and subjective, manual interpretation techniques in the field of applied AR in HE, which lead to new ways of interpreting and gaining information on student perceptions, experience and exceptions towards learning with AR as a TEL method.

INTERPRETATION / ANALYSIS - The selected mixed method approach is not new, but the application of pre/post data collection for learning styles preference is adding a new perspective to researching student learning. This extends existing knowledge in literature where the vast majority of studies reviewed for this study revealed only singular data collection approaches, either pre or post and intervention, for gaining insights of current learning style preferences of students. Additionally, applying AI aided coding tools and combining it with 'traditional manual' coding as well quantitative data extends the portfolio of known triangulation methods by one approach that is capable to handle big data sets.

KNOWABLE - In general, knowable can be understood as all things that can be discovered, recorded, found. This study's research questions, for example, are additionally adding to the body of knowledge by addressing unique aspects to the field of applied AR as TEL method in HE. Specifically, it is the explicit student perspective on AR as learning method, the communicated perceptions, experience and expectations of the students on actively creating digital stories with AR that that creates new knowledge, which might be a, for example, good source for future comparative studies with the subject of AR as learning method. This is similarly true for the specific characteristics of this study's sample, such as the age distribution that is specific for investigated students.

ANALYSIS - Perceived as important contribution is the successful application of the Welch test for scaled data as one *right*, reliable and easy to process test method in contrast to often problematic methods that are not intended for the specific characteristics of *scaled* data, such as the well-know (student) t-test. The gained knowledge from the application in this study might help to establish a place in research for a lesser-known method that can analyse scaled data faster, more reliable, correctly analysed and easier to compare.

LIMITATIONS - The limitations of this study additionally contribute to the body of knowledge, since the acceptance of them offers other researchers to recognize potential issues or pitfalls in their own research projects. It furthermore reveals that there are constellations that probably can't ultimately be answered because outcomes are potentially volatile due to attributes of the measured phenomena, for instance, the influence of student's previous knowledge in relation to a time horizon. This offers criteria for other researchers to design their project accordingly but also offer practitioners a valuable research for their applications of AR in HE learning and teaching.

5.3 Strength and Limitations of the Study

All research is subject to various forms of bias. The research design adopted in this study tried to minimize the impacts of different forms of bias. The research population were post-graduate students, part-time MBA students, who are usually older with more life experience than full-time MBA or undergraduate students but highly motivated. Furthermore, younger students were underrepresented due to the requirements and characteristics of the course. Nevertheless, the sample recruited from three-degree programmes, resulting in a relatively large number of participants in this study.

A majority of the participant were of UK origin, which did not allow pursuing intercultural comparisons within the sample, however, the study could be compared to other research with similar research design and sample restrictions.

Part-time MBA students necessarily balance family life, business commitments, and a challenging MBA course. Data collection took place on a weekend and this required many students to travel significant distances, which caused lower participation on the Sunday post intervention survey due to early departure, thus reducing the overall potential post intervention sample size.

Every research that applies technology is prone to issues with technology (Al-Ataby, 2020; Bower, 2017). This study obviously made use of AR technology, which was hosted off-premises by a supplier over the Internet. Unfortunately, some student experienced Internet service interruptions, which some students expressed as discouraging and it could have influenced their responses. However, a positive side-effect of this was that the future managers raised their awareness towards questioning unconditional trust in Internet technology for business purposes, which was reflected in some responses of student as learning point.

From a methodological view, there was only a short time between the pre and post intervention surveys, which might have influenced the results, especially the ILS. On the other hand, this timely data collection limited non-responses associated with using data collection at a later point in time.

A real strength was the adoption of Felder's ILS, which has high validity and is a reliable method for investigating people's learning style preference because it has been thoroughly tested by many researchers, and it has been successfully applied in many studies. The fact allowed a careful comparison with other studies that adopted the ILS questionnaire to different types of students, fields, and age groups.

The analysis revealed that students kept qualitative answers sometimes very short. This sometimes made it difficult to interpret the intentions, emotions, opinions, and meanings of student answers. Nevertheless, the study benefitted from a high response rate on open questions that compensated for the brevity of some answers. Within the literature there is evidence of the influence of novelty effects, not only of new technology, in learning and teaching (Di Serio, Ibáñez and Kloos, 2013; Akçayır and Akçayır, 2017; Garzón and Acevedo, 2019; Lombardo and Angelini, 2012; Cormier et al., 2019), while Ferguson (2019, p.5) implies a negative correlation and raises the question whether *"[...]teachers and learners be enthusiastic once the novelty is gone?"*. This might have influenced this study too since learning with AR was new for the majority of the students. Yet, AR is a still a new learning technology and did not reach a balancing saturation effect, which leaves space for further research on a longitudinal basis. Finally, a strength of this study is the unique view on active creation of AR content, not limited to digital storytelling, by students that contributes to the knowledge of applied AR in educational settings.

5.4 Implication of the Study

There are a substantial number of studies on technology enabled learning and teaching environments that investigate questions and issues from instructor and educational institution perspectives rather than addressing student perspectives, expectations, and learning style preference changes. This study contributes to broadening the knowledge regarding the potential influence of digital storytelling with AR (AR digital storytelling) on students learning styles and attitudes as a suitable TEL method. Additionally, this study contributes to the body of knowledge that AR storytelling can cause changes in students learning style domains. For students with more non-lateral oriented learning styles, AR storytelling does not necessarily replace traditional learning and teaching methods, rather such students prefer a balanced mix of learning and teaching methods. AR storytelling appears to play an important role in supporting less technically skilled students to foster their technology self-efficacy, which might contribute to a higher student engagement. Interestingly for stakeholder in HE this study suggests that students may perceive creating a digital story with AR as an important 'safe haven' for developing creative and communication skills. It could be further concluded that students can be engaged through learning offerings, such as creating a digital story with AR, as they perceive such approaches as related to their professional environment and potentially offering beneficial skills for their future careers.

5.4.1 Theoretical Implications

There are three distinct points this study that go consistent to Felder's model of Learning Styles preferences (Felder, 1996). Firstly, the task of creating a digital story with AR had an impact on the student preferences towards sequential learning approaches, which goes in line with Kamal and Radhakrishnan's (2019) theory that contemporary students tend to be sequential, non-lateral learners. Furthermore, the iterative sequential design process (Scheer, Noweski and Meinel, 2012), implies that the theory is a valid approach to AR enabled learning and teaching with students with a pronounced SQL style preference.

AR storytelling influenced the preferences for visual learning styles of the students. This learning style domain is the second distinct learning style preference, which confirms VSL as a generally strong preference as reported in many previous studies (Eubank and Pitts, 2011; Marwaha et al., 2019)[64]. Also, AR changed the preferences of the students towards other learning style domains. It can be implied that AR in its current state is predominantly a visually immersing reality (Arth et al., 2015) and this complexity of the required activities frequently overstretched the abilities of some students, which led to a visual cognitive overload, which is consistent what the theory of cognitive overload describes (Benford and Fahlén, 1993; Dunleavy, 2014; Radu, 2014). The observed decreased preferences of the students for VSL confirm the claim within the learning style theory that learning preferences might change over time, depending on subject matters. As the findings show are the learning style dimensions interrelated within each of the four dimensions and influence each other (Felder, Felder and Dietz, 1998; Graf, Viola and Leo, 2007).

Besides findings within the learning styles theory domain the findings of this study consistently confirm existing motivational theories. The AR digital storytelling addressed all four central elements of the model by raising attention of the students for the learning task, by offering skills that have relevance for the students, by supporting confidence through a task that students can achieve, which contributes to the overall satisfaction of the students (Cheng, 2018; Keller, 2000, 1999; Means, Jonassen and Dwyer, 1997; Wei et al., 2015).

Additionally, the findings of this study suggest that digital storytelling with AR can enhance the technology-self-efficacy thus implying that the TSE theory is a suitable element for a framework for the creation of digital stories with AR through students. This consistency with TSE theory is already evident in adoption of TSE to specific types of technologies in TEL, such as computer self-efficacy or Internet self-efficacy, and information technology self-efficacy, due to the specific difference of technology and how people potentially approach it this differentiation (Joo, Bong and Choi, 2000; Fauzi, Ali and Amirudin, 2019; Mahat et al., 2012).

The underlying framework for this research was based on pragmatism, which strives to provide 'good'[65] solutions and approach for reaching a desired outcome in an learning an teaching environment (Kerres and de Witt, 2004). The method of creating a digital story with AR was a

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[64] See also the summary of studies that applied Felder's LS in section 7.6.6 - Meta Table of ILS Results of 42 Studies by VSL.

[65] The adjective good stands here for the differentiation from a 'best practice' approach as discussed in section 1.8.

viable pedagogic mean to ensure a high learning engagement of the students (Deimann, 2002; Di Serio, Ibáñez and Kloos, 2013; Radu et al., 2010). However, the learning engagement was highly dependent on motivational factors, such as the four elements of the ARCS model and the level of confidence with learning technology (Antonioli, Blake and Sparks, 2014; Bacca, Baldiris and Ramon Fabregat, 2018; Di Serio, Ibáñez and Kloos, 2013; Li et al., 2015), which needed to be addressed in a pragmatic approach. The findings of this study are consistent with the framework of pragmatism when viewing it from a student perspective. For example, AR digital storytelling serviced the pragmatic wish to gain skills that are likely to be beneficial for a future career (Baruah, Ward and Brereton, 2017; Concannon, Flynn and Campbell, 2005).

5.4.2 Methodological Implications

This study combined proven research methods in a unique way in order to understand the impact of digital storytelling with AR on student learning style preference and perceptions. The basic design incorporated collecting data at two points in time, pre and post the AR interventions, which allowed a more dynamic understanding of immediate influences on, for instance, learning styles and other preferences of students. Thus, the findings of the two surveys could serve as a basis for future studies by including these as specific and student-centred questions.

Furthermore, the decision to harmonize the scale metrics supported triangulation by circumventing approximations, such as Z-score conversion. This approach would eliminate issues of comparability of different scales, when using the Interquartile Range [IQR] method for comparison (Hartley, 2014).

The Welch test has proved to be very advantageous to analyse data derived from scales, even with small sample sizes, where other test methods are applicable due to their prerequisites. The limited set of prerequisites and its explanatory power can make future studies more robust because the Welch test addresses several issues of other tests, such as a required equality of variances and higher sample size requirements in other p-test variants. A further advance is that the Welch test can be used for both scaled and metric data (De Winter and Dodou, 2010; Ruxton, 2006; Zaiontz, 2015; Rasch, Kubinger and Moder, 2011). These characteristics could accelerate future research since pre-tests can be avoided and the use of one test method would make the analysis results more homogeneous and better comparable.

The application of AI as additional method in the qualitative data analysis can help to understand new confounding variables. The machine learning based NLP with its diverse sentiment analysis is a big advance for studies that have to or want to process large amounts of data. Furthermore, the availability of AI-NLP methods for different languages will improve the access to data for researchers who are not native speakers of one or more targeted languages (Dong and De Melo, 2019; Liu, Li and Thomas, 2017). The integration of AI based tools could therefore imply that future qualitative studies could accelerate, become more generalisable through more processed data, and might therefore reveal additional findings.

5.4.3 Practical Implications

From a practical perspective four professional groups, namely instructional designers, lecturers, researchers in the TEL field, and strategic leaders in HE and educational policy committees, might be interested in using these study's findings. This section looks at why they should pay attention to the findings and how the findings lead to changes in the way professionals 'do' things.

Instructional designers can apply the findings to design curricula that make use of active AR storytelling through students as a learning and teaching component for aligning methods for offering a balanced mixed of learning and teaching vehicles that can attract a large variety of students. By adapting the findings of this study educational designers and practitioners are supported to create and run more balanced curricula that address more diverse learning preferences and perceptions of students (Kibelloh and Bao, 2014; Ronnie and Wakeling, 2015; Carneiro, Lefrere and Steffens, 2007). This might result in a more differentiate weighting of different teaching and learning methods, and the acceptance that these conditions are not static of time. Furthermore, it leads to a deeper analysis of identifying what students' cognitive assumptions are about beneficial future career learning actions and consequently it might help to prevent a pedagogical misalignment with the demand of industry and HE organizations.

For lecturers it provides insights of what students expect from TEL, especially with AR enabled learning and teaching. It supports them in addressing the needs of diverse students when applying AR to an intervention (Karagozlu and Ozdamli, 2017; Majid, Mohammed and Sulaiman, 2015). Practitioners can be more cautious to signs of deficits in technology-self-efficacy of the students, since the findings made salient that the technology readiness of students is related to a beneficial or less beneficial experience with the AR storytelling method (Huang and Lin, 2017).

They might therefore start to recursively check the student TSE levels during intervention, which will require additional methods for lecturers to identify student current motivational level and what are the influencing factors.

In line with the previous methodological implications, researchers find proposals how to cope with scaled based data in qualitative research and a reasonably practicable approach to handle larger amounts of qualitative data from larger sample sizes, which could contribute to a higher generalizability and reduced bias of results (Bryman and Bell, 2011, pp.187-188;195-196). They could apply, for example, the Welch test as a standard routine to address issues scaled data and to make the results more accessible for others. Further, new AI technology could change the approach to qualitative data analysis, where AI can make it more reliable, manage larger data collections. Especially, AI-NLP might change the scope of research samples, since it might allow researchers approaching samples that would be difficult to include, for example, responding in many different languages or mass communication on social media (Dong and De Melo, 2019; Liu, Li and Thomas, 2017).

Finally, leaders in HE and on policy level could find impulses to respect student perspectives of students more regards learning content and methods. The findings on learning with AR storytelling can give a guideline to which extent new technologies, such as AR, should be promoted as additional, new method for TEL. These stakeholders could, on a strategic level, involve students more into the planning and design for learning and teaching in Higher Education (Bovill and Bulley, 2011; Frank and Sieh, 2016).

5.5 Recommendations

From the findings this study provides the following recommendations in three domains: organisational level, instruction design, and future research.

