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Augmenting History: Case Study Measuring Motivation of Students Using Augmented Reality Apps in History Classes

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***Abstract*—**Due to the rapid advances in the use of information technology and students' familiarity with technology, learning styles in higher education are being reshaped. One of the technology developments that has gained considerable attention in recent years is Augmented Reality (AR), where technology is used to combine overlays of digital data on physical real-world settings. While AR is being heavily promoted for entertainment by mobile phone manufacturers, it has had little adoption in higher education due to the required upfront investment that an instructor needs to undertake in creating relevant AR applications. This paper discusses a case study that uses a low upfront development approach and examines the impact on generation-Z students' motivation whilst studying design history over a four-semester period. Even though the upfront investment in creating the AR support was minimal, the results showed a noticeable increase in student motivation. The approach used in this paper can be easily transferred to other disciplines and other areas of design education.

***Keywords*—**Augmented reality, history, motivation, technology.

I. Introduction

MANY students, especially generation-Z students (those born after 1995) have grown up with tablets and mobile phones, and have been able to Google anything they want to know, and as a result generation-Z students do not typically value information for information's sake. Additionally, due to the rapid advancement in information technology, learning styles in higher education are being reshaped. This combination of factors causes challenges for instructors to associate course content to the new learning culture and make the learning outcomes and activities relevant. One possible way to do this is to use AR, which along with the prevalence of ubiquitous computing on mobile phones that are capable of infusing virtual information onto the real world is beginning to foster a new neomillennial learning style. The older model of world-to-desktop interface does not have the same psychological immersive effect as overlaying virtual models into the student's real world. This immersion can have an effect beyond the use of high-end computers with associated implications for higher education.

The use of AR and its possible uses in educational settings have attained much research attention in recent years. AR has been described by [1] as "Bridging virtual and real worlds, AR creates a reality that is enhanced and augmented". As with many technological innovations, it is not the technology itself that creates a successful intervention, but how the design, implementation and integration into formal and informal learning settings is administered. New opportunities for enhancing learning and teaching by utilising AR which allows learners to visualize concepts with the coexistence of virtual objects and real world environments have been increasingly recognized by educational researchers. Reference [2] sees AR as providing an experience phenomena that is not possible in the real world while [3], [4] highlight the advantages of students being able to "develop important practices and literacies that cannot be developed and enacted in other technology-enhanced learning environments".

These educational benefits have made AR one of the key emerging technologies for education over the next five years [5].

II. Theoretical Basis for AR Based Pedagogy

The term augmented reality is described by [6] as technology that enhances the user's sensory perception of the real world with a computer-assisted contextual layer of information. Within the realms of learning, [7] explains how AR technologies help learners engage in authentic exploration in the real world, and virtual objects such as texts, videos, and pictures are supplementary elements for learners to conduct investigations of real-world surroundings. As with other technology enhanced learning environments, AR systems can help students develop skills and knowledge; however, research has also shown that the use of AR can enhance learning in a more effective way [8]. The use of AR in the classroom naturally supports one of the three types of interaction needed in education as identified by [9] that of learner-content interaction. Several authors have highlighted the importance of learner-content interaction to foster cognitive tasks such as understanding, memory, and imagination among others [10], [11]. Reference [12] states that AR has the ability to increase student's motivation and interest seeing an increase in motivation and interest helping students to develop better investigation skills and gain more accurate knowledge on the topic. Although AR technologies involve high-end electronics and sophisticated tools, as [1] argued, these technologies in themselves should not be the driver, it is more important that AR as a concept rather than the use of a certain technology should support learning.

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III. AR Possibilities

AR allows for virtual items and sounds to be overlaid into the real physical environment. This can be in the form of flat images, videos or 3D objects, that can allow the user to inspect the 3D object from a variety of different perspectives to enhance their understanding [13]. An example of this was discussed by [14] who described an example of using 3D AR in teaching astronomy. The AR intervention displayed a virtual 3D spinning earth to allow students to learn about the earth and sun, and day and night. However, what was not investigated by Kerawalla et al. [14] was whether the AR 3D learning experience was significantly more beneficial to students than the manipulation of real-world 3D physical models that teachers traditionally used such as a tennis ball on a sting, a football and a torch.

