TECHNOLOGY MATTERS

Proceedings of the 2018 STORIES Conference

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About the STORIES Conference

STORIES (Students' Ongoing Research in Education Studies) is an international conference for graduate students and early career researchers to discuss their ongoing research in education and education-related projects in other disciplines, such as linguistics, anthropology, social policy intervention, economics, and the wider social sciences. The conference is organised by graduate students and held annually at the Department of Education, University of Oxford. In 2018, the conference theme was Technology Matters.

About the Editors

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What design recommendations can be made for effective exploitation of augmented reality in secondary science classrooms?

Ayşe Inal, Institute of Education, UCL

Key Words

Augmented reality, STEM, science education, 21st century skills, constructivism

Abstract

Augmented reality is a technology-enhanced tool that can assist teachers in presenting difficult-to-grasp abstract scientific concepts that traditional teaching methods struggle to convey, helping tackle the UK's ongoing skills-shortage – a crisis caused by poor uptake of science, technology, engineering and maths subjects. This study, which was originally presented in my master's thesis, set out to derive implications for augmented reality design for use in science lessons, and to make design recommendations for the improvement of features of augmented reality tools and how they can be exploited and enhanced for effective use in the classroom. The thematic analysis of data gathered from questionnaires, observations and focus groups identified seven distinct themes for the design of augmented reality tools and nine recommendations for future educational augmented reality tool development, with an emphasis on substantiality, interactivity and the involvement of subject-experts during the design process.

Introduction

UK educators are keen to find more innovative and engaging ways to deliver their lessons to counter the continuing skills-shortage crisis in science, technology, engineering and maths (STEM) areas (Gill et al, 2017).

Hsu et al (2017) suggest that successful STEM educational practice needs to engage in real-world situations and nurture the interest of students through technology-enhanced hands-on learning, especially when teaching abstract scientific concepts.

One such intervention is augmented reality (AR; Luckin & Fraser, 2011), a stimulating technology that enables the viewing of virtual 3D objects and information in a user's physical environment, making learning more meaningful and contextual (Lindgren & Moshell, 2011; Bloxham, 2013). However, despite the growing body of research recommending AR in education, there still seems to be a reluctance to make AR an everyday part of classroom teaching and learning.

Cuendet et al (2013) identified flawed design to be a key issue, noting that most AR tools to date had been developed and tested in lab settings without consideration of classroom mechanisms (Nussbaum & Diaz, 2013), producing erroneous results, and poor outcomes in a classroom setting.

The purpose of this study was to derive implications for AR design for use in science lessons and to make design recommendations to improve the features of AR tools. Eight secondary science teachers were observed as they interacted with three different AR tools exploring and reflecting on their usefulness, advantages and disadvantages.

Methodology

Underpinned by a constructivist epistemology, whereby children construct their own knowledge and understanding of the world through experience rather than direct instruction (Mooney, 2013; Barillaro et al, 2009), this study was informed by a design thinking methodology. Data was gathered using a mixed-methods approach through online questionnaires, observations and focus groups, and analysed using Braun and Clarke's (2006) six-phase thematic analysis framework (see *Figure 1*).

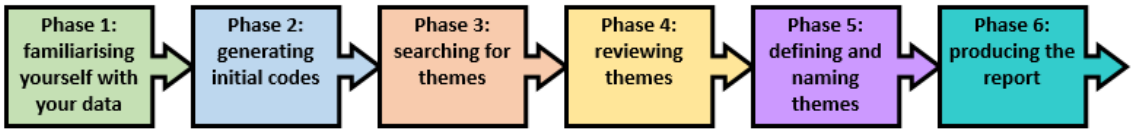

Figure 1. *Six-phase thematic analysis framework (Braun & Clarke, 2006)*

The setting was a mixed state secondary school with academy status for 11 to 19-year olds and the participants were members of the school's science faculty split into two groups based on availability.