5.5.1 Higher Education Policy

Given very rapid digital change, there is a need for both HE policy and pedagogy to be able to creatively adapt to the ongoing digital transformation of society (Balyer and Öz, 2018; Wilms and Meske, 2017; Seres, Pavlicevic and Tumbas, 2018). HE organisation should counteract and implement TEL in a balanced mix with traditional learning and teaching methods to address a wide range of student learning preferences. Furthermore, the linear thinking doctrine should be blurred in favour of creative, innovative skills building, anchored in an organisations vision, mission, and curriculum design policy. This would require a dynamic expectation management to align HE to provide benefits for the students' future careers and to contribute to mitigate the Engagement Issue of students. Digital storytelling might be a candidate for a portfolio from which instruction designers could choose due to the engaging, creative and supportive attributes, but also the relatively low investment costs[66] as in this study.

5.5.2 Instructional Design

Course design should combine traditional (non-lateral) with agile learning and teaching methods to address student diversity and heterogeneity. This might support a wider range of learning styles, a greater perceived variety of methods, better aligned to context, which could lead to higher engagement and motivation. Furthermore, new technology methods might help to foster digital skills and efficacy of students with less or poor digital experiences.

Curriculum design, not only for MBA students, should make more use of design theory to educate students back to creative thinking (Robinson, 2017a; Land, 2011), generating better capabilities and abilities to create innovation, solve problems, and adapt faster and better to new situations in their future[67]. To reach such aims an instructional designer should carefully select a range of learning goals that allow students connect to the issue. Furthermore, instructional designers should consider that a curriculum grants the students the required thinking space, supporting environment, pedagogic and technical support, and enough time to expand their creative thinking processes.

Hence, digital AR storytelling could offer students an open room to get access to new technology and the opportunity to enhance their thinking processes through experimenting and making mistakes on the path to the desired learning objective of the designed curriculum. Furthermore,

[66] The AR environment costs for this study stemmed from one lecturer seat and student seats. Both licenses were billed annual for the lecturer £160 and each student £2. The student seats are dynamically assigned and could be reused by other students or allow an HE organisation to grant student access to the AR environment for a whole time of a course.

[67] It was intended not to limit to just to career but to include all social context.

different level of technical complexity[68] can motivate more technological advanced students, as well raise technology self-efficacy for less technology proficient students.

5.5.3 Further Research

This study revealed that there potentially interesting variations on an AR research design connected to this study that can explore ways to enhance the scope of educational AR research.

DIFFERENT SAMPLES - Due to different life and learning experience it would be interesting to expand research by other student samples, such as younger undergraduates, full-time MBA students, and students from other HE and FE institutions. This expansion could reveal more perceptions and preferences of other student groups and how their data compares to existing studies. Furthermore, adding long-term observations could reveal if changes to learning styles that were longer lasting and if there were implications for careers and the world of work.

CULTURAL DIFFERENCES – One of the acknowledged limitations of this study was the lack of diverse nationalities, which might have permitted the exploration of the interaction between cultural background and digital storytelling with AR.

DEVELOPMENT STATUS – Sourcing students from various countries at different levels of development in terms of socio-economic and educational status could further extend the implications of cultural variation. In particular, it would be interesting to compare countries with highly progressed digital transformation with other countries. Such comparisons could reveal new aspects of the impact of integrated AR learning and teaching. Variables, such as, heritage, religious beliefs[69], school systems with different teaching cultures[70] might influence the student

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[68] The AR environment used in this study offered three levels of complexity that could address student with different skills and motivations. The first level offered a click'n run experience that could be used for introductions or quick win interventions. The second offered a web-based more sophisticated AR environment that do not require any programming, which allows students to create AR content in a relatively short time. The last level offers a fully fletched AR development system that needed to be installed on local computer and requires to learn programming, which might be more suited for technical programmes or longer timed modules as, for instance, a programming introduction.

[69] For example, in Japan people consider that things have a soul, which is rooted in Zen Buddhism.

[70] Example for an extreme juxtaposition could be the Waldorf and the Thai approaches: more laisser-faire versus typical recite and repetition, but on the other hand, less technology savvy versus progressive application of TEL (especially AR) in learning and teaching.

learning and thus reveal interesting relationships that could be later serve as basis for meta-analyses.

STUDENT INTEGRATION - Further research could investigate how students would perceive learning with AR when they were integrated into the learning and teaching process. There are a number of interesting possible ways to integrate students in AR learning and teaching: the first could integrate students into co-authoring modules that make use of AR and the second approach could embed students in active teaching and consulting/support roles by using their expertise with an AR intervention. Questions could explore if students would accept such integration, how this might influence their learning motivation and perception of this method, and whether this differed from the approach in this study.

META ANALYSIS – To a certain extent, this study compared its findings to a number of previous studies on learning style preferences. Nevertheless, the available corpus of research on learning style preferences gained from studies that did and did not apply AR, suggests further comparisons with existing data. This might include referencing different learning and teaching methods in relation to variables such as educational form, age of sample, cultural backgrounds, and other attributes that are commonly available in the data sets.

5.6 Conclusion Summary

The diversity of the students in this study revealed highly varied opinions, perceptions, expectations, and learning preferences. Nevertheless, there were three main themes identified: the impact of AR on student learning style preferences, their perceptions of AR in learning, and their experiences with AR as a learning method. The most interesting findings within these themes were that students prefer serial (non-lateral) learning styles and a balanced mix of learning and teaching methods. The study revealed that AR storytelling supports skills acquisition and personal learning as well as addressing many aspects of diversity among the students. Learning with AR can foster technology self-efficacy of certain students and had an impact on motivational dimensions related to the novelty of AR, a perceived ease of use and the engaging characteristics of digital storytelling with AR such as the interactive approach of these learning and teaching methods. Furthermore, the students considered that actively creating a digital story with AR was a suitable TEL method. Finally, digital AR storytelling seemed to offer valuable benefits for their future career, such as digital, storytelling, and communications skills.

The sample recruited from three part-time MBA programmes generated a relatively large number of participants for this making the results more broadly applicable. Furthermore, the adoption of the highly reliable and valid Learning Style Inventory go Felder et al. contributed to the strength of this research design. Finally, a strength of this study is the unique aspect of the active creation of AR content by students, which contributes to the body of knowledge of applied AR in educational settings.

These significant findings allowed the formulation of recommendations for HE policy and instructional design that could influence the implementation of digital AR storytelling in curriculum design with the aim of offering useful additional and relevant skills. Future research can build on a range of questions that emerge from this study that could connect and complement existing knowledge on learning and teaching with AR technology.

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7 Appendix

7.1 Excerpt of Literature Focusing on Teaching and Educational Perspectives

Table 39 - Keys for Type of References

Type	Meaning
A	Article
B	Book
C	Conference Proceeding
R	Report

Table 40 - Examples of Literature for AR in Education

Title (Reference)	Type	Published in
Learning Design: Gestaltung eLearning-gestützter Lernumgebungen in Hochschulen und Unternehmen (Seufert and Euler, 2005).	R	2005
E-Learning by Design (Horton, 2006).	B	2006
Virtual reality and mixed reality for virtual learning environments (Pan et al., 2006).	A	2006
E-Learning and the Science of Instruction (Clark, Mayer and Kay, 2011).	B	2008
The Future of Learning and Training in Augmented Reality (Lee, 2012).	A	2009
Using Augmented Reality as a Medium to Assist Teaching in Higher Education (Liarokapis and Anderson, 2010).	C	2010
Augmented Reality Technology for Education (Alcaniz et al., 2010).	B	2010
Augmented Reality in the Future of Education (Radu et al., 2010).	C	2010
Augmented Reality in Education (Agogi, 2011).	C	2011
Technology Integration in Higher Education (Surry, Stefurak and Gray Jr., 2011).	B	2011
Informed Design of Educational Technologies in Higher Education (Olofsson and Lindberg, 2011).	B	2012
Designing augmented reality for the classroom (Cuendet et al., 2013).	A	2013
Augmented Reality Textbook for Future Blended Education (Ivanova, Aliev and Ivanov, 2014).	B	2014
Design in Educational Technology (Hokanson and Gibbons, 2013).	B	2014
Technology Enhance Learning - The Art & Science of Learning Design (Maina et al., 2015).	B	2015
Implementing Augmented Reality in the Classroom (Miller and Dousay, 2015).	A	2015
ArQuest: Augmented reality in education (Karlsson et al., 2016).	C	2016
Technology-Enabled Learning Implementation Handbook (Kirkwood and Price, 2016).	B	2016
The educational possibilities of Augmented Reality (Cabero and Barroso, 2016)	A	2016

7.2 Rationale for Selecting Felder's Learning Styles Questionnaire

Literature offers various Learning Style Models [LSM] whereat Felder and Solomon's model stands out because of its application to TEL environments. Nevertheless, for this study it was necessary to identify suitable LSM that also offers a questionnaire that fulfils certain requirements.

Based on the critical reviews the study applied a decision-making process to find a suitable LSM and questionnaire that could be unmodified and applied to TEL environments, defining first a set of questions (excerpt below):

- What LSM exist?
- What is the aim of the single model?
- Which are 'Learning' style related?
- Which address rather personality indicator, group behaviour, etc.
- What were typical fields of application in previous research (traditional learning, TEL, business, etc.?)
- Which have a strong commercial background, which might question the reliability?
- Which are freely available for Research?
- Which of them easily offer data from research to compare?
- Which have been independently challenged?
- Where are limitations?
- Which offer a length that students might accept to answer twice to ensure a certain level of response quality?

These questions led to a decision matrix, below a reduced version, for selecting a suitable LSM and its linked scale:

Figure 18 - Decision Matrix for Learning Style Models

	Apter	Grasha - Riechmann Student Learning Style Scale	Felder & Soloman - ILS	Herrmann's Brain Dominance Instrument (HBDI)	Honey and Mumford's Learning Styles Questionnaire (LSQ)	Jackson's Learning Styles Profiler (LSP)	Kolb's Learning Style Inventory (LSI)	Myers-Briggs Type Indicator - MBTI	VAK	VARK	Vermunt's Inventory of Learning Styles (ILS)
Try to explain Learning Styles		x	x		x	x	x		x	x	x
Try to explain Personality Types	x							x			
Focus on group dynamics, etc.				x							
Application in TEL research		x	x								x
Application in Traditional Learning		x	x		x	x	x		x	x	x
independently validated	x	x	x	x	x		x	x	x	x	x
4rd party accredited reliability	x	x	x		x	x	x	x		x	x
Availability of previous research data			x				x		x		
Commercially driven		x			x		x	x		x	
Freely available for research purposes			x						x		x
Amount of question in FREE tools *			44						30		120
Highly sophisticated method		x	x					x		x	x

	Apter	Grasha - Riechmann Student Learning Style Scale	Felder & Soloman - ILS	Herrmann's Brain Dominance Instrument (HBDI)	Honey and Mumford's Learning Styles Questionnaire (LSQ)	Jackson's Learning Styles Profiler (LSP)	Kolb's Learning Style Inventory (LSI)	Myers-Briggs Type Indicator - MBTI	VAK	VARK	Vermunt's Inventory of Learning Styles (ILS)
Try to explain Learning Styles		x	x		x	x	x		x	x	x
Try to explain Personality Types											
Focus on group dynamics, etc.											
Application in TEL research			1								1
Application in Traditional Learning			1						1		1
independently validated			1						1		1
4rd party accredited reliability			1								1
Availability of previous research data			1						1		
Commercially driven											
Freely available for research purposes			1						1		1
Amount of question in FREE tools *			3						2		1
Highly sophisticated method			1								1
			10						6		7
Ranking			1						3		2

= exclusion criteria * closest to avg.

The Felder-Soloman Inventory of Learning Styles [FS-ILS] questionnaire with 44 binary questions is suitable for the application in traditionally and technology enabled learning and teaching, and for a cross teaching method comparison.

As participants are often difficult to motivate to complete surveys, especially if they are long. Instruments with a large number of questions can be utilised only once because participants tend to choose answers without being aware of the future application or consequences of the survey results (Popescu, 2017). It can be claimed that these issues are valid for Vermut's well-judged ILS model that presents 120 questions. Honey and Mumford suggest that there is a danger of nonconforming credibility of the student's self-perception (of their learning styles) since *"self-perceptions can be misleading and the answers are easy to fake if someone is determined to give a misleading impression"* (Honey and Mumford, 2000, p.20).

Based on the number of 44 questions of the ILS I assumed and self-tested that it should not require an enormous time to complete, which indicated that the ILS was feasible to apply to a survey twice to allow additional comparison of pre- and post-intervention data.

7.3 Learning Styles in Felder's ILS

The following table illustrates the eight different learning styles that form the ILS:

Table 41 - ILS Learning Styles Descriptions

Types of Learning Styles Preferences

Active	Reflective
Active learners prefer to apply new information to retain it and discussing or explaining information. They perceive group work beneficially by working together, discussing, and solving tasks. It is important for them to put learned immediately into an application context.	Reflective learners need to study in peace and with enough time to think about the subject matter and process it theoretically. They prefer periodical reviews on previous content and generating potential questions and applications. They prefer to work alone or with a close person.
Sensing	**Intuitive**
Sensory learners prefer data and facts as well as proven solutions when learning. They like to solve problems with well-established methods and do not like complications and surprises. Sensory learners are patient with details, and they are good at remembering facts and doing practical work, while being more cautious than intuitive learners. They also prefer courses that offer a recognizable connection to the real world.	Intuitive learners prefer innovations and quickly understand and retain new, complex concepts. They like innovation and have an aversion to repetition. Intuitive learners often pick up on new concepts better and they cope better with abstractions and mathematical formulas. Intuitive learners tend to work faster than sensory learners and they are usually more innovative than sensory learners. They don't like courses where they have to learn a by heart or where they have to do a lot of routine work, such as calculations.
Visual	**Verbal**
Visual learners remember information better that they can take from pictures, diagrams, films. They prefer finding or creating visual material for learning content, while outlining the course material in a logical order. They often like to concept/mind mapping and color-coding to arrange key concepts visually.	Verbal learners remember information better from written or oral media. They will retain content particularly well if they write summaries or explain the material to each other in learning groups.
Sequential	**Global**
Sequential learners work through the subject matter step by step in logical and chronological order. They tend to follow logical, step-by-step paths when solving problems, thus prefer working with organized and systematic information.	Global learners tend to learn in great leaps and bounds by almost randomly picking up the material without seeing connections, and then suddenly understanding it. They can often solve complex problems more quickly or put things together in new ways once they have grasped the big picture, but they often have difficulty explaining how they actually did it.