IV. Barriers from Technological, Pedagogical, and Learning Issues

Numerous AR systems, and in particular those relating to the teaching of science and mathematics have been developed and tested through empirical studies often conducted in lab settings. While lab studies can be insightful, they leave out the complexity of a classroom environment. In addition to normal teaching, the use of AR as an educational innovation raises a number of intrinsic issues such as the peculiarities of the learners, and the principles of educational psychology. Innovation within the classroom can also be hampered by institutional constraints such as the requirement to cover a certain amount of content within a given time frame [14].

In recent years, a number of scholars have also been directing their attention to extrinsic constraints. These extrinsic constraints refer to those that are not related to learning theory, but nonetheless shape classroom practices. This could be physical constraints of the classroom, budgets, time and the requirement to keep a reasonable amount of discipline in the classroom [15]-[17]. These constraints have been referred to as the 'logistics' of classrooms by [18], who describe these constraints as not corresponding to a grand learning theory but to practicalities that, if they are neglected, may spoil the most effective instructional design.

On first impressions, the use of AR for teaching and learning seems promising; however, some research has indicated negative effects on learning such as low engagement by teachers. A perceived barrier has been the inflexibility and large upfront commitment to create AR apps for the classroom. Reference [14] describes how within some AR systems, the content and the teaching sequence are fixed; teachers are not able to make changes to accommodate students' needs or to accomplish instructional objectives. Reference [19] suggests that this issue can be overcome by using authoring tools, or software development kits (SDKs) which allow teachers and students to revise and create AR activities and applications.

V. AR in the History of Design

AR has been described as lending itself well to participatory simulations and more studio-based teaching methods. The nature of these instructional approaches as described by [14], [20] is quite different from the teacher-centred, delivery-based focus in conventional teaching methods. Unfortunately, for this paper's case study, the History of Design course is a traditional lecture based course that all students studying bachelor level Art and Design majors are required to take. When considering the use of AR in the History of Design class, institutional constraints of having to cover a certain amount of context within the restricted time frame resulted in the student-centred exploratory nature of the use of AR implementation to be limited as the content and the teaching sequence was fixed.

To try to minimise the challenges students may have encountered by possible cognitive overload, the 'usability' of the app was very important. In the interaction between a user and the app, this variable can be estimated by measures of performance, rate of errors, or user satisfaction. The design had to take into consideration individual constraints such as the student's previous experience of using AR apps. The implementation of AR can be more time consuming and more difficult to manage than presentational instruction [21], and has been described by [2] as more akin to organising a field trip.

To maintain high usability, it was decided to keep the AR interaction to a minimum with images and animations simply appearing over exiting images. This was to avoid the issues noted by [22], who reported that students often felt overwhelmed and confused when they were engaged in a multi-user AR simulation because they had to deal with unfamiliar technologies as well as complex tasks.

VI. AR in the History of Design

There are many development kits available for creating AR applications, offered by small software companies through to large multinational corporations. In September 2017 during Apple's keynote, they announced they were providing developers with a new SDK for iOS11, ARKit that claims to open up the possibility of developing AR apps for Apple mobiles in a few months compared to the previous few years. Google on the other hand had been touting their Tango AR platform, but as it only worked on a couple of smartphones was dropped and they have unveiled ARCore which will work on millions of Android phones.

Apart from the two main mobile phone manufacturers, there are a number of SDKs that are available for use in creating educational apps. It is beyond the scope of this paper to describe each AR SDK's capabilities, but a short summary of some of the main SDKs are shown in Table I. For this paper, the main driver for choosing which SDK to use was functionality versus the time investment required to create the app. The author experimented with a number of SDKs and found the Aurasma [23] SDK to be the most compatible. Aurasma is currently free and very simple to use. To create an AR app, first a trigger image is uploaded to the online platform. Then an overlay which the instructor wants to appear when the student points their mobile at the trigger is selected. This can be an image, video or 3D model. The only slightly more technical issue is for 3D models as Aurasma requires a 'Collada' formatted 3D model, which can be exported from a number of 3D modelling packages. The 3D model needs to be packaged inside a '.tar' archive file, which is very much like a '.zip' file. The'.tar' file needs to include the 3D model, textures and a thumbnail. It can also have sounds added. After the overlay has been selected or created, the new trigger images are saved to the instructors account and are ready to be used. The author found this to be a very straightforward and a fast process with no advanced technical knowledge required. For the students, they simply need to download the free Aurasma app and then link to the instructor's account.

