Project Title: Use of augmented reality in a second level human biology module: benefits and challenges

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Executive Summary

Use of augmented reality in a second level human biology module: benefits and challenges

- This project explored the use of a vision-based augmented reality (AR) application (Heart App), which has been developed by the Open University, specifically for a second level Human Biology module (SK299).
- Through multiple methodologies, including web survey, questionnaires, focus-groups and interview, this project aimed to explore student and practitioner experiences and perceptions relating to potential benefits and challenges associated with this Heart App.
- Findings indicate that although most students reported finding the Heart App easy to install on their device(s), a number experienced some difficulty, and as a result of this project, the student instructions are being improved for the next presentation of the module.
- The results also suggest that there is some uncertainty with regards to whether students understand the nature of augmented reality. As a result of this project, the initial user interface on Open Science Laboratory is going to be changed, to make it clearer for students the best devices to use, how to download the Heart App, and what to expect in terms of output during use.
- Students reported that they valued being in control of the pace of their learning. They also commented positively on the ability to visualise aspects of the heart; students indicated that being able to manipulate and visualise structures consolidated their learning from the text.
- However, it is important to acknowledge that just over one-fifth of the combined email survey respondents (students on 18J and 17J presentations) felt that the Heart App did not aid their understanding of the anatomy/physiology of the heart, with some 17% of respondents overall finding the 3D heart too complex to interpret. Although the reasons behind this result are difficult to unpick, it may be related to technological/practicalities of use, and hence improved support around use of the Heart App may help students on future presentations.
- The majority of students found the Heart App was fun to use (approx. 58% of non-nursing students, 65% nursing students), and over three quarters of respondents wanted to see AR used more often to support their learning, a finding which supports experiences in the wider literature on the use of AR in education. However, approx. 45% reported that they preferred learning about the heart using the text, 2Dimages and videos on the module website. Again, this finding may be tied to technological issues; however, this finding also reinforces the need for a mixed media approach when supporting student learning in an online environment. Students are not a homogenous group, and different educational approaches and tools may suit different students.
- Most practitioners responded positively towards the Heart App; reporting that overall, the Heart App was a good use of student time and that it aided understanding of the anatomy and physiology of the heart.

Use of augmented reality in a second level human biology module: benefits and challenges

Project background

'Brick' based universities have traditionally taught anatomy and physiology using a range of approaches, including laboratory demonstrations, dissections and models, alongside lectures and text-based resources. Within a distance, online-only environment, such as that experienced by many students at The Open University (OU), the student learning experience is different, with video, animations, audio, figures and text descriptions as the primary learning material, supplemented with optional online tutorials provided by video conferencing software.

This project explores the use of a vision-based (Dunleavy and Dede, 2014) augmented reality (AR) application (referred to as the 'Heart App'), which has been developed by the OU, specifically for a second level Human Biology module (SK299). This module lies in the natural science, health sciences and open degree pathways. SK299 attracts a large number of students, including those studying a variety of nursing programmes. It is hoped that the Heart App (Figure 1) will support students' understanding of the cardiovascular system and may offer our online, distance students, the ability to explore the anatomy and physiology of the human heart in a more authentic manner. The 3D augmented reality may extend the learning opportunities more typically provided within the online distance learning experience, where the 2-dimensional images offer limited affordances for spatial information.

SK299 students are introduced to the Heart App early in their study of the cardiovascular system topic, and access it via the OpenScience Laboratory (the Heart App is also freely available to the general public in the Apple App Store). At the time of writing, the Heart App is available for use on laptops and desktop computers, however, the full augmented reality tools are only available on Android and iOS devices (e.g. smart phones and tablets); PC and Mac versions of the Heart App used on laptops and desktops, instead provide a series of 2D videos/images.