Adopted from (Felder, 2016; Felder and Brent, 2005; Felder and Spurlin, 2005)

7.4 Survey Question Matrix

The study applied the following questions construct:

Table 42 - Number of Questions Types

Survey	Binary	Likert	Statistical-open	Independent-Open	Paired Likert-Open
Pre	2	2	2	-	-
Post	1	8	2	4	3
ILS (pre / post)	44	-	-	-	-

In summary, the pre-intervention survey consisted of 50 questions and the post-intervention survey of 62 questions[71].

[71] See 7.8 in the appendix for the complete pre- and post-intervention survey templates.

7.5 Demographic Data

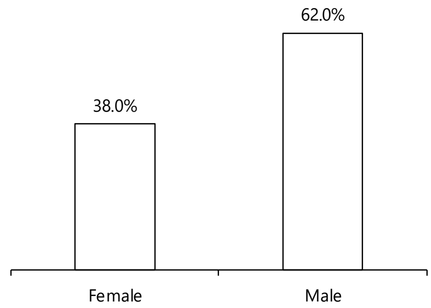
7.5.1 Gender

Pre-intervention survey

Table 43 - Frequency for Gender - Pre

	Female	*Male*	N
N	35	57	92
Percentage	38.00%	62.00%	100.00%

Figure 19 - Frequency for Gender - Pre

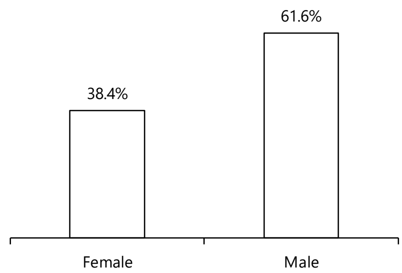


Post-intervention survey

Table 44 - Frequency for Gender - Post

	Female	*Male*	N
N	28	45	73
Percentage	38.4%	61.6%	100.0%

Figure 20 - Frequency for Gender - Post



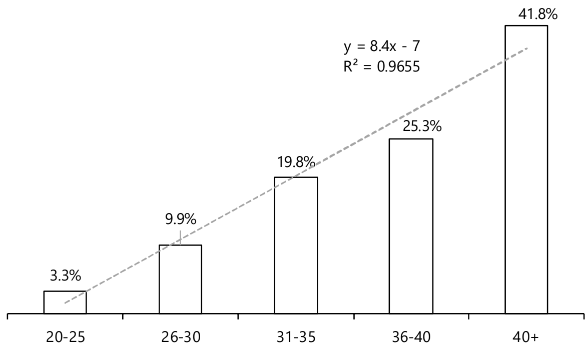
7.5.2 Age

Pre-intervention survey

Table 45 - Frequency for Age - Pre

	20-25	*26-30*	*31-35*	*36-40*	*40+*	*N*
N	3	9	18	23	38	92
Percentage	3.3%	9.9%	19.8%	25.3%	41.8%	100.0%

Figure 21 - Frequency for Age - Pre

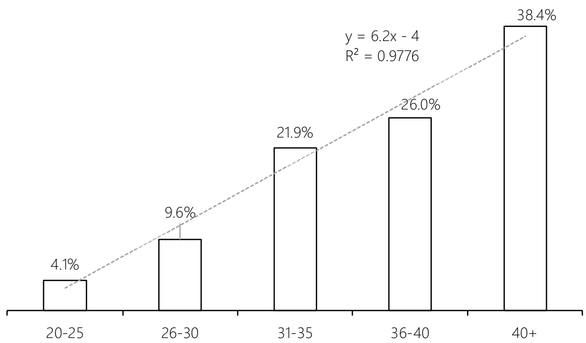


Post-intervention survey

Table 46 - Frequency for Age - Post

	20-25	26-30	31-35	36-40	40+	N
N	3	7	16	19	28	73
Percentage	4.1%	9.6%	21.9%	26.0%	38.4%	100.0%

Figure 22 - Frequency for Age - Post



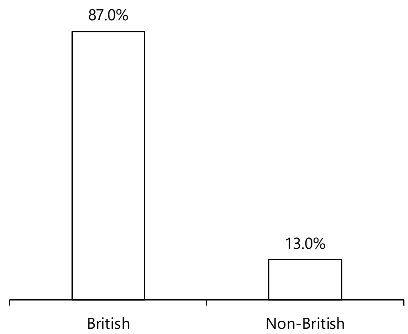
7.5.3 Nationality

Pre-intervention survey

Table 47 - Frequency for Nationality - Pre

	British	*Non-British*	*N*
N	80	12	92
Percentage	87.0%	13.0%	100.0%

Figure 23 - Frequency for Nationality - Pre

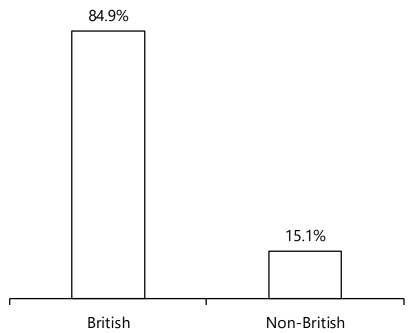


Post-intervention survey

Table 48 - Frequency for Nationality - Post

	British	Non-British	N
N	62	11	73
Percentage	84.9%	15.1%	100.0%

Figure 24 - Frequency for Nationality - Post



7.5.4 Familiarity with AR

Participants were asked before the AR intervention if they were familiar with the term "Augmented Reality" and if they made already experiences with AR in learning and teaching.

The familiarity with AR approached a normal distribution where 32.6% of all participants (n=92) reported a slight familiarity as the maximum amplitude. The familiarity declined then quickly to a low 5.4% of extreme familiarity. This shows that overall, many participants were not aware of AR at all, despite the fact that this technology is known for more than half a century and reached a certain maturity.

Figure 25 - $Q1_{pre}$: Familiarity with the Term "Augmented Reality"

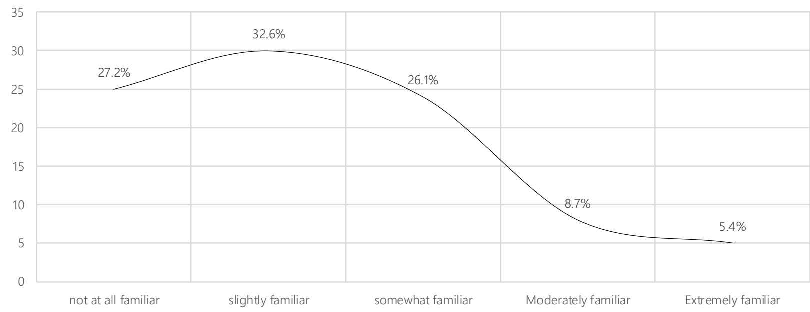


Table 49 - $Q1_{pre}$: Familiarity with the Term "Augmented Reality"

	not at all familiar	*slightly familiar*	*somewhat familiar*	*Moderately familiar*	*Extremely familiar*	N
N	25	30	24	8	5	925
Percentage	27.2%	32.6%	26.1%	8.7%	5.4%	100%

Interesting was the discrepancy between male (n=57) and female (n=35) participants. The female sample showed a significant shift to not being familiar with AR (40,00%), while the male sample reported more a normal distributed pre-knowledge around being somewhat familiar with AR (31.58%).

Figure 26 - $Q1_{pre}$: Familiarity with the term "Augmented Reality" by Gender

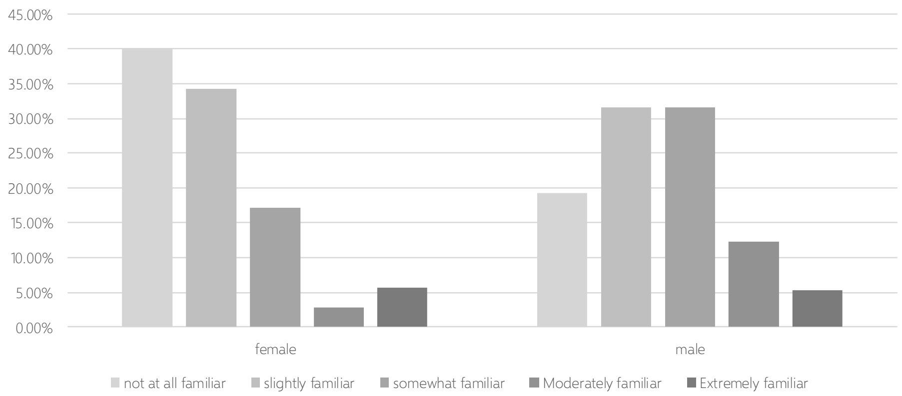


Table 50 - $Q1_{pre}$: Familiarity with the term "Augmented Reality" by Gender

	not at all familiar	*slightly familiar*	*somewhat familiar*	*Moderately familiar*	*Extremely familiar*	N
female	40.00%	34.29%	17.14%	2.86%	5.71%	35
male	19.30%	31.58%	31.58%	12.28%	5.26%	57

Only the age rage 40+ distinguished with a steady decrease of familiarity with AR, while the other the age range samples have settled around the neutral centre.

Figure 27 - $Q1_{pre}$: Familiarity with the term "Augmented Reality" by Age Range

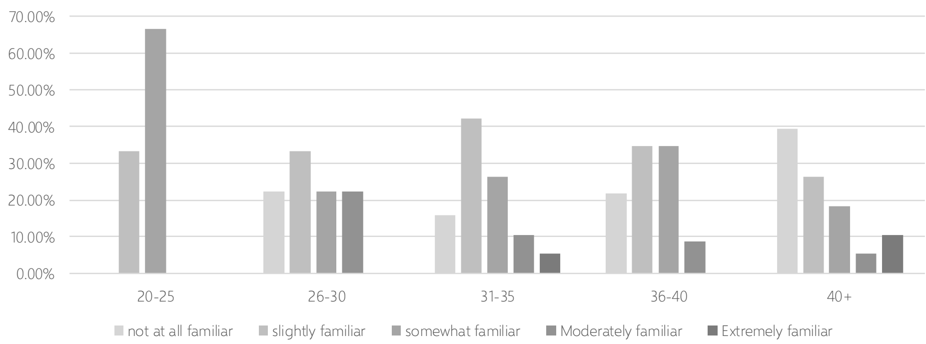


Table 51 - $Q1_{pre}$: Familiarity with the term "Augmented Reality" by Age Range

	not at all familiar	*slightly familiar*	*somewhat familiar*	*Moderately familiar*	*Extremely familiar*	MD	IQR
20-25	0.00%	33.33%	66.67%	0.00%	0.00%	2.0	0.5
26-30	22.22%	33.33%	22.22%	22.22%	0.00%	1.0	1.0
31-35	15.79%	42.11%	26.32%	10.53%	5.26%	1.0	1.0
36-40	21.74%	34.78%	34.78%	8.70%	0.00%	1.0	1.0
40+	39.47%	26.32%	18.42%	5.26%	10.53%	1.0	2.0

7.5.5 Previous Experience with AR in Learning

The participants were asked if they made experience with AR in learning and teaching environments before the AR intervention, and the absolute majority of 91.30% denied it.

Figure 28 - Q2$_{pre}$: Experience with AR in Learning

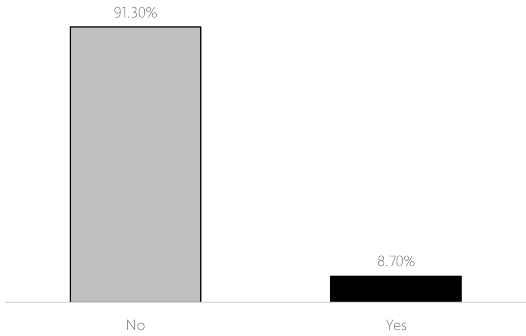


Table 52 - Q2$_{pre}$: Experience with AR in Learning

	Yes	*No*
N	8	84
Percentage	8.70%	91.30%

The distribution between were almost identical (male=91.23%; female=91.43%). Nevertheless, the distribution within the age range is approximately linear increasing for both agreement and denial.