TABLE I
SOME OF THE MOST POPULAR AR SDK OPTIONS

	License	Supported platforms	Cloud recognition	3D recognition
Apple ARKit	Free	iOS	x	x
ARToolkit	Free Open Source	Android, iOS, Linux,Windows, macOS		
EasyAR	Free / Commercial	Android, iOS, Windows, macOS	x	x
Kudan	Free / Commercial	Android, iOS		x
Maxst	Free / Commercial	Android, iOS, Windows, macOS		x
Vuforia	Free / Commercial	Android, iOS, Windows	x	x
XZIMG	Free / Commercial	Android, iOS, Windows		
AR Core	Free	Android	x	x
Aurasma	Free	Android, iOS	x	

VII. MEASURING STUDENT MOTIVATION

Reference [24] defined motivation in the educational arena as the student's desire to engage in a learning environment. The impact of motivation on students' academic achievements and learning outcomes has been addressed in several studies. D. Schunk, cited by [25] states that motivation has the potential to influence the what, when, and how of learning, and increases the likelihood of engaging in activities that will help students to learn and achieve better performance. Reference [26] supports this motivational influence so that learning strategies that connect with students' interests and provide them with opportunities to take an active part in their instruction can lead to increased engagement, effort, and eventual success. Reference [24] proposes a problem-solving approach by applying motivation to instructional design called ARCS, which is directly based on four out of the six components reported by the abovementioned survey by Theall: attention, relevance, confidence and satisfaction. The ARCS model was originally developed as a descriptive model for diagnosing problems associated with learning motivation [27].

Within Keller's ARCS model there is a motivational design process. The first step of this process is to gain and sustain the students' attention and stimulate their curiosity to learn. The second step should guarantee that learning activities are aligned with the students' personal goals and needs in order to be perceived as relevant. According to Keller's motivational design process, students should build confidence by feeling in control and having expectancy for success because the degree of expectancy achieved will determine the amount of effort students invest to accomplish the activities. Goal-directed effort will also be influenced by external factors such as teacher enthusiasm, social values, quality of instruction and availability of resources [28]. Finally, the students' cognitive evaluation and the reflection students' make on their performance will determine their levels of satisfaction. Adequate levels of satisfaction are needed to help them to maintain motivation [29].

Even though each ARCS component plays a significant role in motivating students throughout the learning process, there needs to be some sort of diagnostic tool to determine the final motivational strengths and weaknesses of instructional design. For this paper's case study, a modified version of the Instructional Materials Motivation Survey (IMMS) was used. IMMS is an instrument that was developed to measure learner motivation following the ARCS model [30]. The IMMS is a 36 item Likert scale survey measuring the attention, relevance, confidence and satisfaction components of instructional materials. The survey is particularly relevant for this paper's case study as it has been validated and used on several research studies using technology as a motivational factor in student learning [31], [32], [29].

VIII. CASE STUDY

To compare the motivational impact of using the AR app in the case study, the History of Design course was taught using two different learning scenarios, the first one only used traditional PowerPoint slides, and the second one incorporated AR technology.

The study was conducted over a two-year period, covering four different student cohorts averaging 50 students per cohort. The student cohort is made up of mainly Gulf Cooperation Council (GCC) countries, plus a small number of international students. The History of Design course uses Meggs' History of Graphic Design as the main course text book, which has a distinct Western canon, and covers design history from cave paintings through to the modern day.

The experiment was performed over two specific sessions during the module, which covered the Industrial Revolution. The AR app intervention was based on module material comprising of information relating to the development of photography and the moving image. Students were expected to acquire specific knowledge relating to these developments as well as a general understanding of the impact of this technology to design.