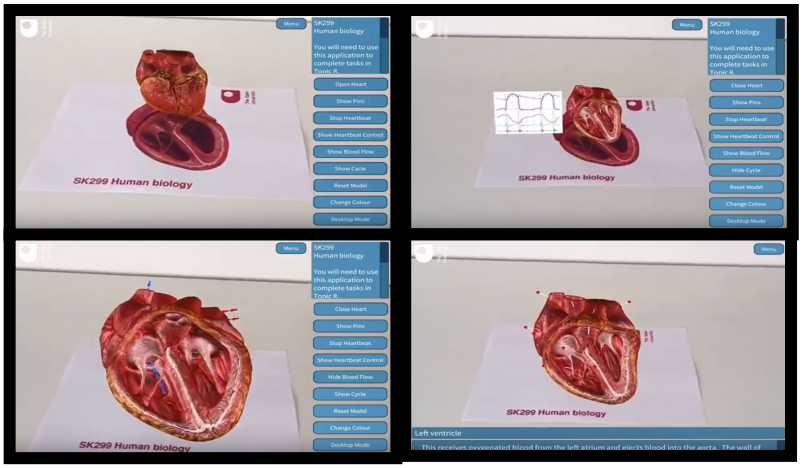

Figure 1: The heart app. As seen in this figure, the hand-held Heart App developed by the OU, overlays 3-dimensional virtual images onto a 2-dimensional trigger image. This trigger image is necessary to activate the digital information overlay. By pointing the camera of an appropriate device at the image, students can use the Heart App to rotate a virtual heart, in 3D and cross-section, to aid identification of anatomical structures and to manipulate mechanical events (e.g. blood flow and heart beat).

Embedding this Heart App as an independent activity within a module, may follow a constructivist framework, enabling active, contextually relevant learning where students use the digital information to consolidate and extend their existing knowledge (Wang *et al.,* 2018). With a significant proportion of OU students combining study alongside work and/or caring responsibilities, enabling students to control the pace and time of their exploration of the Heart App, and to pause or repeat the activity, to suit their learning, is likely to be important.

AR interfaces have been used for over 50 years (Herron, 2016) and technological developments, alongside decreased costs, have widened the applicability and availability. Triggers such as Quick Response codes, can now be found in many public spaces, which may facilitate informal learning, whilst AR games such as Pokémon Go suggest that applications have the potential to be used by any age group, regardless of computing experience or technological background. Nonetheless, AR might still be considered an emergent technology within tertiary education.

Project aims and scope

Whilst literature suggests AR may promote motivation (Acosta, 2019) and have positive effects on learning outcomes (Chen *et al.,* 2017), there may be challenges associated with the technology. The extent to which AR places demands on working memory during the learning tasks, and hence the potential for cognitive overload is unclear (Sweller, 1998; Akcayir and Akcayir*,* 2017). Drawing on Moreno *et al.,* (2017) and perhaps of particular relevance in our setting, with time-poor adult learners, the extent to which a student may use technologies – such as the Heart App - may be linked to their perceptions of their usefulness and ease-of-use. Additionally, just under one quarter of our students live in the 25% most deprived areas (Open University, 2020) and may therefore experience financial hardship, and there is uncertainty with regards to potential barriers which might include lack of access to suitable hardware.

Through multiple methodologies, including questionnaires, focus-groups and interviews, this project aims to explore student experiences and perceptions relating to potential benefits and challenges associated with this Heart App, within a distance, online, higher education environment. Specific goals of this work are to explore usability, aid in learning, and engagement and motivation. The project will attempt to gain insight into any age or gender difference in the use/perception of AR, as well as explore the experiences of students from a variety of ethnic backgrounds and with various additional requirements/disabilities. Furthermore, as a new tool within the Open University, practitioner pedagogical and technical knowledge of AR is likely to be limited, and hence views of Associate Lecturers supporting students on this module, are also explored.

Methodologies and planned activities

Overview

This project adopted a mixed method approach, to gain an understanding of the student and practitioner experiences with the Heart App. Email surveys were issued to ALs, and to students on 17J (first presentation of the module) and 18J presentations. Additionally, direct observation of the Heart App in use, via the User Labs were planned. However, internal staff-turnover and role-changes within the University meant that the User Labs became unavailable at short notice. As an alternative, a small pool of volunteers was obtained via the Curriculum Design Student Panel Community to form a focus group, who would report on their experiences of using the Heart App. Additional data was also collected direct from the SK299 module website, which was amended to add a series of questions at key points during the students use of the Heart App as part of their study. Student demographic data (age, gender, ethnicity, module-variant (to identify nurses/non-nurses) and disability status) were obtained from centrally held student records.

1. **Student email surveys**

A JISC electronic survey was sent via email to a subset of students registered on the second level Human Biology Module SK299, at the Open University. Invitations were issued to 294 students for the 2017 presentation and 573 on the 2018 presentation. Following Saleh and Bista (2017) recommendations, to increase response rate, invitations were personalised; responders were asked for their help and were issued with reminders 4 weeks after initial invite. Students were informed of estimated time to complete the questionnaire (approx. 15 minutes). Data was collected from the 17J cohort of students in January 2019 (approx. 6 months post module completion). Data was collected immediately post activity for the 18J cohort of students.