Figure 29 - Q2$_{pre}$: Experience with AR in Learning by Age Range

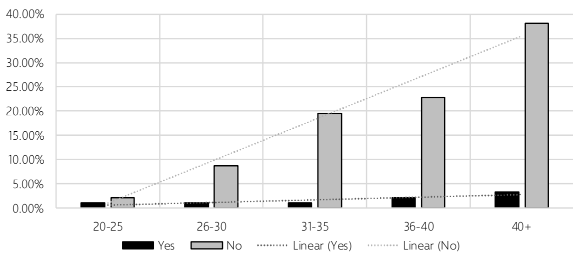


Table 53 - Q2$_{pre}$: Experience with AR in Learning by Age Range

	Yes	*No*
20-25	1.09%	66.67%
26-30	1.09%	88.89%
31-35	1.09%	94.74%
36-40	2.17%	91.30%
40+	3.26%	92.11%
M	1.74%	86.74%
σ	0.97%	11.41%

7.6 ILS Results

7.6.1 ILS Results: Complete Sample

Figure 30 - Sample Sizes (Pre/Post)

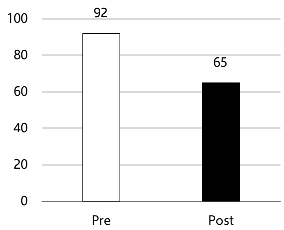


Table 54 - ILS Sample Size (Pre - Post)

	N
Pre	92
Post	65

Figure 31 - ILS Overall Scores (Pre/Post)

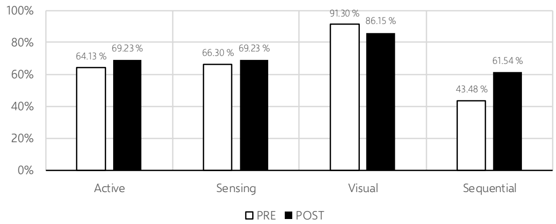


Table 55 - ILS Overall Scores (Pre/Post)

	Pre	*Post*	**Δ**
Active	64.13%	69.23%	5.10%
Sensing	66.30%	69.23%	2.93%
Visual	91.30%	86.15%	-5.15%
Sequential	43.48%	61.54%	18.06%
σ	16.96%	9.00%	8.33%
MD	65.22%	69.23%	5.13%

Figure 32 - ILS Overall Grades (Pre/Post)

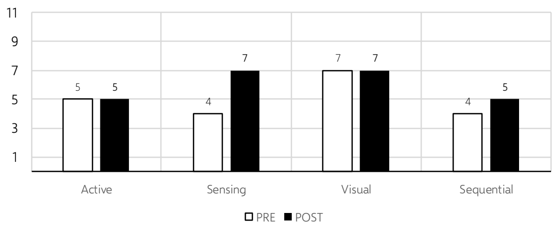


Table 56 - ILS Overall Grades (Pre/Post)

	Pre	*Post*	**Δ**	**MD**
Active	5	5	0	5.0
Sensing	4	7	3	6.0
Visual	7	7	0	7.0
Sequential	4	5	1	5.0
σ	1.2	1.0		
MD	4.5	6.0		
IQR	1.5	2.0		

Table 57 - Welch Anova on Complete Sample (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.05	Alpha	0.05	Alpha	0.05	Alpha	0.05
F-stat	0.306	F-stat	13.940	F-stat	0.344	F-stat	1.606
df1	1	df1	1	df1	1	df1	1
df2	81.408	df2	87.290	df2	106.287	df2	77.138
p-value	0.582	p-value	0.000	p-value	0.559	p-value	0.209
sig	no	sig	yes	sig	no	sig	no

7.6.2 ILS Results: Gender Pre / Post

Figure 33 - Sample Sizes by Gender (Pre/Post)

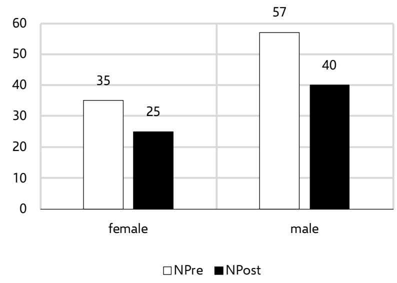


Table 58 - ILS Sample Size by Gender (Pre/Post)

	N_{Pre}	N_{Post}
female	35	25
male	57	40

Figure 34 - ILS Scores by Gender (Pre)

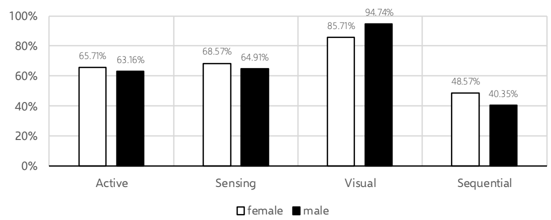


Table 59 - ILS Scores by Gender (Pre)

	Active	*Sensing*	*Visual*	*Sequential*	**σ**	MD
female	65.71%	68.57%	85.71%	48.57%	15.21%	67.14%
male	63.16%	64.91%	94.74%	40.35%	22.31%	64.04%
σ	1.81%	2.59%	6.38%	5.81%		
MD	64.44%	66.74%	90.23%	44.46%		

Figure 35 - ILS Scores by Gender (Pre)

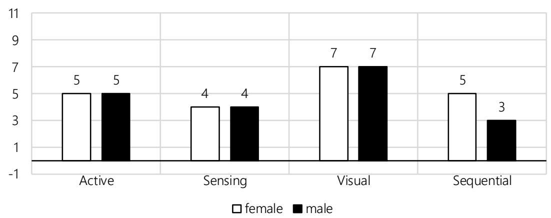


Table 60 - ILS Grades by Gender (Pre)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD	IQR
female	5	4	7	5	1.26	5.0	0.75
male	5	4	7	3	1.71	4.0	1.75
σ	0.00	0.00	0.00	1.41			
MD	5.0	4.0	7.0	4.0			

Figure 36 - ILS Scores by Gender (Post)

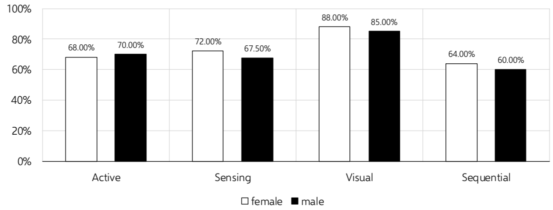


Table 61 - ILS Scores by Gender (Post)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD	IQR
female	68.00%	72.00%	88.00%	64.00%	10.52%	70.00%	0.50
male	70.00%	67.50%	85.00%	60.00%	10.48%	68.75%	2.00
σ	1.41%	3.18%	2.12%	2.83%			
MD	69.00%	69.75%	86.50%	62.00%			

Figure 37 - ILS Grades by Gender (Post)

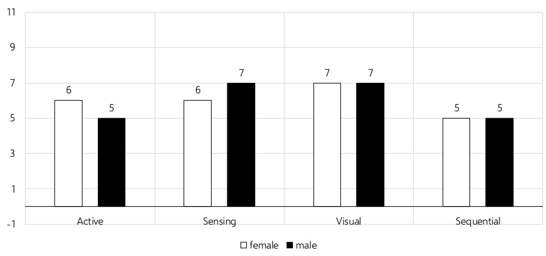


Table 62 - ILS Grades by Gender (Post)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD
female	6	6	7	5	0.82	6.0
male	5	7	7	5	1.15	5.0
σ	0.71	0.71	0.00	0.00		
MD	5.5	6.5	7.0	5.0		

Figure 38 - ILS Scores Delta by Gender (Pre/Post)

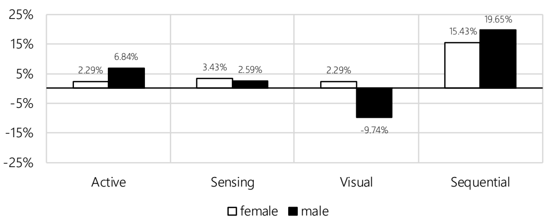


Table 63 - ILS Scores Delta by Gender (Pre/Post)

	Active	Sensing	Visual	Sequential	M	σ	MD
female	2.29%	3.43%	2.29%	15.43%	5.86%	6.40%	2.86%
male	6.84%	2.59%	-9.74%	19.65%	4.84%	12.12%	4.71%
M	4.56%	3.01%	-3.73%	17.54%			
σ	3.22%	0.59%	8.50%	2.98%			
MD	4.56%	3.01%	-3.73%	17.54%			

Figure 39 - ILS Grades Delta by Gender (Pre/Post)

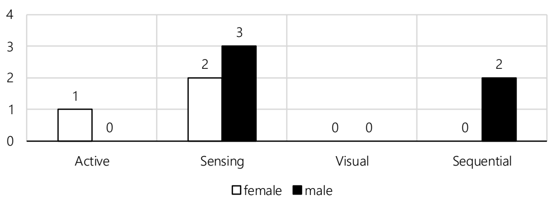


Table 64 - ILS Grades Delta by Gender (Pre/Post)

	Active	Sensing	Visual	Sequential	M	σ	MD	IQR
female	1	2	0	0	1	1	1	1.25
male	0	3	0	2	1	2	1	2.25
M	0.5	2.5	0.0	1.0				
σ	0.7	0.7	0.0	1.4				
MD	0.5	2.5	0.0	1.0				

Table 65 - Welch Anova by Female (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.05	Alpha	0.05	Alpha	0.05	Alpha	0.05
F-stat	0.975	F-stat	1.939	F-stat	0.249	F-stat	0.247
df1	1	df1	1	df1	1	df1	1
df2	28.981	df2	28.201	df2	40.605	df2	30.682
p-value	0.332	p-value	0.175	p-value	0.620	p-value	0.623
sig	no	sig	no	sig	no	sig	no

Table 66 - Welch Anova by Male (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.05	Alpha	0.05	Alpha	0.05	Alpha	0.05
F-stat	0.000	F-stat	5.209	F-stat	0.001	F-stat	0.851
df1	1	df1	1	df1	1	df1	1
df2	15.387	df2	14.072	df2	15.215	df2	16.943
p-value	1.000	p-value	0.039	p-value	0.973	p-value	0.369
sig	no	sig	yes	sig	no	sig	no

7.6.3 ILS Results: Age Range Pre / Post

Figure 40 - Sample Sizes by Age Range (Pre/Post)

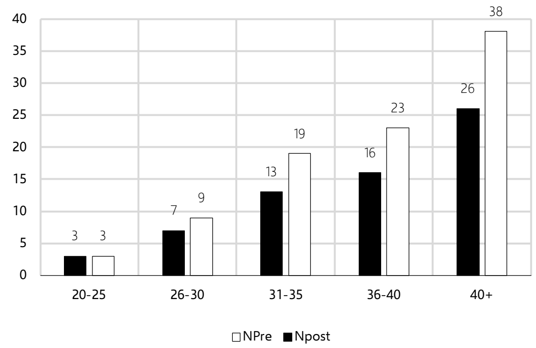


Table 67 - ILS Sample Size by Age Range (Pre/Post)

	N_{Pre}	N_{post}
40+	38	26
36-40	23	16
31-35	19	13
26-30	9	7
20-25	3	3
∑	92	65

Figure 41 - ILS Scores by Age Range (Pre)

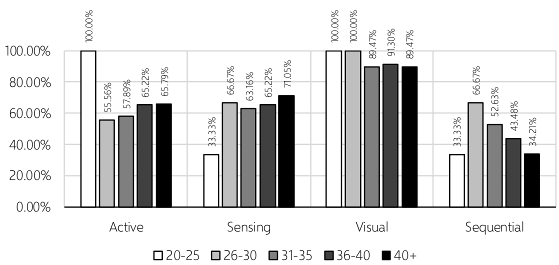


Table 68 - ILS Scores by Age Range (Pre)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD	IQR
40+	65.79%	71.05%	89.47%	34.21%	22.98%	68.42%	0.50
36-40	65.22%	65.22%	91.30%	43.48%	66.31%	19.57%	0.75
31-35	57.89%	63.16%	89.47%	52.63%	16.36%	60.53%	0.75
26-30	55.56%	66.67%	100.00%	66.67%	19.25%	66.67%	2.00
20-25	100.00%	33.33%	100.00%	33.33%	38.49%	66.67%	7.50
σ	17.96%	15.12%	5.48%	13.94%			
MD	65.22%	65.22%	91.30%	43.48%			

Figure 42 - ILS Grades by Age Range (Pre)

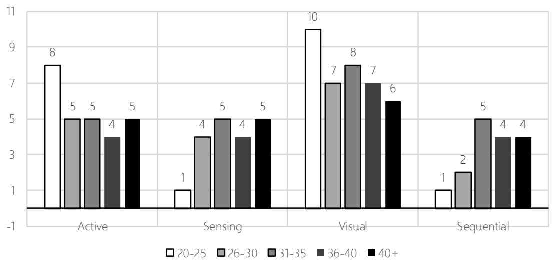


Table 69 - ILS Grades by Age Range (Pre)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD	IQR
40+	5	5	6	4	0.82	5.0	0.50
36-40	4	4	7	4	1.50	4.0	0.75
31-35	5	5	8	5	1.50	4.5	0.75
26-30	5	4	7	2	2.08	3.5	2.00
20-25	8	1	10	1	4.69	1.5	7.50
σ	1.5	1.6	1.5	1.6			
MD	5.0	4.0	7.0	4.0			
IQR	0.0	1.0	1.0	2.0			

Figure 43 - ILS Scores by Age Range (Post)

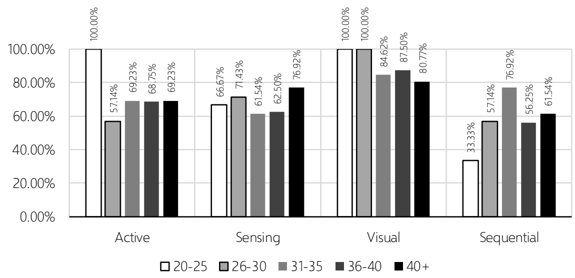


Table 70 - ILS Scores by Age Range (Post)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD
40+	69.23%	76.92%	80.77%	61.54%	8.53%	73.08%
36-40	68.75%	62.50%	87.50%	56.25%	13.50%	65.63%
31-35	69.23%	61.54%	84.62%	76.92%	9.93%	73.08%
26-30	57.14%	71.43%	100.00%	57.14%	20.20%	64.29%
20-25	100.00%	66.67%	100.00%	33.33%	31.92%	83.34%
σ	16.02%	6.42%	8.93%	15.64%		
MD	69.23%	66.67%	87.50%	57.14%		

Figure 44 - ILS Grades by Age Range (Post)

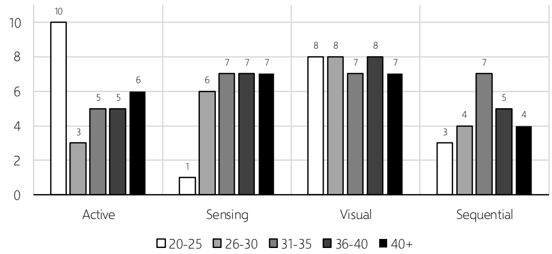


Table 71 - ILS Grades by Age Range (Post)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD	IQR
40+	6	7	7	4	1.41	6.5	1.50
36-40	5	7	8	5	1.50	5.0	2.25
31-35	5	7	7	7	1.00	5.5	0.50
26-30	3	6	8	4	2.22	4.5	2.75
20-25	10	1	8	3	4.20	2.0	6.00
σ	2.59	2.61	0.55	1.52			
MD	5.0	7.0	8.0	4.0			
IQR	1.0	1.0	1.0	1.0			

Figure 45 - ILS Scores Delta by Age Range (Pre/Post)