Three off-the-shelf AR tools for science education were randomly selected for this study: *Elements 4D* for chemistry, *AugmentifyIt* for physics, and *Secrets of the Human Body* for biology. The participants were observed interacting and exploring the tools and their uses, and contributed to a focus group to discuss their experience.

Design Thinking Process: Findings and Discussion

Design thinking methodology (see *Figure 2*) requires empathy, including awareness of and compassion toward the needs of people affected by a problem, and a desire to create an innovative solution.

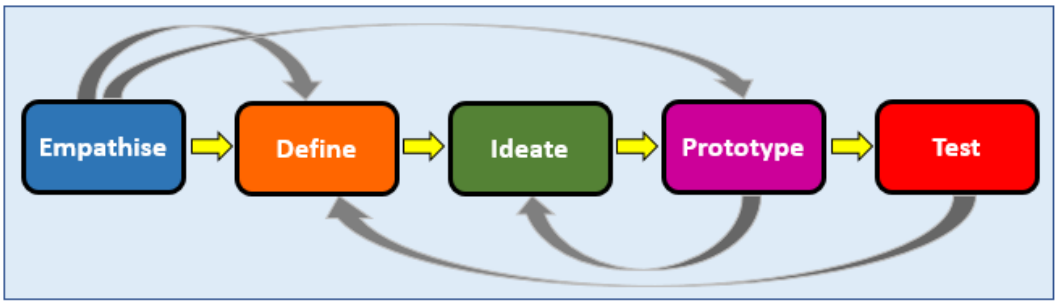

Figure 2. *The iterative design thinking process, Hasso-Plattner Institute of Design at Stanford (Ratcliffe, 2009)*

This study only engaged with the first three phases (empathise, define and ideate) as the intention was not to produce or test a prototype tool.

Step 1 - Empathise

The *empathise* phase consisted of a literature review and data collection through questionnaires, the observation of two participant groups, and their subsequent focus groups. This phase facilitated an understanding of the problem, and the people.

Step 2 - Define

During the *define* phase, all the collected data was sorted and analysed through iterative manual open coding in Word, followed by re-coding in NVivo. The quantitative data from the questionnaires were collated into Excel charts.

Hardcopy handouts, drywipe boards and whiteboard/projector use indicated the prevalence of the transmitter model (see *Figure 3*), confirmed by a preference for teacher-centred methods (see *Figure 4*). The lack of technology adoption in a school that considers itself forward-facing is surprising.