Due to extrinsic constraints mentioned earlier, the teaching sessions were conducted in the same tiered auditorium classroom as had been previously used in the PowerPoint based classes. Prior to the lecture, the students had been asked to download the free Aurasma app to their mobiles and link to the class folder. During the lecture when an AR intervention had been created, it was indicated to the students by a small icon on the slide to indicate that an AR app was available. The AR app was then used to enhance an image with added information in a multimodal fashion, including text, video and 3D models.

IX. Interaction

On being prompted, the students were very keen to get their mobiles out and try the application. There was a definite buzz of excitement in the class whilst the students engaged with the images, videos and models (see Fig. 1).

Fig. 1 Students interacting with the AR app

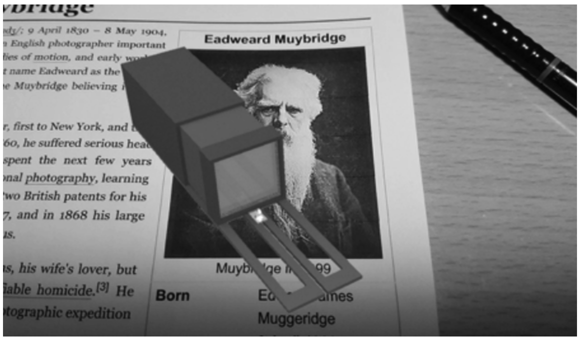

Fig. 2 Using a portrait of Muybridge a 3D model of a camera he used appears in the AR app

Questions posed by the faculty during this period appeared to be more positively responded to. After the initial excitement and the students had calmed down the lecture continued. It was interesting to note that their attention appeared to be enhanced as whenever a new slide appeared with an AR icon they would immediately get out their phones and try the app again. The AR intervention also worked on images from their text book so this encouraged more collaborative discussions in the lecture as many students shared a text book. A major advantage of augmenting the text book was the additional interactivity. Students could manipulate the AR 3D model by rotating the book or tilting the pages to experience the AR content from different positions (see Fig. 2). This interaction with the text book appeared to help establish common ground and served as a discussion point amongst the students.

X. Research Questions

Providing an AR experience does not necessarily mean that students will be more motivated to learn. As with any new technology introduced into the classroom, important lessons need to be learned about how best to use AR in a learning environment.

To analyse the impact of introducing AR apps within the History of Design course on student motivation a number of research questions needed to be answered:

1) When using AR apps within the teaching material, how motivated are students to use them?
2) Was there a difference in student's motivation depending on which teaching method was used?
3) If there were differences, were they relating to the four areas used for measuring student motivation?
4) What are the barriers that prevent AR from being accepted?

XI. Procedure

The case study was conducted over a four semester, two-year period. Cohorts in the first and fourth semester were taught with only traditional PowerPoint slides (C_ppt), whilst the Spring and Fall semesters, two and three, students were exposed to PowerPoints with the enhanced AR apps (C_ar). After the module had been completed, the students were handed the IMMS questionnaire to collect quantitative data. The data was then analysed to compare the paired-samples relating to the students' motivation in both the traditional teaching environment and with the AR intervention. Qualitative data was also collected by surveying students interacting with the AR app. The students were a mix of sophomore and junior students. Each cohort on average had 50 +/-2 students. Within the cohorts, the male/female ratio remained on average 80% female.

XII. Data Collection Survey and Exams

The quantitative questionnaire is a closed-item Likert style (five point) questionnaire consisting of four areas measuring major motivational variables related to instructional materials.

1) The first area, confidence, comprises of nine questions which measure to what degree students felt they could successfully accomplish the goals and tasks laid out in the class materials.
2) The second area, attention, consists of 12 questions which measure to what degree the teaching materials initiated and sustained students' motivation.
3) The third area, satisfaction, comprises of six questions which measure to what degree students felt that they had

accomplished a task and the inherent appeal of the teaching materials.

4) The fourth area, relevance, consists of nine questions which measure the perceived value and usefulness of the materials to the students.

XIII. Scoring

The IMMS survey was scored for each of the four sub areas and the total scale score (see Table II). The IMMS survey has a Likert scale of 1 to 5 so the maximum score is 180 and a minimum is 36, with a midpoint of 108. The minimums, maximums, and midpoints for each sub area vary because they do not all have the same number of items.