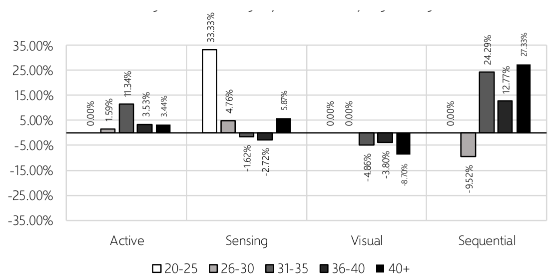


Table 72 - ILS Scores Delta by Age Range (Pre/Post)

	Active	*Sensing*	*Visual*	*Sequential*	σ	MD
40+	3.44%	5.87%	-8.70%	27.33%	14.99%	4.66%
36-40	3.53%	-2.72%	-3.80%	12.77%	7.60%	0.41%
31-35	11.34%	-1.62%	-4.86%	24.29%	13.32%	4.86%
26-30	1.59%	4.76%	0.00%	-9.52%	6.15%	0.80%
20-25	0.00%	33.33%	0.00%	0.00%	16.67%	0.00%
σ	4.37%	14.70%	3.66%	15.72%		
MD	3.44%	4.76%	-3.80%	12.77%		

Figure 46 - ILS Grades Delta by Age Range (Pre/Post)

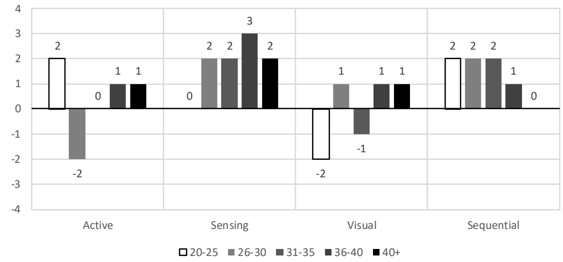


Table 73 - ILS Grades Delta by Age Range (Pre/Post)

	Active	*Sensing*	*Visual*	*Sequential*	**σ**	MD	IQR
40+	1	2	1	0	0.82	5.0	0.50
36-40	1	3	1	1	1.50	4.0	0.75
31-35	0	2	-1	2	1.50	4.5	0.75
26-30	-2	2	1	2	2.08	3.5	2.00
20-25	2	0	-2	2	4.69	1.5	7.50
σ	1.5	1.1	1.4	1.4			
MD	1.0	2.0	1.0	0.9			
IQR	1.00	0.00	2.00	2.0			

Table 74 - Welch Anova by Age Range (40+) (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.05	Alpha	0.05	Alpha	0.05	Alpha	0.05
F-stat	0.377	F-stat	4.811	F-stat	0.850	F-stat	0.168
df1	1.000	df1	1.000	df1	1.000	df1	1.000
df2	28.289	df2	34.426	df2	39.204	df2	25.991
p-value	0.544	p-value	0.035	p-value	0.362	p-value	0.685
sig	no	sig	yes	sig	no	sig	no

Table 75 - Welch Anova by Age Range (36-39) (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.050	Alpha	0.050	Alpha	0.050	Alpha	0.050
F-stat	0.308	F-stat	11.335	F-stat	0.023	F-stat	0.549
df1	1.000	df1	1.000	df1	1.000	df1	1.000
df2	17.352	df2	19.615	df2	22.574	df2	12.340
p-value	0.586	p-value	0.003	p-value	0.880	p-value	0.473
sig	no	sig	yes	sig	no	sig	no

Table 76 - Welch Anova by Age Range (31-35) (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.05	Alpha	0.05	Alpha	0.05	Alpha	0.05
F-stat	0.000	F-stat	5.209	F-stat	0.001	F-stat	0.851
df1	1.000	df1	1.000	df1	1.000	df1	1.000
df2	15.387	df2	14.072	df2	15.215	df2	16.943
p-value	1.000	p-value	0.039	p-value	0.973	p-value	0.369
sig	no	sig	yes	sig	no	sig	no

Table 77 - Welch Anova by Age Range (26-30) (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.050	Alpha	0.050	Alpha	0.050	Alpha	0.050
F-stat	7.567	F-stat	3.600	F-stat	0.152	F-stat	3.049
df1	1.000	df1	1.000	df1	1.000	df1	1.000
df2	5.053	df2	7.692	df2	10.419	df2	5.833
p-value	0.040	p-value	0.096	p-value	0.704	p-value	0.133
sig	yes	sig	no	sig	no	sig	no

Table 78 - Welch Anova by Age Range (20-25) (Pre/Post)

ACTIVE		SENSING		VISUAL		SEQUENTIAL	
Alpha	0.050	Alpha	0.050	Alpha	0.050	Alpha	0.050
F-stat	0.500	F-stat	0.000	F-stat	n/a*	F-stat	0.400
df1	1.000	df1	1.000	df1	n/a*	df1	1.000
df2	2.000	df2	2.000	df2	n/a*	df2	1.220
p-value	0.553	p-value	1.000	p-value	n/a*	p-value	0.625
sig	no	sig	no	sig	n/a*	sig	no

*The Age range 20-25 does not offer required amount of data for calculating a Welch Anova test!
A minimum of four to 5 observations is recommended.

7.6.4 Meta Table of ILS Results of 42 Studies

The table below shows a selection of ILS results reported by other studies

Table 79 - Meta Table of ILS Results of 42 Studies

Sampled Population	Sample Groups	Field	Active	Sensing	Visual	Sequential	n	Reference	Original Reference
Iowa State	Accumulated	Materials Engineering	63.00 %	67.00 %	85.00 %	58.00 %	129	Felder & Spurlin, 2005	Constant
Michigan Tech	Accumulated	Environment Engineering	56.00 %	63.00 %	74.00 %	53.00 %	83	Felder & Spurlin, 2005	Paterson
Oxford Brookes University	Accumulated	Business	64.00 %	70.00 %	68.00 %	64.00 %	63	Felder & Spurlin, 2005	De Vita
Oxford Brookes University	British Students	Business	85.00 %	86.00 %	52.00 %	76.00 %	21	Felder & Spurlin, 2005	De Vita
Oxford Brookes University	International Students	Business	52.00 %	62.00 %	76.00 %	52.00 %	42	Felder & Spurlin, 2005	De Vita
Ryerson Univ., Elec. Engr.	Students (2000)	Electric Engineering	53.00 %	66.00 %	86.00 %	72.00 %	87	Felder & Spurlin, 2005	Zywno & Waalen
Ryerson Univ., Elec. Engr.	Students (2001)	Electric Engineering	60.00 %	66.00 %	89.00 %	59.00 %	119	Felder & Spurlin, 2005	Zywno
Ryerson Univ., Elec. Engr.	Students (2002)	Electric Engineering	63.00 %	63.00 %	89.00 %	58.00 %	132	Felder & Spurlin, 2005	Zywno
Ryerson Univ., Elec. Engr.	Faculty	Electric Engineering	38.00 %	42.00 %	94.00 %	35.00 %	48	Felder & Spurlin, 2005	Zywno
Tulane	2nd-year Students	Engineering	62.00 %	60.00 %	86.00 %	48.00 %	245	Felder & Spurlin, 2005	Livesay et al.
Tulane	1st-year Students	Engineering	56.00 %	46.00 %	83.00 %	56.00 %	192	Felder & Spurlin, 2005	Dee et al.
Universities in Belo Horizonte (Brazil)	Accumulated	Sciences	65.00 %	81.00 %	79.00 %	67.00 %	214	Felder & Spurlin, 2005	Lopes
Universities in Belo Horizonte (Brazil)	Accumulated	Humanities	52.00 %	62.00 %	39.00 %	62.00 %	235	Felder & Spurlin, 2005	Lopes
University of Limerick	Accumulated	Manufacturing Engineering	70.00 %	78.00 %	91.00 %	58.00 %	167	Felder & Spurlin, 2005	Seery et al.
University of Michigan	Accumulated	Chemical Engineering	67.00 %	57.00 %	69.00 %	71.00 %	143	Felder & Spurlin, 2005	Montgomery
University of Puerto Rico-Mayaguez	Semester 1	Biology	65.00 %	77.00 %	74.00 %	83.00 %	39	Felder & Spurlin, 2005	Buxeda & Moore
University of Puerto Rico-Mayaguez	Semester 2	Biology	51.00 %	69.00 %	66.00 %	85.00 %	37	Felder & Spurlin, 2005	Buxeda & Moore
University of Puerto Rico-Mayaguez	Semester 3	Biology	56.00 %	78.00 %	77.00 %	74.00 %	32	Felder & Spurlin, 2005	Buxeda & Moore
University of Puerto Rico-Mayaguez	Accumulated	Electric & Comp. Engineering	47.00 %	61.00 %	82.00 %	67.00 %	???	Felder & Spurlin, 2005	Buxeda et al.
University of Sao Paulo	Accumulated	Engineering	60.00 %	74.00 %	79.00 %	50.00 %	351	Felder & Spurlin, 2005	Kuri & Truzzi
University of Sao Paulo	Civil Engineering	Engineering	69.00 %	86.00 %	76.00 %	54.00 %	110	Felder & Spurlin, 2005	
University of Sao Paulo	Electric Engineering	Engineering	57.00 %	68.00 %	80.00 %	51.00 %	91	Felder & Spurlin, 2005	
University of Sao Paulo	Mechanical Engineering	Engineering	53.00 %	67.00 %	84.00 %	45.00 %	94	Felder & Spurlin, 2005	
University of Sao Paulo	Industrial Engineering	Engineering	66.00 %	70.00 %	73.00 %	50.00 %	56	Felder & Spurlin, 2005	
University of Technology, Kingston, Jamaica	Accumulated		55.00 %	60.00 %	70.00 %	55.00 %	???	Felder & Spurlin, 2005	Smith et al.
University of Western Ontario	Accumulated	Engineering	69.00 %	59.00 %	80.00 %	67.00 %	858	Felder & Spurlin, 2005	Rosati
University of Western Ontario	1st-year Students	Engineering	66.00 %	59.00 %	78.00 %	69.00 %	499	Felder & Spurlin, 2005	Rosati
University of Western Ontario	4th-year Students	Engineering	72.00 %	58.00 %	81.00 %	63.00 %	359	Felder & Spurlin, 2005	Rosati
University of Western Ontario	Faculty	Engineering	51.00 %	40.00 %	94.00 %	53.00 %	53	Felder & Spurlin, 2005	Rosati
University of Mauritius	Bsc (Hons)	Management	58.80 %	60.50 %	69.10 %	55.80 %	120	Heenaye et al., 2012	
University of Mauritius	Bsc (Hons)	Computer Science	50.20 %	53.50 %	56.00 %	51.20 %	120	Heenaye et al., 2013	
Dublin Institute of Technology	Level 7, Year 1	Engineering	66.00 %	75.00 %	93.00 %	67.00 %	208	O'Dwyer, 2010	
Dublin Institute of Technology	Level 8, Years 1, 3, 4	Engineering	66.00 %	62.00 %	90.00 %	56.00 %	71	O'Dwyer, 2010	
Dublin Institute of Technology	Level 9	Engineering	56.00 %	78.00 %	94.00 %	58.00 %	126	O'Dwyer, 2010	
Dublin Institute of Technology	Accumulated	Engineering	63.00 %	73.00 %	93.00 %	62.00 %	405	O'Dwyer, 2010	
Dublin Institute of Technology	Second Level, Engineering for the Leaving Cert	Engineering	70.00 %	79.00 %	91.00 %	58.00 %	163	O'Dwyer, 2010	Seery et al., 2003
LIT	Predominately Year 1	Engineering	70.00 %	80.00 %	86.00 %	54.00 %	101	O'Dwyer, 2010	O'Brien, 2008
IT Tallaght	Level 7, Year 1, 2002-3	Engineering	81.00 %	63.00 %	85.00 %	29.00 %		O'Dwyer, 2010	Cranley & O'Sullivan, 2005
IT Tallaght	Level 7, Year 1, 2003-4	Engineering	78.00 %	52.00 %	88.00 %	26.00 %		O'Dwyer, 2010	Cranley & O'Sullivan, 2005

IT Tallaght	Level 7, Year 1, 2004-5	Engineering	69.00 %	67.00 %	76.00 %	37.00 %		O'Dwyer, 2010	Cranley & O'Sullivan, 2005
UCC	Process and Chemical Engineering	Engineering	45.00 %	70.00 %	82.00 %	68.00 %	38	O'Dwyer, 2010	Byrne, 2007
Aston University	eMBA Accumulated, Pre AR-Intervention	Business	64.13 %	66.30 %	91.30 %	43.48 %	92		Hamer, 2020
Aston University	eMBA Accumulated, Post AR Intervention	Business	69.23 %	69.23 %	86.15 %	61.54 %	65		Hamer, 2020
Aston University	eMBA, Female, Pre AR-Intervention	Business	65.71 %	68.57 %	85.71 %	48.57 %	35		Hamer, 2020
Aston University	eMBA, Female, Post AR Intervention	Business	68.00 %	72.00 %	88.00 %	64.00 %	25		Hamer, 2020
Aston University	eMBA, Male, Pre AR-Intervention	Business	63.16 %	64.91 %	94.74 %	40.35 %	57		Hamer, 2020
Aston University	eMBA, Male, Post AR Intervention	Business	70.00 %	67.50 %	85.00 %	60.00 %	40		Hamer, 2020
		$M_{not\ accumulated}$	61.88 %	65.76 %	81.47 %	56.39 %			
		σ	10.42 %	11.47 %	10.47 %	14.11 %			