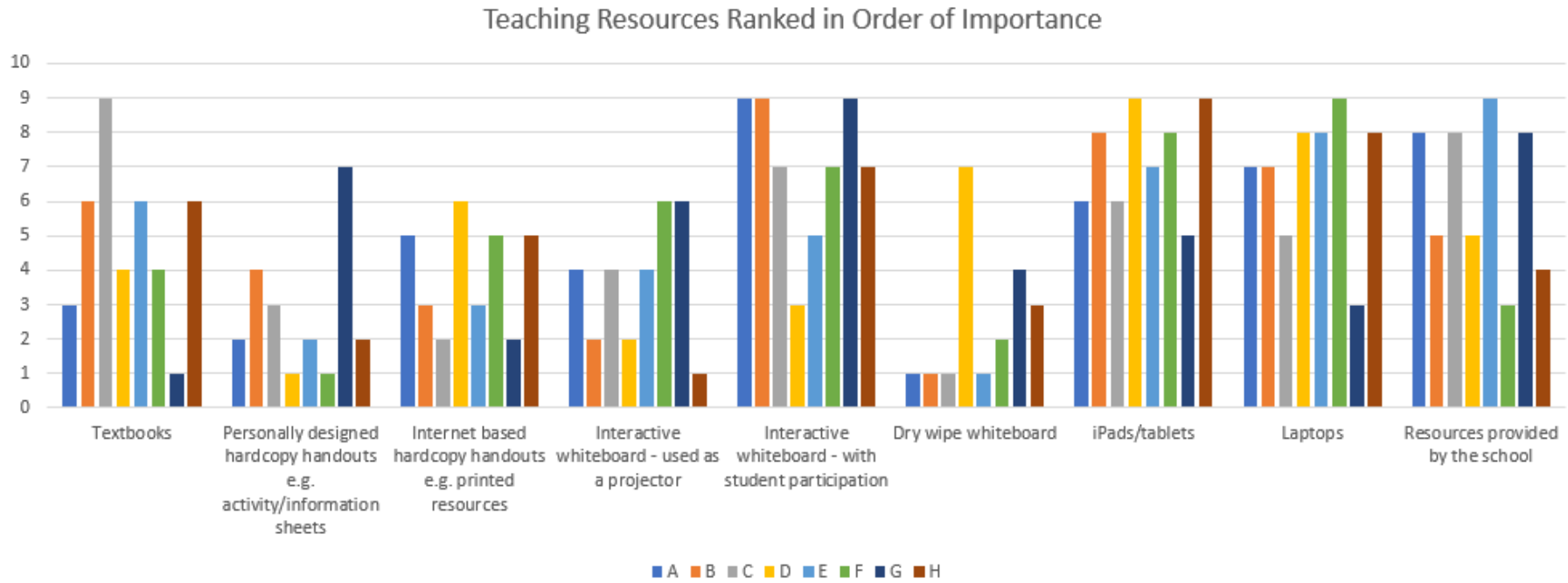

Figure 3. *Question 4 of the questionnaire: "Rank the following in order of importance when teaching"*

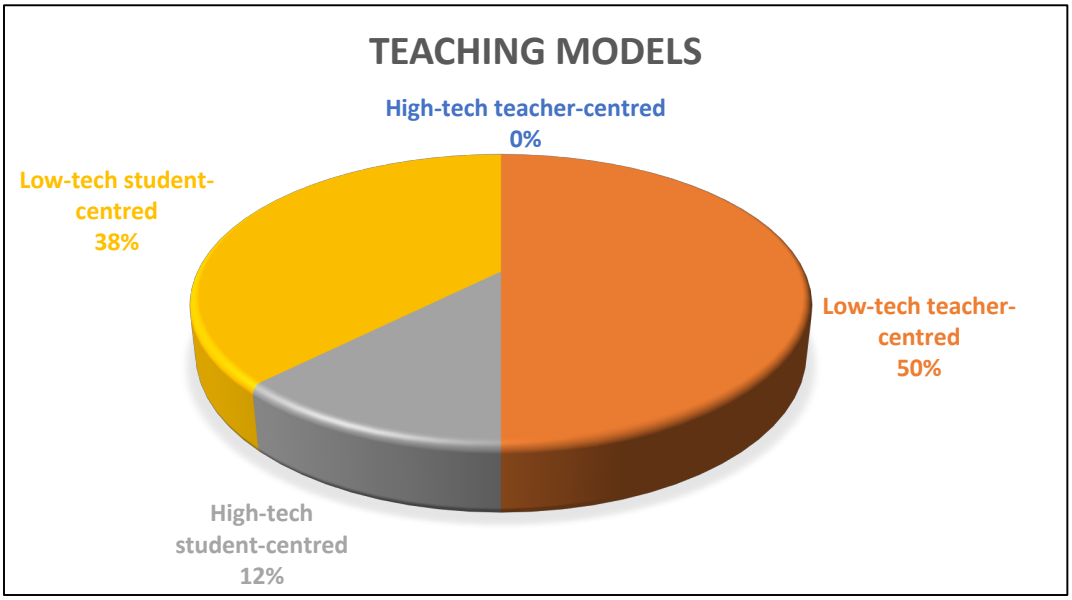

Figure 4. *Question three of the questionnaire: "What model/method of teaching do you usually adopt in your lessons?"*

In contrast to these teacher-centred, low-tech findings however, positive comments were made by participants who could see the creativity the tools could bring to the lesson and to the students, e.g. whilst putting together the more dangerous elements using Elements 4D, one participant in particular commented that when showing the students chemicals that were too hazardous to bring into class "…you'd have to show a video and sometimes that gets a bit tedious and a bit boring for them".