The student surveys were identical; they contained two sections, the first collecting data relating to prior experiences of technology, as well as a compulsory question asking the student how often they had used the App. If students had not used the App, they were routed to the end of the survey. Students who used the Heart App were routed to a final section collecting data on aspects of usability, engagement and motivation. This section used a mix of open-response questions, and a Likert scale to collect data on student perceptions.

2. **AL email survey**

A JISC electronic survey was sent via email to all ALs with a live contract on SK299. Invitations were issued to 53 ALs for the 2018 presentation. To increase anonymity of responses, no identifiable data was collected from ALs, and the first part of the survey collected only age range and gender information. Again, the survey was routed if ALs had not used the App, and the second part collected data on their experiences of using the Heart App and their thoughts on its use in learning. This section used a mix of open-response questions, and a Likert scale to collect data on AL perceptions. The AL survey was emailed to ALs immediately following the end of the marking period for the final assignment of the module.

3. **Module website survey**

A mix of check boxes and radio buttons were added to the 2018 module website to collect quantitative data immediately post Heart App activity.

4. **Focus group**

12 students from the Curriculum Design Student Panel Community volunteered to test the Heart App and report on their findings and two focus groups were planned in the OU conferencing software, Adobe Connect. Instructions and trigger image were emailed to all participants, and a doodle poll used to arrange suitable dates/times. Interview and focus group would be recorded and transcribed for analysis. None of the student volunteers were studying biological sciences.

Findings

Student response rates

In common with other studies where electronic questionnaires have been used, there was a low response rate (Sax, *et al.,* 2003): the emailed 18J and 17J student surveys achieved a 10% and 8% response rate respectively. It is acknowledged that some caution is needed when interpreting these student surveys, due to the differences in timing of data collection, however, similar responses were observed in each set. Only 4 students across both 17J and 18J students had a disability marker, similarly only 8 BAME students responded, and hence interpretation of user experiences for this group of students is not possible. Similarly, low numbers of male students responded, so investigation of experiences by gender was not possible.

Unfortunately, 9 students dropped out of the focus group at last minute and the single focus group involved 2 students. One other student asked if they could give an individual interview instead, which was conducted via Skype.

Although there were approximately 1500 students registered on the 18J cohort at module start, by the time the cardiovascular system was timetabled for study, the numbers had dropped to 1400. Using data from SAS Dashboard, 18J module website footfall decreased substantially during weeks 20-22 (when students are scheduled to use the Heart App), ranging from approximately 70% to 50% of students registered, having peaked in the previous two-week period due to iCMA and TMA submission dates. Nonetheless, there was a high response rate to the module-based web survey, with 434 respondents to the first part and 365 individuals responded to the web survey set after the second anticipated use of the Heart App.

Student perception of Heart App usability

Aspects of 'usability' that were explored related to downloading the Heart App, manipulating images, use of menu buttons and text used in the Heart App.

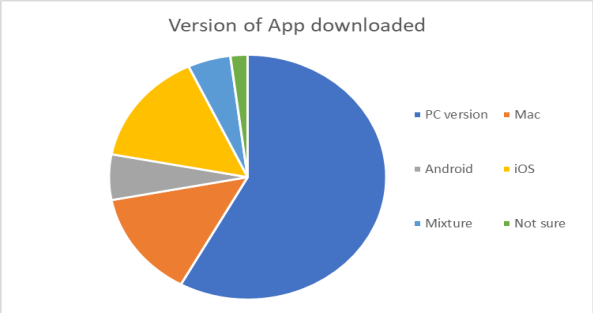

Figure 2: Versions of the Heart App students downloaded, based on module website data. As the majority of SK299 students reported using a PC to study SK299 generally, in both 17J and 18J email surveys, the data in Figure 2 is not surprising. The 17J and 18J email surveys also confirm that the PC version is the primary version downloaded. However, this finding raises some uncertainty as to the proportion of students who used the Heart App in the full 'augmented' mode, and not just viewed the 2D version, especially considering that most students reported having not used AR previously. Notably, during the one-to-one interview with a non-SK299 student tester, they commented that it had taken some time for them to realise the difference between the 2D desktop and the AR version, and wished this had been clearer in the instructions, and this point was also picked up by the students in the focus group.