7.6.5 Meta Table of ILS Results of 42 Studies by SQL

Table 80 - Meta Table of ILS Results of 42 Studies by SQL

Sampled Population	Sample Groups	Field	Rank	Sequential	n
University of Puerto Rico-Mayaguez	Semester 2	Biology	1	85.00	37
University of Puerto Rico-Mayaguez	Semester 1	Biology	2	83.00	39
Oxford Brookes University	British Students	Business	3	76.00	21
University of Puerto Rico-Mayaguez	Semester 3	Biology	4	74.00	32
Ryerson Univ., Elec. Engr.	Students (2000)	Electric Engineering	5	72.00	87
University of Michigan	Accumulated	Chemical Engineering	6	71.00	143
University of Western Ontario	1st-year Students	Engineering	7	69.00	499
UCC	Process and Chemical Engineering	Engineering	8	68.00	38
Universities in Belo Horizonte (Brazil)	Accumulated	Sciences	9	67.00	214
University of Puerto Rico-Mayaguez	Accumulated	Electric & Comp. Engineering	9	67.00	???
University of Western Ontario	Accumulated	Engineering	9	67.00	858
Dublin Institute of Technology	Level 7, Year 1	Engineering	9	67.00	208
Oxford Brookes University	Accumulated	Business	13	64.00	63
Aston University	eMBA, Female, Post AR Intervention	Business	13	64.00	25
University of Western Ontario	4th-year Students	Engineering	15	63.00	359
Universities in Belo Horizonte (Brazil)	Accumulated	Humanities	16	62.00	235
Dublin Institute of Technology	Accumulated	Engineering	16	62.00	405
Aston University	eMBA, Accumulated, Post AR Intervention	Business	18	61.54	65
Aston University	eMBA, Male, Post AR Intervention	Business	19	60.00	40
Ryerson Univ., Elec. Engr.	Students (2001)	Electric Engineering	20	59.00	119
Iowa State	Accumulated	Materials Engineering	21	58.00	129
Ryerson Univ., Elec. Engr.	Students (2002)	Electric Engineering	21	58.00	132
University of Limerick	Accumulated	Manufacturing Engineering	21	58.00	167
Dublin Institute of Technology	Level 9	Engineering	21	58.00	126
Dublin Institute of Technology	Second Level, Engineering for the Leaving Cert	Engineering	21	58.00	163
Tulane	1st-year Students	Engineering	26	56.00	192
Dublin Institute of Technology	Level 8, Years 1, 3 and 4	Engineering	26	56.00	71
University of Mauritius	Bsc (Hons)	Management	28	55.80	120
University of Technology, Kingston, Jamaica	Accumulated		29	55.00	???
LIT	Predominately Year 1	Engineering	30	54.00	101
University of Sao Paulo	Civil Engineering	Engineering	30	54.00	110
Michigan Tech	Accumulated	Environment Engineering	32	53.00	83
University of Western Ontario	Faculty	Engineering	32	53.00	53
Oxford Brookes University	International Students	Business	34	52.00	42
University of Mauritius	Bsc (Hons)	Computer Science	35	51.20	120
University of Sao Paulo	Electric Engineering	Engineering	36	51.00	91
University of Sao Paulo	Accumulated	Engineering	37	50.00	351
University of Sao Paulo	Industrial Engineering	Engineering	37	50.00	56
Aston University	eMBA, Female, Pre AR-Intervention	Business	39	48.57	35
Tulane	2nd-year Students	Engineering	40	48.00	245
University of Sao Paulo	Mechanical Engineering	Engineering	41	45.00	94
Aston University	eMBA, Accumulated, Pre AR-Intervention	Business	42	43.48	92
Aston University	eMBA, Male, Pre AR-Intervention	Business	43	40.35	57
IT Tallaght	Level 7, Year 1, 2004-5	Engineering	44	37.00	
Ryerson Univ., Elec. Engr.	Faculty	Electric Engineering	45	35.00	48
IT Tallaght	Level 7, Year 1, 2002-3	Engineering	46	29.00	
IT Tallaght	Level 7, Year 1, 2003-4	Engineering	47	26.00	
		M		56.03	
		σ		13.67	
		MD	21	56.00	
		IQR	25	14.22	

7.6.6 Meta Table of ILS Results of 42 Studies by VSL

Table 81 - Meta Table of ILS Results of 42 Studies by VSL

Sampled Population	Sample Groups	Field	Rank	Visual	n
Aston University	eMBA, Male, Pre AR-Intervention	Business	1	94.74	57
Ryerson Univ., Elec. Engr.	Faculty	Electric Engineering	2	94.00	48
University of Western Ontario	Faculty	Engineering	2	94.00	53
Dublin Institute of Technology	Level 9	Engineering	2	94.00	126
Dublin Institute of Technology	Level 7, Year 1	Engineering	5	93.00	208
Dublin Institute of Technology	Accumulated	Engineering	5	93.00	405
Aston University	eMBA, Accumulated, Pre AR-Intervention	Business	7	91.30	92
University of Limerick	Accumulated	Manufacturing Engineering	8	91.00	167
Dublin Institute of Technology	Second Level, Engineering for the Leaving Cert	Engineering	8	91.00	163
Dublin Institute of Technology	Level 8, Years 1, 3 and 4	Engineering	10	90.00	71
Ryerson Univ., Elec. Engr.	Students (2001)	Electric Engineering	11	89.00	119
Ryerson Univ., Elec. Engr.	Students (2002)	Electric Engineering	11	89.00	132
Aston University	eMBA, Female, Post AR Intervention	Business	13	88.00	25
IT Tallaght	Level 7, Year 1, 2003-4	Engineering	13	88.00	
Aston University	eMBA, Accumulated, Post AR Intervention	Business	15	86.15	65
Ryerson Univ., Elec. Engr.	Students (2000)	Electric Engineering	16	86.00	87
Tulane	2nd-year Students	Engineering	16	86.00	245
LIT	Predominately Year 1	Engineering	16	86.00	101
Aston University	eMBA, Female, Pre AR-Intervention	Business	19	85.71	35
Iowa State	Accumulated	Materials Engineering	20	85.00	129
Aston University	"visual learning style"~15	Business	20	85.00	40
IT Tallaght	Level 7, Year 1, 2002-3	Engineering	20	85.00	
University of Sao Paulo	Mechanical Engineering	Engineering	23	84.00	94
Tulane	1st-year Students	Engineering	24	83.00	192
University of Puerto Rico-Mayaguez	Accumulated	Electric & Comp. Engineering	25	82.00	???
UCC	Process and Chemical Engineering	Engineering	25	82.00	38
University of Western Ontario	4th-year Students	Engineering	27	81.00	359
University of Sao Paulo	Electric Engineering	Engineering	28	80.00	91
University of Western Ontario	Accumulated	Engineering	28	80.00	858
Universities in Belo Horizonte (Brazil)	Accumulated	Sciences	30	79.00	214
University of Sao Paulo	Accumulated	Engineering	30	79.00	351
University of Western Ontario	1st-year Students	Engineering	32	78.00	499
University of Puerto Rico-Mayaguez	Semester 3	Biology	33	77.00	32
Oxford Brookes University	International Students	Business	34	76.00	42
IT Tallaght	Level 7, Year 1, 2004-5	Engineering	34	76.00	
University of Sao Paulo	Civil Engineering	Engineering	34	76.00	110
Michigan Tech	Accumulated	Environment Engineering	37	74.00	83
University of Puerto Rico-Mayaguez	Semester 1	Biology	37	74.00	39
University of Sao Paulo	Industrial Engineering	Engineering	39	73.00	56
University of Technology, Kingston, Jamaica	Accumulated		40	70.00	???
University of Mauritius	Bsc (Hons)	Management	41	69.10	120
University of Michigan	Accumulated	Chemical Engineering	42	69.00	143
Oxford Brookes University	Accumulated	Business	43	68.00	63
University of Puerto Rico-Mayaguez	Semester 2	Biology	44	66.00	37
University of Mauritius	Bsc (Hons)	Computer Science	45	56.00	120
Oxford Brookes University	British Students	Business	46	52.00	21
Universities in Belo Horizonte (Brazil)	Accumulated	Humanities	47	39.00	235
		M		82.26	
		σ		10.17	
		MD	24	85.00	
		IQR	22	12.50	

7.6.7 Meta Table of ILS Results of 42 Studies by SNL

Table 82 - Meta Table of ILS Results of 42 Studies by SNL

Sampled Population	Sample Groups	Field	Rank	Sensing	n
Oxford Brookes University	British Students	Business	1	86.00	21
University of Sao Paulo	Civil Engineering	Engineering	1	86.00	110
Universities in Belo Horizonte (Brazil)	Accumulated	Sciences	3	81.00	214
LIT	Predominately Year 1	Engineering	4	80.00	101
Dublin Institute of Technology	Second Level, Engineering for the Leaving Cert	Engineering	5	79.00	163
University of Limerick	Accumulated	Manufacturing Engineering	6	78.00	167
University of Puerto Rico-Mayaguez	Semester 3	Biology	6	78.00	32
Dublin Institute of Technology	Level 9	Engineering	6	78.00	126
University of Puerto Rico-Mayaguez	Semester 1	Biology	9	77.00	39
Dublin Institute of Technology	Level 7, Year 1	Engineering	10	75.00	208
University of Sao Paulo	Accumulated	Engineering	11	74.00	351
Dublin Institute of Technology	Accumulated	Engineering	12	73.00	405
Aston University	eMBA, Female, Post AR Intervention	Business	13	72.00	25
Oxford Brookes University	Accumulated	Business	14	70.00	63
University of Sao Paulo	Industrial Engineering	Engineering	14	70.00	56
UCC	Process and Chemical Engineering	Engineering	14	70.00	38
Aston University	eMBA, Accumulated, Post AR Intervention	Business	17	69.23	65
University of Puerto Rico-Mayaguez	Semester 2	Biology	18	69.00	37
Aston University	eMBA, Female, Pre AR-Intervention	Business	19	68.57	35
University of Sao Paulo	Electric Engineering	Engineering	20	68.00	91
Aston University	eMBA, Male, Post AR Intervention	Business	21	67.50	40
Iowa State	Accumulated	Materials Engineering	22	67.00	129
University of Sao Paulo	Mechanical Engineering	Engineering	22	67.00	94
IT Tallaght	Level 7, Year 1, 2004-5	Engineering	22	67.00	
Aston University	eMBA, Accumulated, Pre AR-Intervention	Business	25	66.30	92
Ryerson Univ., Elec. Engr.	Students (2000)	Electric Engineering	26	66.00	87
Ryerson Univ., Elec. Engr.	Students (2001)	Electric Engineering	26	66.00	119
Aston University	eMBA, Male, Pre AR-Intervention	Business	28	64.91	57
Michigan Tech	Accumulated	Environment Engineering	29	63.00	83
Ryerson Univ., Elec. Engr.	Students (2002)	Electric Engineering	29	63.00	132
IT Tallaght	Level 7, Year 1, 2002-3	Engineering	29	63.00	
Oxford Brookes University	International Students	Business	32	62.00	42
Universities in Belo Horizonte (Brazil)	Accumulated	Humanities	32	62.00	235
Dublin Institute of Technology	Level 8, Years 1, 3 and 4	Engineering	32	62.00	71
University of Puerto Rico-Mayaguez	Accumulated	Electric & Comp. Engineering	35	61.00	???
University of Mauritius	Bsc (Hons)	Management	36	60.50	120
Tulane	2nd-year Students	Engineering	37	60.00	245
University of Technology, Kingston, Jamaica	Accumulated		37	60.00	???
University of Western Ontario	Accumulated	Engineering	39	59.00	858
University of Western Ontario	1st-year Students	Engineering	39	59.00	499
University of Western Ontario	4th-year Students	Engineering	41	58.00	359
University of Michigan	Accumulated	Chemical Engineering	42	57.00	143
University of Mauritius	Bsc (Hons)	Computer Science	43	53.50	120
IT Tallaght	Level 7, Year 1, 2003-4	Engineering	44	52.00	
Tulane	1st-year Students	Engineering	45	46.00	192
Ryerson Univ., Elec. Engr.	Faculty	Electric Engineering	46	42.00	48
University of Western Ontario	Faculty	Engineering	47	40.00	53
		M		66.04	
		σ		10.84	
		MD	22	67.00	
		IQR	23	9.75	

7.6.8 Meta Table of ILS Results of 42 Studies by ACL

Table 83 - Meta Table of ILS Results of 42 Studies by ACL

Sampled Population	Sample Groups	Field	Rank	Active	n
Oxford Brookes University	British Students	Business	1	85.00	21
IT Tallaght	Level 7, Year 1, 2002-3	Engineering	2	81.00	
IT Tallaght	Level 7, Year 1, 2003-4	Engineering	3	78.00	
University of Western Ontario	4th-year Students	Engineering	4	72.00	359
Aston University	eMBA, Male, Post AR Intervention	Business	5	70.00	40
Dublin Institute of Technology	Second Level, Engineering for the Leaving Cert	Engineering	5	70.00	163
LIT	Predominately Year 1	Engineering	5	70.00	101
University of Limerick	Accumulated	Manufacturing Engineering	5	70.00	167
Aston University	eMBA, Post AR Intervention	Business	9	69.23	65
IT Tallaght	Level 7, Year 1, 2004-5	Engineering	10	69.00	
University of Sao Paulo	Civil Engineering	Engineering	10	69.00	110
University of Western Ontario	Accumulated	Engineering	10	69.00	858
Aston University	eMBA, Female, Post AR Intervention	Business	13	68.00	25
University of Michigan	Accumulated	Chemical Engineering	14	67.00	143
Dublin Institute of Technology	Level 7, Year 1	Engineering	15	66.00	208
Dublin Institute of Technology	Level 8, Years 1, 3 and 4	Engineering	15	66.00	71
University of Sao Paulo	Industrial Engineering	Engineering	15	66.00	56
University of Western Ontario	1st-year Students	Engineering	15	66.00	499
Aston University	eMBA, Female, Pre AR-Intervention	Business	19	65.71	35
Universities in Belo Horizonte (Brazil)	Accumulated	Sciences	20	65.00	214
University of Puerto Rico-Mayaguez	Semester 1	Biology	20	65.00	39
Aston University	eMBA, Pre AR-Intervention	Business	22	64.13	92
Oxford Brookes University	Accumulated	Business	23	64.00	63
Aston University	eMBA, Male, Pre AR-Intervention	Business	24	63.16	57
Dublin Institute of Technology	Accumulated	Engineering	25	63.00	405
Iowa State	Accumulated	Materials Engineering	25	63.00	129
Ryerson Univ., Elec. Engr.	Students (2002)	Electric Engineering	25	63.00	132
Tulane	2nd-year Students	Engineering	28	62.00	245
Ryerson Univ., Elec. Engr.	Students (2001)	Electric Engineering	29	60.00	119
University of Sao Paulo	Accumulated	Engineering	29	60.00	351
University of Mauritius	Bsc (Hons)	Management	31	58.80	120
University of Sao Paulo	Electric Engineering	Engineering	32	57.00	91
Dublin Institute of Technology	Level 9	Engineering	33	56.00	126
Michigan Tech	Accumulated	Environment Engineering	33	56.00	83
Tulane	1st-year Students	Engineering	33	56.00	192
University of Puerto Rico-Mayaguez	Semester 3	Biology	33	56.00	32
University of Technology, Kingston, Jamaica	Accumulated		37	55.00	???
Ryerson Univ., Elec. Engr.	Students (2000)	Electric Engineering	38	53.00	87
University of Sao Paulo	Mechanical Engineering	Engineering	38	53.00	94
Oxford Brookes University	International Students	Business	40	52.00	42
Universities in Belo Horizonte (Brazil)	Accumulated	Humanities	40	52.00	235
University of Western Ontario	Faculty	Engineering	42	51.00	53
University of Puerto Rico-Mayaguez	Semester 2	Biology	42	51.00	37
University of Mauritius	Bsc (Hons)	Computer Science	44	50.20	120
University of Puerto Rico-Mayaguez	Accumulated	Electric & Comp. Engineering	45	47.00	???
UCC	Process and Chemical Engineering	Engineering	46	45.00	38
Ryerson Univ., Elec. Engr.	Faculty	Electric Engineering	47	38.00	48
		M		62.44 %	
		σ		9.95	
		MD	24	64.13	
		IQR	22	13.00	