For each sub area, the mean was calculated by dividing the total score on a given scale by the number of items in that scale.

TABLE II
Statistics for the Four Motivation Sub Areas

	C_ppt	SD1	C_ar	SD2	Difference
Attention	3.26	0.57	4.02	0.71	0.76
Confidence	3.54	0.72	3.74	0.77	0.2
Relevance	3.51	0.55	3.66	0.56	0.15
Satisfaction	3.19	0.8	3.77	0.72	0.58

This allows for the scores to range from 1 to 5, making it easier to compare responses on each of the sub areas. There are a number of questions that are stated in a negative manner, so for these to become relevant they need to be reversed before they can be added to the total response scores. So for these items, 5 = 1, 4 = 2, 3 = 3, 2 = 4, and 1 = 5.

TABLE III
IMMS Scoring Guide

Attention	Relevance	Confidence	Satisfaction
1	2	3	7 (reverse)
4 (reverse)	5	6 (reverse)	12
10	8 (reverse)	9	14
15	13	11 (reverse)	16
21	20	17 (reverse)	18
24	22	27	19
26 (reverse)	23	30	31 (reverse)
29	25 (reverse)	34	32
	28		33

Research Question 1:

When using AR apps within the teaching material, how motivated are students to use them?

Table II displays descriptive statistics for the four motivation areas comparing the C_ppt to the C_ar. The highest mean scores were generated by the attention scale (M 4.02) and the satisfaction area (M 3.77). The lowest mean value was obtained by the satisfaction area (M 3.19).

Analyzing the attention questions as shown in Table IV the highest mean score was for question 8 'AR technology is attention-grabbing'. From the students surveyed who experienced the C_ar, 82% of the students indicated that they thought it was mostly true or very true. Similar responses were for question 17, that 'The way the information is arranged using this technology helped keep my attention' with 74% students indicating it was true or very true.

The AR app was also an attention grabber, with 78% of students indicating that it was true or very true that there was something interesting at the beginning of the C_ar lesson that caught the students' attention (question 2).

TABLE IV
Mean Scores and Standard Deviations for Questions Relating to Attention

		M	SD
2	There was something interesting at the beginning of the AR lesson that caught my attention.	4.16	1.35
8	AR technology is attention-grabbing.	4.47	1.29
11	The quality of the AR material helped to hold my attention.	4.13	1.3
12	The material is so abstract that it was hard to keep my attention on it (Reversed).	3.88	1.44
15	The images, videos and text that I discovered through the lesson are unappealing (Reversed).	3.94	1.51
17	The way the information is arranged using this technology helped to keep my attention.	4.28	1.44
20	The information discovered through the experience stimulated my curiosity.	3.83	1.37
22	The amount of repetition of the activities made me feel bored (Reversed).	3.8	1.64
24	I learned some things from the AR that were surprising or unexpected.	3.75	1.42
28	The variety of audio visual material helped keep my attention on the lesson	3.81	1.13
29	The audio-visual material is boring (Reversed)	4.05	1.42
31	There is so much content that it is irritating (Reversed)	3.77	1.5

TABLE V
Mean Scores and Standard Deviations for Questions Relating to Confidence

		M	SD
1	When I first looked at the lesson, I had the impression that it would be easy for me.	3.9	1.35
3	This material was more difficult to understand than I would like for it to be (Reverse).	4.37	1.45
4	After the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	3.46	1.13
7	The information that I was exploring was so much that it was hard to remember the important points (Reverse).	3.8	1.39
13	As I worked on this lesson, I was confident that I could learn the content.	4	1.54
19	It was difficult to discover the digital information associated with the real image (Reverse).	3.86	1.58
25	After working on this lesson for a while, I was confident that I would be able to pass a test on it.	3.67	1.3
34	I could not really understand quite a bit of the material in this lesson (Reverse).	3.78	1.55
35	The good organization of the material helped me be confident that I would learn this material.	3.93	1.61

The highest scores in the confidence sub area indicated that "the subject matter was more difficult to understand than I would like for it to be" (Reverse) question 3. Fortunately, the organization of the material had 96% of the student's surveyed indicating that it was mostly true or very true that the good organization of the material helped them feel confident that they would learn this lesson (item 35).