Information on usability was collected from the 18J module website at the time the Heart App was used in an Activity, and 80% of those who responded to the question 'Was the Heart App easy to install?' found the Heart App easy or very easy to install, which was also confirmed in the focus group and interview. However, this still left a large number of students who had found this initial aspect of using the Heart App a challenge. Indeed, students' qualitative responses in the emailed surveys suggest that some students found it too complicated and time consuming, '*process heavy*' and slow to run on some devices (with reports of being '*glitchy*' and a high CPU usage for some computers). Additionally, some 17% of respondents to the combined 17J and 18J email survey reported not using the Heart App at all, with the majority of these respondents reporting that they could not get it to work (all except 1 of these students were female).

Once using the Heart App, 86% of students reported finding the Heart App easy to use, and over 90% found both text and menu buttons easily accessible. Students in the focus group, along with qualitative comments from the emailed surveys, noted that manipulation of the heart was '*fiddly*' on a small screen. Survey feedback also indicates that some students found that it took time to initially work out how to manipulate images – it was not always intuitive, and students found the need for a separate trigger image cumbersome.

Although it is reassuring to find that overall, the Heart App was perceived positively in terms of usability, there is a lack of clarity over what the students were expecting to use, in terms of AR or 2D image. These findings have led to enhancements to guidance and instructions provided to students in the 19J presentation of the module.

Student perception of the Heart App and learning

Given the uncertainty with regards to the version of the Heart App the students thought they were using, unpicking whether the Heart App aided understanding of the anatomy, physiology and dynamic nature of the heart is difficult. It would have been easier to ascertain had data been available via observation/testing within the User Labs. However, with appropriate reservations relating to this self-reported data, it was reassuring that only 2% of the respondents to the module website survey reported that the Heart App did not aid understanding in these biological aspects. Similarly, it was reassuring to read that approximately 43% of respondents to the emailed surveys reported that the Heart App helped them to recall the structure of the heart more easily than simply reading text. Some 59% of students felt that the Heart App demonstrated the physiological processes more effectively than studying 2D images on a screen.

Lee (2012) suggested that augmented reality applications provide the opportunity for students to follow their own 'learning path' and the findings from this project suggest that the Heart App may increase agency for students, facilitating a more inquiry-based approach, in line with constructivist learning theories. Qualitative responses from the emailed surveys indicate that students valued being in control of the pace of their learning; not only when (and how often) to undertake the activity, but also being able to modify heart rate, or change the view of heart. They

reported that being able to manipulate and visualise structures consolidated their learning from the text. These points were also discussed positively in the focus group, who felt that despite being non-biologists, they had learnt something about the physiological processes.

However, just over one fifth of the combined email survey respondents felt that the Heart App did not aid their understanding of the anatomy/physiology of the heart (27% of nursing respondents, 20% non-nurses), with some 17% of respondents overall finding the 3D heart too complex to interpret. This is an interesting finding and worth unpicking in future work; the concepts and structures of cardiovascular system are complex, and it is possible that the opportunities for visual and spatial exploration provided by the Heart App reinforced existing student concerns about the topic. This finding also reinforces the need for a mixed media approach when supporting student learning in an online environment; students are not a homogenous group, and different educational approaches and tools may suit different students.

Student perception of the Heart App in terms of engagement and motivation

The majority of students thought the Heart App was fun to use (approximately 58% of non-nursing students, 65% nursing students), with one student commenting that they enjoyed the Heart App so much they shared it with friends and family. Students' qualitative responses indicated that they valued a change from text-based learning, responding positively to the visual aspect afforded by the technology. Students in the focus group, who were not biology students, said they found the Heart App engaging and much more '*real and interesting*' than text-based learning. These findings are in line with other research in the wider field of the use of augmented reality within education (e.g. Safadel and White, 2018; Chien, *et al.,* 2017). Although this project did not quantitively assess the extent to which the Heart App effects student achievement, these findings do suggest that the Heart App has the potential to enrich the student experience, and positively contribute to and support learning of aspects of the cardiovascular system covered within the module.