7.7 Excerpts from Qualitative Data Collection of Post-intervention survey

7.7.1 Perceptions for Balanced Mix of Learning and Teaching Methods

Table 84 - Perceptions for Balanced Mix of Learning and Teaching Methods

Post Q12	*Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?*	
Student Number	*Why*	*Extract for balanced view / mix of methods*
1	I'd still like a mix of methods	mix
3	A variety of methods is interesting	variety
12	Variety is welcome	variety
20	other methods of technology	other method of technology
21	Compliments other learning. Doesn't necessarily replace it.	compliment
31	I would like to use this as one of many ways to learn.	one of many
36	Yes, but in combination with traditional.	in combination with
39	Yes, can be very engaging and visual. However, would suit some subjects more than others.	would suit some more subjects than others
62	Depends. Depends on what type of information is being delivered.	depends on what type

7.7.2 Question 1: Response, Tagging, and AI Text Analysis

Table 85 - Question 1: Response, Tagging, and AI Text Analysis

Q1: Why do you perceive AR as suitable as a technology enabled learning method?

	Q1
Absolutely	13
Very well	27
Quite well	22
Very little	10
Not at all	0

	Q1E: Why?
Not answered	14
Invalid	0
Participants	73
N	59

AI Text analysis					
Sentiment			Emotion		
n	59		n	59	
positive	41	69.49%	Excited	29	49.15%
neutral	11	18.64%	Happy	18	30.51%
negative	7	11.86%	Indifferent	5	8.47%
			Bored	2	3.39%
			Sad	4	6.78%
			Angry	0	0.00%
			Fear	1	1.69%
			M		14.29%
			σ		18.49%

Table 86 - Question 1: Response, Tagging, and AI Text Analysis - Details

#	Rating	Why?	Tags	PD - AI	Adjusted	PD - AI	Adjusted
1	Very well	Engaging, interactive, suited to the digital age we're in.	Engaging, Interactive	positive	positive	Excited	Excited
2	Quite well	Given that we are at an exponential sale in terms of technology I think Augmented Reality will become more prevalent within many areas in the future.		positive	positive	Excited	Happy
3	Very well	Technology is the core of Augmented Reality therefore making it very well suited.		positive	positive	Excited	Excited
4	Absolutely	Brings a brand or topic or subject to life and interacts with its potential user, buyer or client.		positive	positive	Excited	Happy
5	Absolutely						
6	Quite well						
7	Very well	It helps your imaginative skills.		positive	positive	Excited	Happy
8	Very well	Augmented Reality is a great tool to explain to customers, engineers and other individuals require learning to have a feel and knowledge about a product or idea or service that is available in the market.		positive	positive	Excited	Excited
9	Absolutely	It makes the learning content more interactive and visual, which helps to better understand and memorise the concepts.	interactive	positive	positive	Excited	Excited
10	Absolutely	Everyone remembers interactive learning above reading in my opinion.	interactive	positive	positive	Excited	Excited
11	Quite well	I feel it is just making things a little flash. Maybe just my limited imagination for its potential.		neutral	neutral	Sad	Indifferent
12	Quite well	Able to help visualise		positive	positive	Excited	Happy
13	Very well	An interesting format to allow you to experience the content in a different way. It could also be great for children.	Novelty	positive	positive	Happy	Happy
14	Very well	Engagement of learners. Visual Memory plus impact. More kinaesthetic impact.	Engagement	positive	positive	Excited	Excited
15	Absolutely	I believe that learning by practicing is much better than traditional learning by explaining.	Engagement	positive	positive	Happy	Happy
16	Very well						
17	Very little	Difficult to tell as the site went down :-(		negative	negative	Sad	Sad
18	Very well	There are clearly opportunities to create real-world experiences in a virtual environment, e.g. surgery, manufacturing processes, even hanging art in a gallery.		negative	positive	Excited	Excited
19	Very well	Engaging.	Engaging	positive	positive	Happy	Happy
20	Very well	if executed correctly.		neutral	neutral	Angry	Indifferent
21	Quite well	Work in learning & have seen it before.		neutral	neutral	Bored	Bored
22	Very little	Can be done other ways with same impact.		negative	negative	Bored	Bored
23	Quite well	Future potential.	Relevance	neutral	neutral	Excited	Happy
24	Absolutely	Gives learners different method to learn.		positive	positive	Excited	Excited
25	Quite well						

26	Very well	It can make content more interactive.	Interactive	neutral	neutral	Happy	Happy
27	Quite well	For us a part of a mix of learning and teaching methods. Also depends on the sector. It worked well in the welding example.		positive	positive	Excited	Excited
28	Quite well	Interesting and fairly accessible - quite easy to learn and navigate.	Engaging, easiness	positive	positive	Excited	Excited
29	Quite well						
30	Very well	Interacting, engaging, fun media.	Interactive, engaging	positive	positive	Excited	Excited
31	Absolutely	You can make the learning more interactive for those who learn that way.	Interactive	positive	positive	Excited	Excited
32	Very well	It combines images with plain written facts, creating an interesting visual learning tool.		negative	positive	Fear	Happy
33	Very little	My role is more people interactive based and doesn't really fit with Augmented Reality.		negative	negative	Sad	Sad
34	Very little	Has some applications. Welding example a good one.	Relevance	neutral	neutral	Happy	Happy
35	Quite well	Showed possibilities on how you can make a PowerPoint interactive. Definitely for the future.	Relevance	positive	positive	Excited	Excited
36	Very well	Allows users an interactive experience using lots of different types of material which they can use.	Interactive	positive	positive	Excited	Excited
37	Very well	Future method to help with learnings.	Relevance	positive	positive	Excited	Excited
38	Very little	Limited information for learning.		neutral	negative	Angry	Sad
39	Absolutely	Has potential to be very engaging.	Engaging	positive	positive	Excited	Excited
40	Quite well	Visually engaging.	Engaging	neutral	neutral	Excited	Excited
41	Absolutely	The interactivity promotes learning.	Interactive	positive	positive	Excited	Excited
42	Quite well						
43	Absolutely						
44	Quite well						
45	Quite well						
46	Very little	Nice additional feature but extensive investment in getting it working reliably on all devices.		positive	positive	Excited	Excited
47	Very well	Because it opens up another dimension to the lectures and students.		neutral	positive	Excited	Excited
48	Very well	Dependent on the subject matter.		neutral	neutral	Angry	Indifferent
49	Very well	Interactive learning, (in my opinion), works best.	Interactive	positive	positive	Excited	Excited
50	Quite well	Simple / Factual / on hand.	Engaging	positive	positive	Happy	Happy
51	Very little	Possibly, but limited at this stage.		negative	negative	Sad	Sad
52	Absolutely	Engaging.	Engaging	positive	positive	Happy	Happy
53	Absolutely						
54	Absolutely	Learning new technology.		positive	positive	Excited	Excited
55	Very well	Interaction - touch and feel and modernisation. Very much new generation friendly learning.	Interactive	positive	positive	Excited	Excited
56	Very little	I am unsure that the technology has many advantages against normal teaching methods.		negative	negative	Fear	Fear
57	Very little	Relevance to the next generation of learning.	Relevance	neutral	neutral	Excited	Happy
58	Very well	More engaging for students.	Engaging	positive	positive	Excited	Excited
59	Very little	A lot of effort for little gain. Information that is presented can be accessed via books or websites in a more user-friendly manner than through an app.		positive	negative	Happy	Happy
60	Very well	longer time for a project to submit as a group coursework.		neutral	neutral	Angry	Indifferent
61	Very well	Think good to show information and interactive.		positive	positive	Happy	Happy
62	Very well	Illustrate information visually well.		positive	positive	Excited	Excited
63	Quite well	Yes, but it needs time to learn it and implement it. I can see it being good for the younger generation as it is a part of their daily life and will use and adopt to it easier.	Satisfaction, Engaging	negative	positive	Happy	Happy
64	Very well	Yes, very interesting and keeps it interesting.	Engaging	positive	positive	Happy	Happy
65	Very well	Once familiar with this technique it could be good.		positive	positive	Excited	Excited
66	Quite well	Clever concept - useful in certain instances.	Satisfaction	positive	positive	Excited	Excited
67	Quite well						
68	Very well	It's interesting, easy to use, and AR create a multi-faceted experience.	Novelty, Easiness	positive	positive	Excited	Excited
69	Quite well	If used well it could be effective, but there would need to be a genuine application for the technology - not just a gimmick.		negative	neutral	Fear	Indifferent
70	Quite well	Much more interesting and interactive way of learning. It seems to engage the student much more thoroughly.	Engaging	positive	positive	Excited	Excited
71	Very well						

72	Quite well							
73	n/a							

Perception of interactivity	9
	15.25%
Satisfaction through engaging approach	13
	22.03%

7.7.3 Question 12: Response, Tagging, and AI Text Analysis

Table 87 - Question 12: Response, Tagging, and AI Text Analysis

Would you prefer an AR intervention over other methods or technology enabled or traditional learning and teaching?

	Q12
Absolutely	5
Very well	17
Quite well	28
Very little	12
Not at all	6

	Q12E: Why?
Not answered	26
Invalid	1
Participants	73
N	46

AI Text analysis					
Sentiment			Emotion		
n	47		n	47	
positive	32	68.09%	Excited	10	21.28%
neutral	10	21.28%	Happy	23	48.94%
negative	5	10.64%	Indifferent	10	21.28%
			Bored	0	0.00%
			Sad	4	8.51%
			Angry	0	0.00%
			Fear	0	0.00%
			M		14.29%
			σ		18.00%

Table 88 - Question 12: Response, Tagging, and AI Text Analysis - Details

#	Rating	Why?	Tags	PD - AI	Adjusted	PD - AI	Adjusted
1	Quite well	I'd still like a mix of methods		negative	negative	Angry	Indifferent
2	Quite well	People have less time within their working + personal times therefore anything that provides an opportunity to use technology is beneficial		positive	positive	Excited	Excited
3	Quite well	A variety of methods is interesting		positive	positive	Fear	Happy
4	Quite well	useful & interactive	Interactive	neutral	positive	Happy	Happy
5	Quite well	Would depend on the subject matter you are teaching.		neutral	neutral	Angry	Indifferent
6	Very well						
7	Very well	I'm still new with the programme, so, will need some more time.		positive	positive	Fear	Indifferent
8	Absolutely	AR give a feel of the real situation and provides a nicer way to pass message or info to others.		neutral	positive	Happy	Happy
9	Very well	Easier to remember, interactive, catches the audience's attention much better than traditional learning methods.	Attention, interactive	positive	positive	Excited	Excited
10	Absolutely	Because it enhances the learning		neutral	positive	Excited	Excited
11	Not at all	Don't see full potential. Limited experience of what it really could do.		negative	neutral	Sad	Indifferent
12	Quite well	Variety is welcome		positive	positive	Happy	Happy
13	Very well	More interesting than recorded lectures that I have seen.		negative	positive	Fear	Happy
14	Very little	Prefer a variety - all are useful in their own way.		positive	positive	Excited	Happy
15	Very well	It will add great value to the learning outcome.		positive	positive	Excited	Excited
16	Quite well						
17	Not at all						
18	Very well	The "practical" feel is better than simple lectures online.		positive	positive	Fear	Happy
19	Quite well	novelty	Novelty	neutral	neutral	Happy	Happy
20	Very well	other methods of technology		neutral	neutral	Angry	indifferent
21	Quite well	Compliments other learning. Doesn't necessarily replace it.		positive	positive	Happy	Happy
22	Quite well						