The highest mean score was generated by question 21, where the students enjoyed studying the lesson; 83% of the students indicated that it was mostly true or very true. This was also shown with the amount of extra 'chatter' and responses happening in the class.

Finally, the lowest rated motivation factor is the relevance sub area.

TABLE VI
MEAN SCORES AND STANDARD DEVIATIONS FOR QUESTIONS RELATING TO SATISFACTION

		M	SD
5	Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.	3.23	1.32
14	I enjoyed this lesson so much that I would like to know more about this topic.	3.56	1.33
21	I really enjoyed studying this lesson.	3.69	1.23
27	The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	3.37	1.32
32	It felt good to successfully complete this lesson.	3.46	1.19
36	It was a pleasure to work on such a well-designed lesson.	3.42	1.16

TABLE VII
MEAN SCORES AND STANDARD DEVIATIONS FOR QUESTIONS RELATING TO RELEVANCE

		M	SD
6	It is clear to me how the content of this material is related to things I already know.	3.31	1.23
9	There were images, videos and texts that showed me how this material could be important to some people.	3.27	1.32
10	Completing this lesson successfully was important to me.	3.23	1.08
16	The content of this material is relevant to my interests.	3.16	1.18
18	There are explanations or examples of how people use the knowledge in this lesson.	2.77	1.29
23	The content and the audio-visual material in this lesson convey the impression that its content is worth knowing.	3.41	1.08
26	This lesson was not relevant to my needs because I already knew most of it (Reversed).	3.3	1.25
30	I could relate the content of this lesson to things I have seen, done, or thought about in my own life.	2.91	1.33
33	The content of this lesson will be useful to me.	3.17	1.15

The two lowest mean scores were for question 18 and question 30, it does not appear that the use of AR apps was the cause of these low scores. There was only a low response to questions 6 and 30 where they could relate the information from the Industrial Revolution to things they already know, or relate to things they have seen of done in their own lives, which considering the GCC background of the students is not surprising.

Research Question 2:

Was there a difference in student's motivation depending on which teaching method was used?

Analysing the IMMS survey, the mean score for overall motivation for C_ppt was 123 in a range from 94 to 152 and for C_ar the mean rating was 136, in a range from 102 to 170 showing a higher mean motivation.

In addition to the overall range of motivation, a paired-sample mean-test was conducted to compare motivation through the IMMS Likert scales. The results showed that for the C_ar the mean for motivation was M3.80 compared to M3.38, (SD M0.66 and M0.69).

Research Question 3:

If there were differences, what were they relating to the four areas used for measuring student motivation?

TABLE VIII
MEAN SCORES AND STANDARD DEVIATIONS FOR QUESTIONS RELATING TO RELEVANCE

	C_ppt	SD1	C_ar	SD2	Difference
Attention	3.26	0.57	4.02	0.71	0.76
Confidence	3.54	0.72	3.74	0.77	0.2
Relevance	3.51	0.55	3.66	0.56	0.15
Satisfaction	3.19	0.8	3.77	0.72	0.58
Likert Mean	3.38	0.66	3.8	0.69	0.03

As can be seen for all four subscales the C_ar had higher mean scores than the standard C_ppt. For C_ppt all the subscales had a mean below 3.5, whilst for C_ar they were all above 3.5. The highest difference between mean scores was for the attention with a difference of 0.76.

The impact on the attention of students has been noted by [10], [33], who predicted this affordance when students work with emerging technologies such as Virtual Reality and AR. This improved satisfaction perception could also be tied to the active participation discovering new information whilst using the AR app.

The lowest difference was for relevance with a difference of 0.15. As the AR app apparently did not make an impression on the relevance factor, it unfortunately appears that the use of AR did not increase the student's interest in the History of Design.

Research Question 4:

What are the barriers that stop AR being accepted?

Beyond the IMMS survey, this research also wanted to gather some information relating to the difficulties or barriers regarding how easily accepted AR technology is in learning environments?