However, nearly 20% did not find the experience fun, with similar proportions of students from 17J and 18J reporting that the Heart App made the learning experience less enjoyable, with 17% reporting that they felt anxious and not relaxed whilst completing the activities. Approx. 45% reported that they preferred learning about the heart using the text, 2D images and videos on the module website (50% of nursing students would prefer these more 'traditional' approaches, compared with 40% of non-nurses). Although the reasons behind these findings are unclear, as Rogers (2000) identified, a stumbling block for the use of AR are technological issues; difficulties downloading the Heart App or slow loading of images may have increased anxiety and concerns over students perceived self-competency (i.e. students anxious whether they were 'doing it right'), or the time required to download/learn a new tool may have contributed to pre-existing time-pressures. Additionally, as discussed previously, the current version of the Heart App requires the use of a trigger image, and some students may have found manipulating the image and device, whilst navigating the menus and controls within the Heart App, overly complicated and hence any benefits from the Heart App itself were overwhelmed by the practicalities of its use; in such cases, simple text-based material is likely to seem less troublesome.

Despite this, over three quarters of respondents from both cohorts reported wanting to see AR used more often to support their learning (with no difference between nurses and non-nursing students). The focus group also picked up on this point, adding 'wish lists' for their (non-science) disciplines, including tours of roman villas and famous sculptures. This seems to be in agreement with Martin-Gutierrex *et al.,* (2015) and Klopfer and Yoon (2004), who have suggested that, as the use of augmented reality and immersive technologies becomes more wide-spread in society generally, learners may desire/expect its use within their education.

AL perception of the Heart App

There was a 26% response rate to the AL survey; this was lower than expected, however, although the survey was emailed post-TMA marking on SK299, a significant proportion of ALs with live contracts on SK299 work on multiple modules/work outside the OU and hence may have moved onto other work commitments. Furthermore, although

timed to not coincide with a high workload on SK299, once marking has finished for the presentation, footfall in the tutor forum decreases and engagement with the module may inevitably begin to 'wind-down'. More female ALs responded than males, which reflects the AL gender balance on the module. A low response rate might also be triggered where individuals have not used the Heart App; despite the anonymous nature of the survey, it is likely that there may be some reticence for individuals to admit to a lack of familiarity with teaching tools to the module team. Nonetheless, two ALs responded to the survey explaining they had not used the Heart App, one of whom was not aware of it. It may be important to speculate on the need to offer ALs support and training, to raise awareness and confidence in using this digital tool.

In common with the students, most ALs used a PC to run the Heart App – and once again, this raises concerns over whether the 2D or the AR apps were used. Most ALs reported installation was easy, although it was apparent that virus-checkers on devices made the process more complicated than anticipated, which was also a point that had been made in qualitative feedback in the student survey and as a discussion on the SK299 national student forum.

As found by Delello (2014) in her study on the experience of teachers use of augmented reality tools, the majority of ALs who responded to the survey, indicated positivity towards the technology. ALs indicated that the Heart App was a good use of student time and that it aided understanding of the anatomy and physiology of the heart. Most ALs found the Heart App easy to use, with easy-to-read text and menu buttons. However, one respondent felt the complex 'authenticity' of the Heart App might make student learning difficult, a view which was also expressed in the student survey.

Only two ALs reported being contacted by their students with queries on the Heart App and student queries to ALs related to the ICT aspects of the tool. A concern was raised that ICT issues might cause the exercise to be time confusing and frustrating, which was the main negative feedback in the qualitative responses. Reporting on the strengths of the Heart App, most responses highlighted the visualisation and manipulation, although interestingly, one responder commented that there are excellent animations on the internet which demonstrate key aspects better than the Heart App.

Project outcome

As primary stakeholders, the results of the project have been discussed with the Module Team Chair (Kerry Murphy) and the author of the Cardiovascular Topic (Lynda Cook) to consider impact on teaching strategy. The results suggest that some students may have found downloading and running the Heart App challenging, and as a result, the instructions associated with the Heart App within the OpenScience Laboratory have been made clearer. It may be the case that once this initial step is made clearer to students, there will be an impact on later experiences. These instructions will also need clarification with the Apple App Store, as the Heart App is available to a wider audience beyond the OU – this will impact users outside of the confines of the module.

As the majority of students who responded to the 18J and 17J student surveys reported that they had not used augmented reality applications before, a short video has also been produced, which will be added to the SK299 module website, to clearly demonstrate to students what the Heart App should look like, when it is running in full AR mode. This should remove any uncertainty as to whether the Heart App is running in desktop 2D mode, or AR mode and ensure that the students can fully use all the designed features, and hence may more fully support learning. Additionally, the check boxes and radio buttons have been maintained on the module website, and it is anticipated that these will be collected data each year, to assess usage of the Heart App.

This project found that over three quarters of students reported that they would like to see augmented reality used more often to support learning, which suggests that students have an appetite for the use of new technologies.