23	Quite well	Could make learning more interactive.	Interactive	neutral	positive	Sad	Happy
24	Very well						
25	Very little	More APP based storyboarding; less specific AR based. Spent most of time learning the tool instead of tackling through ideas.					
26	n/a						
27	Quite well	Yea, but it depends on the content.		neutral	positive	Happy	Happy
28	Very little	Doesn't look developed enough to be accepted by all & to be an efficient use of time and resources.		negative	negative	Sad	Sad
29	Very well	Easy story telling		positive	positive	Bored	Happy
30	Quite well	Depends on subject. It may or may not be appropriate or gimmicky but has a lot of potential.		neutral	neutral	Excited	Happy
31	Quite well	I would like to use this as one of many ways to learn.		neutral	positive	Happy	Happy
32	n/a						
33	Not at all	Prefer simple PowerPoint based learning.		positive	neutral	Happy	Indifferent
34	Not at all						
35	Very well						
36	Quite well	Yes, but in combination with traditional.		positive	positive	Happy	Happy
37	Quite well	It is still early days of my learning of AR, so would like to practice it more.		neutral	positive	Fear	Happy
38	Very little	Not enough detail		negative	negative	Sad	Sad
39	Very well	Yes, can be very engaging and visual. However, would suit some subjects more than others.		negative	positive	Happy	Happy
40	Quite well	Interactive and visually engaging as a teaching & learning tool.	Interactive	neutral	positive	Excited	Excited
41	Quite well						
42	Absolutely	If a whole day of teaching was done and we are participants not playing software developers.		negative	negative	Angry	sad
43	Very well						
44	Quite well						
45	n/a						
46	Very little	Yes, for scripted mechanical, repeatable tasks, e.g. Welding.		positive	positive	Excited	Happy
47	Quite well	Would like a balance of traditional & new technology.		neutral	neutral	Fear	Indifferent
48	Very little						
49	Quite well	Interactive learning is better than traditional learning!	Interactive	positive	positive	Excited	Happy
50	Quite well						
51	Very little						
52	Very well	Intuitive, different, engaging	Engaging	positive	positive	Excited	Excited
53	Absolutely	Engaging & futuristic	Engaging	neutral	positive	Happy	Excited
54	Very well						
55	Very well	More fitting with my preferred learning style.	Satisfaction	positive	positive	Excited	Excited
56	Very little						
57	Very little						
58	Very well						
59	Not at all	I prefer lectures & physical activity, including question answering, e.g. Practice exam questions.	Interactive	positive	positive	Sad	Happy
60	Quite well						
61	Quite well	I enjoyed interacting with it.	Interactive	positive	positive	Happy	Happy
62	Quite well	Depends. Depends on what type of information is being delivered.		neutral	neutral	Fear	Indifferent
63	Very little	Not yet as I don't understand it enough. An animate teaching me a subject to make it more fun would be good. Would be good for remote learning like the MBA.		positive	neutral	Happy	Indifferent

64	Quite well	Needs more understanding but very interesting.	Satisfaction	positive	positive	Fear	Happy
65	Very little	It is not sufficient developed or widely enough available, very little knowledge about how to use.		negative	negative	Excited	Sad
66	Not at all						
67	Quite well						
68	Very well	Yes, more fun & creative	Satisfaction, engaging	positive	positive	Happy	Happy
69	Very little	Only if it genuinely added value.		neutral	neutral	Sad	Indifferent
70	Absolutely	More interesting and engaging.	Satisfaction, engaging	positive	positive	Excited	Excited
71	Quite well	The interaction makes it more engaging.	Interaction, engaging	positive	positive	Excited	Excited
72	n/a						
73	n/a						

Perception of interactivity	7
	14.89%
Satisfaction through engaging approach	7
	14.893%

7.8 Questionnaires

7.8.1 Felder's ILS Questionnaire and Key

1	I understand something better after I …	
	try it out. ○	think it through. ○
2	I would rather be considered …	
	realistic. ○	innovative. ○
3	When I think about what I did yesterday, I am most likely to get …	
	a picture. ○	words. ○
4	I tend to …	
	understand details of a subject but may be fuzzy about its overall structure. ○	understand the overall structure but may be fuzzy about details. ○
5	When I am learning something new, it helps me to …	
	talk about it. ○	think about it. ○
6	If I were a teacher, I would rather teach a course …	
	that deals with facts and real-life situations. ○	that deals with ideas and theories. ○
7	I prefer to get new information in …	
	pictures, diagrams, graphs, or maps. ○	written directions or verbal information. ○
8	Once I understand …	
	all the parts, I understand the whole thing. ○	the whole thing, I see how the parts fit. ○
9	In a study group working on difficult material, I am more likely to …	
	jump in and contribute ideas. ○	sit back and listen. ○
10	I find it easier …	
	to learn facts. ○	to learn concepts. ○
11	In a book with lots of pictures and charts, I am likely to …	
	look over the pictures and charts carefully. ○	focus on the written text. ○

12	When I solve mathematical problems ... I usually work my way to the solutions one step at a time. ○ I often just see the solutions but then have to struggle to figure out the steps to get to them. ○
13	In classes I have taken ... I have usually gotten to know many of the students. ○ I have rarely gotten to know many of the students. ○
14	In reading non-fiction, I prefer... something that teaches me new facts or tells me how to do something. ○ something that gives me new ideas to think. ○
15	I like teachers ... who put a lot of diagrams on the board or projector. ○ who spend a lot of time explaining. ○
16	When I'm analysing a story or a novel ... I think of the incidents and try to put them together to figure out the themes. ○ I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them. ○
17	When I start a homework problem, I am more likely to ... start working on the solution immediately. ○ try to fully understand the problem first. ○
18	I prefer the idea of ... certainty. ○ theory. ○
19	I remember best ... what I see. ○ what I hear. ○
20	It is more important to me that an instructor ... lay out the material in clear sequential steps. ○ something that gives me new ideas to think. ○
21	I prefer to study ... in a study group. ○ alone. ○
22	I am more likely to be considered ... careful about the details of my work. ○ creative about how to do my work. ○
23	When I get directions to a new place, I prefer ... a map. ○ written instructions. ○

24	I learn ...	at a fairly regular pace. If I study hard, I'll "get it. ○	in fits and starts. I'll be totally confused and then suddenly it all "clicks.". ○
25	I would rather first ...	try things out. ○	think about how I'm going to do it. ○
26	When I am reading for enjoyment, I like writers to ...	clearly say what they mean. ○	say things in creative, interesting ways. ○
27	When I see a diagram or sketch in class, I am most likely to remember ...	the picture. ○	what the instructor said about it. ○
28	When considering a body of information, I am more likely to ...	focus on details and miss the big picture. ○	try to understand the big picture before getting into the details. ○
29	I more easily remember ...	something I have done. ○	something I have thought a lot about. ○
30	When I have to perform a task, I prefer to ...	master one way of doing it. ○	come up with new ways of doing it. ○
31	When someone is showing me data, I prefer ...	charts or graphs. ○	text summarizing the results. ○
32	When writing a paper, I am more likely to ...	work on (think about or write) the beginning of the paper and progress forward. ○	work on (think about or write) different parts of the paper and then order them. ○
33	When I have to work on a group project, I first want to ...	have "group brainstorming" where everyone contributes ideas. ○	brainstorm individually and then come together as a group to compare ideas. ○
34	I consider it higher praise to call someone ...	sensible. ○	imaginative. ○
35	When I meet people at a party, I am more likely to remember ...	what they looked like. ○	what they said about themselves. ○

36	When I am learning a new subject, I prefer to …		
	stay focused on that subject, learning as much about it as I can. ○	try to make connections between that subject and related subjects. ○	

37	I am more likely to be considered …	
	outgoing (extroverted). ○	reserved (introverted). ○

38	I prefer courses that emphasize …	
	concrete material (facts, data). ○	abstract material (concepts, theories). ○

39	For entertainment, I would rather …	
	watch television. ○	read a book. ○

40	Some lecturers start their lectures with an outline of what they will cover. Such outlines are …	
	somewhat helpful to me. ○	very helpful to me. ○

41	The idea of doing homework in groups, with one grade for the entire group, …	
	appeals to me. ○	does not appeal to me. ○

42	When I am doing long calculations, …	
	I tend to repeat all my steps and check my work carefully. ○	I find checking my work tiresome and have to force myself to do it. ○

43	I tend to picture places I have been …	
	easily and fairly accurately. ○	with difficulty and without much detail. ○

44	When solving problems in a group, I would be more likely …	
	think of the steps in the solution process. ○	think of possible consequences or applications of the solution in a wide range of areas. ○

7.8.2 Pre – Questionnaire

Age Please, tick the circle that corresponds to your age in a range.	20-25 years	26-30 years	31-35 years	36-40 years	>40 years
	○	○	○	○	○

Gender Please, tick the circle that corresponds your gender.	female	male
	○	○

Nationality Please, name your nationality.	

Last occupation Please, tell your professional background, e.g. finance, engineering, medical, IT, software, etc..	

Q1: Augmented Reality [AR] Do you think you are familiar with term "Augmented Reality"?	not at all familiar	Slightly familiar	Somewhat familiar	Moderately familiar	Extremely familiar
	○	○	○	○	○

Q2: AR in Learning & Teaching Did you made already experiences with Augmented Reality in Learning or Teaching environments.	No	Yes
	○	○

7.8.3 Post – Questionnaire

Age Please, tick the circle that corresponds to your age in a range.	20-25 years	26-30 years	31-35 years	36-40 years	>40 years
	O	O	O	O	O

Gender Please, tick the circle that corresponds your gender.	female	male
	O	O

Nationality Please, name your nationality.	

Last occupation Please, tell your professional background, e.g. finance, engineering, medical, IT, software, etc..	

Q1: Do you perceive AR as suitable as a technology enabled learning method?	Not at all	Very little	Quite well	Very well	Absolutely
	O	O	O	O	O
Please, explain shortly why?					

Q2: Did you find the AR intervention engaging and stimulating?	Not at all	Very little	Quite well	Very well	Absolutely
	O	O	O	O	O

Q3: Were the AR tools easy to use?	Very difficult	Difficult	Neutral	Easy	Very easy
	O	O	O	O	O

Q4: Did you enjoy creating your own reflective AR story as a learning option?	Not at all	Very little	Quite well	Very well	Absolutely
	O	O	O	O	O

Q5: Do you think the workload for the AR intervention is appropriate?	Absolutely inappropriate	Inappropriate	Neutral	Appropriate	Absolutely appropriate
	O	O	O	O	O

Q6: Do you consider what you learned from this AR intervention to be value for your future?	Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely
	O	O	O	O	O

Q7: Do you think the AR experience supported your personal learning process?	Not at all	Very little	Quite well	Very well	Absolutely
	O	O	O	O	O
Please, explain shortly why?					

Q8: Did the AR intervention influenced your skills development in e.g. problems solving, critical thinking, planning or communication?	Not at all influential	Slightly influential	Somewhat influential	Very influential	Extremely influential
	O	O	O	O	O

Q9: Do you think the AR intervention makes you more confident about your ability to learn?	Not at all	Very little	Quite well	Very well	Absolutely
	O	O	O	O	O

Q10: What is the most important thing you learned personally?

Q11: What were some of your most challenging moments and what made them so?

Q12: Would you prefer an AR intervention over other methods of technology enabled or traditional learning and teaching?	Not at all	Very little	Quite well	Very well	Absolutely
	○	○	○	○	○
Please, explain shortly why?					

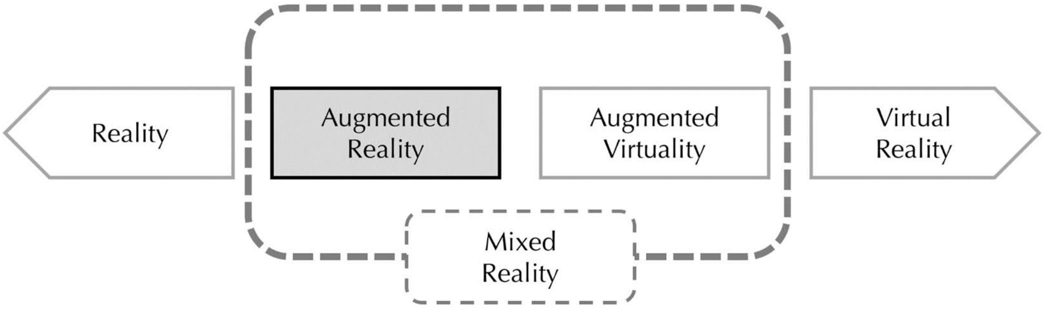
Q13: What do you think could be improved for future AR interventions?

Q14: Is there anything else important to you like to share regarding your learning experience with the AR intervention?

7.9 Augmented Reality – Graphical Illustration of Definitions

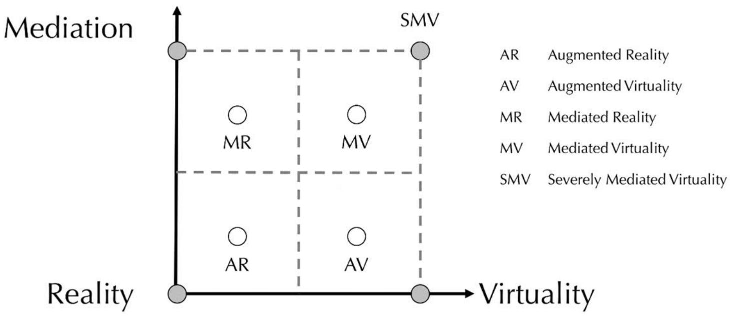
7.9.1 Milgram's AR Continuum

Figure 47 - Adoption of Milgram's AR continuum



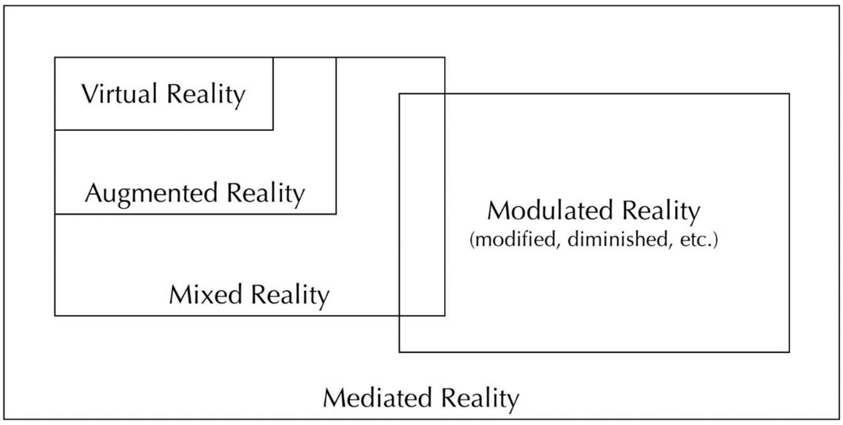
7.9.2 Mann's AR Continuum

Figure 48 - Adoption of Mann's Reality-Virtuality Continuum



7.9.3 Mann's Mediate Reality

Figure 49 - Adoption of Mann's Mediated Reality



7.9.4 Siltanen's Extended Mediated Reality Taxonomy

Figure 50 - Extended adoption of Siltanen's Mediated Reality Taxonomy