Students had been asked to download the Aurasma app before coming to class. The majority of students had complied with this request, a few downloaded during the explanation of how to use the app. The only slight stumbling block was linking to the History of Design markers, but as most of the students had done this before class they were able to show their colleagues. When the AR graphic indicator was shown to them the students swiftly operated the app and engaged with the images, 3D objects and videos. The only unexpected reaction was the number of students who stood up or came closer to the screen to get a better view of the projected image. After the first use, students were looking out for the graphic indicator and also tried the app on additional images in their text book, 'just in case'. This interaction soon created a collaborative interconnection between students showing others if they found additional images to use the app on.

The comments from the students support the premise that the AR app was easy and enjoyable to use. The small technical issues were not found to be serious enough to have an effect on the students' enthusiasm to complete the learning activities whilst using the AR apps. A selection of the comments from the qualitative survey is shown below:

"It was fun"

"I really liked looking out for the App indicator"

"It was very easy to use"

"Made history less boring"

"I liked the 3D models and videos"

"All classes should have this"

Lastly, the students indicated an interest in using the Aurasma app in other classes.

"This would be great for my other classes"

"Professor can you show me how to use this for my Interior Design class?"

"I'm going to show my friends"

XIV. Considerations on How The Study Was Conducted

All the sessions followed the same pedagogical structure and students received similar learning contents. However, it is worth considering the delivery and content of the course material in order to identify any potential factors that could have biased either of the cohorts.

The attention sub area shows a positive interest from the students towards the activities undertaken in the classes. As both cohorts had the same content and information delivered in the same order, neither the content nor order of the sessions can be seen a determining factor in the results.

The introduction of the AR app had an advantage over the PowerPoint sessions, grabbing the students' attention and allowing an additional multimodal interaction with the contents of the class. The quantitative and qualitative data both show that the AR app had an impact on the students' motivation. However, the use of AR may have had an impact on the confidence sub area, as students indicated that they were more confident in what they had learnt in the AR app sessions. This may be due to the fact that the AR app interaction appeared to be easier to remember when students were asked, than the PowerPoint slides.

On the flip side, the satisfaction sub area could be argued that it should have been more favourable for the PowerPoint slide sessions as this is something the students are very used to and comfortable with. The AR app on the other hand was a new learning environment requiring the use of an unknown technology. With this in mind, it was reassuring to see that the usability study showed that students had very few issues or problems.

Analysing the relevance sub areas on how well the two courses met the students' needs and goals, there did not appear to be any significant data either quantitatively or qualitatively that suggested there was any change in student's motivation.

XV. Conclusions and Future Work

The goal of this study was to compare design students' motivational responses to traditional PowerPoint instructional materials against AR enhanced materials. As presented in previous sections, the analyses and discussions show that the quantitative results indicate that the use of AR apps in the learning environment had a positive motivation on the undergraduate design students.

It was noted that there was a clear improvement in attention and satisfaction motivation factors when using the AR app. These results were also supported by a qualitative study where students stated that the enjoyed using the AR app and found it easier to remember details compared to PowerPoint slides.

The enhancement of memorisation and comprehension was supported by the results from the end of semester exams which showed a statistical impact for the questions relating to the Industrial Revolution. For the AR app, exam results showed an average 74% success rate in answering the questions correctly, compared to the PowerPoint lessons where the correct answers were only 65% correct.

Due to the multimodal interactions whilst using the AR app, it is the author's belief that the interactive capabilities of the AR app helped the students to maintain higher levels of attention and interest in the content of the course. Further studies are needed to corroborate this hypothesis.

Regarding the relevance motivation scores, it is not surprising that both cohorts had similar results. History of Design is a required course and not necessarily aligned with the students' own interests. If it was, it may not need to be a required course.

Due to the preliminary nature of this study, the findings discussed above require further inquiry to substantiate them. It would also be advisable to undertake further, longer term studies to irradiate the possible novelty aspect. As the upfront investment to create the AR app was minimal, it would also be beneficial to investigate where AR technology can provide greater benefits to other design related learning environments beyond a History of Design course.

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