The results of the project indicated that ALs may not necessarily be aware of the Heart App and as a result of this, as Link Staff Tutor for SK299, in conjunction with the Module Team, we will provide further guidance to encourage

them to use the Heart App themselves, to help them appreciate the student experience. ALs will also be encouraged to post a message in their tutor group forums, to support students use of this learning tool.

Figures and tables

Figure 1: The virtual heart app

Figure 2: Versions of the Heart App students downloaded, based on module website data

References

Acosta, J. L. B. (2019) "Framework for designing motivational augmented reality applications in vocational education and training", *Australasian Journal of Educational Technology,* Vol 35, No 3

Akçayır, M. and Akçayır, G. (2017) "Advantages and challenges associated with augmented reality for education: A systematic review of the literature", *Educational Research Review*, Vol *20*, pp.1-11

Chen, P., Liu, X., Cheng, W. and Huang, R. (2017) "A review of using Augmented Reality in Education from 2011 to 2016", In *Innovations in smart learning* (pp. 13-18). Springer, Singapore

Chien, Y. C., Su, Y. N., Wu, T. T., and Huang, Y. M. (2017) "Enhancing students' botanical learning by using augmented reality", *Universal Access in the Information Society*, pp1–11

Delello, J. (2014) "Insights from pre-service teachers using science-based augmented reality", *Journal of Computers in Education,* Vol 1, 295-311

Dunleavy, M. and Dede, C. (2014) "Augmented reality teaching and learning", In *Handbook of research on educational communications and technology* (pp. 735-745). Springer, New York, NY

Herron, J. (2016) "Augmented Reality in Medical Education and Training", *Journal of Electronic Resources in Medical Libraries*, Vol 13, No2, pp.51-55

Klopfer, E. and Yoon, S. (2004) "Developing games and simulations for today and tomorrow's tech savvy youth" *Tech Trends,* Vol *49,* No 3, pp.33–41

Lee, K. (2012) "The future of learning and training in augmented reality", *In Sight: A Journal of Scholarly Teaching, 7*, pp.31–42

Martín-Gutiérrez, J., Fabiani, P., Benesova, W., Meneses, M. D., and Mora, C. E. (2015) "Augmented reality to promote collaborative and autonomous learning in higher education", *Computers in Human Behavior,* Vol *51*, pp.752–761

Moreno V., Cavazotte, F. and Alves, I. (2017) "Explaining university students' effective use of e-learning platforms", *British Journal of Educational technology,* Vol 48, No 4, pp.995-1009

Open University (2020) "Facts and Figures", http://www.open.ac.uk/about/main/strategy-and-policies/facts-and-figures (accessed 21 April 2020)

Rogers, P. L. (2000) "Barriers to adopting emerging technologies in education", *Journal of Educational Computing Research,* Vol *22,* No 4, pp.455–472

Safadel, P., and White, D. (2018) "Facilitating molecular biology teaching by using augmented reality (AR) and protein data bank (PDB)", *TechTrends*, Vol 63, pp.188-193

Saleh A., and Bista, K. (2017) "Examining Factors Impacting Online Survey Response Rates in Educational Research: Perceptions of Graduate Students", *Journal of multidisciplinary evaluation*, Vol 13, No 29

Sax, L J, Gilmartin, S K and Bryant, A N (2003) "Assessing Response Rates and Nonresponse Bias in Web and Paper Surveys", *Research in Higher Education,* Vol 44, pp.409-432

Sweller, J. (1988) "Cognitive load during problem solving: Effects on learning", *Cognitive Science*, Vol *12,* No 2, pp.257–285

Wang, M., Callaghan, V., Bernhardt, J., White, K. and Pena-Rios, A. (2018) "Augmented reality in education and training: pedagogical approaches and illustrative case studies" *Journal of Ambient Intelligence and Humanized Computing,* Vol 9, pp.1391-1402

University approval processes

- *SRPP/SSPP – Approval from the Student Research Project Panel/Staff Survey Project Panel was obtained according to the Open University's code of practice and procedures before embarking on this project. Application number* SRPP 2018 / 111
- *Ethical review – An ethical review was obtained according to the Open University's code of practice and procedures before embarking on this project. Reference number* HREC/3062/New
- *Data Protection Impact Assessment/Compliance Check – A Data Protection Impact Assessment/Compliance Check was obtained according to the Open University's code of practice and procedures before embarking on this project. Data Protection registration number* 4285