Key themes were identified and used to define and frame the core problem (Dam & Siang, 2017). The seven key themes identified during the study's thematic analysis were *Desired improvements*, *Usefulness*, *Potential use*, *Positive discovery and reaction*, *Interactivity*, *Obstacles*, and *Deficiencies and inconsistencies*.

Step 3 - Ideate

One of the overarching themes was *Desired improvements* and this was selected as the focus for the ideate phase. There was a clear need for the tools to be more interactive to improve engagement, rather than relying on books and videos (Group 2 participant).

This illustrates the difficulties currently faced by teachers when teaching abstract concepts that students often find boring. Digitally enhanced interventions in the classroom with game-based tools have the potential to increase interest and motivation in the sciences (Hwang et al, 2012).

Design Recommendations

These findings underline the role that pedagogical methods and materials play in creating an image of science as something boring and difficult (Palmer, 2009), and has demonstrated the interest and excitement generated by visually stimulating technologies such as AR and the feeling of being immersed in the content.

Therefore, the recommendations of this study are:

1. Ensure the tools are more substantial
2. Include links to more detailed information for extended and differentiated lessons
3. Allow for the creation of quizzes to allow for better formative assessment
4. Include a higher level of content detail
5. Allow for more teacher control through interactivity to tailor lessons to age groups
6. Link the content more closely to the national curriculum
7. Enable more interactivity within the app and user manipulation of content
8. Incorporate artificial intelligence (AI) or data analytics for student assessment over a long period of time
9. Provide real-time feedback on progress

Conclusion

This study set out to make design recommendations for the development of future AR tools. The literature review identified poor design to be one of the reasons why AR has not been embraced in the classroom. The data highlighted the attitudes and feelings of the teachers: for them to consider allowing a disruptive technology such as AR into their classroom, it has to be worth the effort. The tools have to be better designed and go deeply enough into the topic, with more detail and access to supporting information to allow for differentiated learning. They also must foster higher levels of interactivity between the student and the content, for example, being able to manipulate the digital image to learn and retain more, and also between the teacher and the technology so they can tailor content by age and ability to maintain control over their lessons.

About the Author

Currently working as an IT trainer developing digital learning, Ayse has recently completed her Master's in Education and Technology at UCL, and is looking to progress this research further at PhD level.

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Tracing teachers' beliefs and changes in pedagogy when using 1:1 iPad in the classroom

Olympia Christina Kalogianni, Institute of Education, UCL

Key Words

Technology, 1:1 iPad, school, pedagogy, learning

Abstract

This research was originally presented in my master's thesis and focuses on teachers' perspectives when using 1:1 iPad in the classroom. The aim was to trace teachers' pedagogical changes when they were implementing technology into their teaching, the alterations of their beliefs and what mediated these changes. The research was conducted in a Greek school, which uses 1:1 iPad daily for learning activities. An online questionnaire was filled in by 20 teachers, and six follow-up interviews were conducted to examine teachers' experiences in detail. The findings illustrated overall positive trends in the use of 1:1 iPad. All teachers were satisfied by its use and described it as a crucial change for them. Despite some initial difficulties, such as technical issues and parental intervention, they also agreed that 1:1 iPad promotes a collaborative way of effective teaching. Most teachers stated that 1:1 iPad fosters more student-centred learning and reported both time and creativity as additional benefits.

Introduction

In today's society, technology plays a key role in our lives and has gradually increased its significance in the field of Education (Kirkwood & Price, 2014). With the continuous developments in the world of technology, students have upgraded access to educational opportunities, including a range of digital texts. It is therefore important to understand the nature of

technological interventions, like 1:1 iPad, and how educators and learners make use of such technology (Tondeur et al, 2007).

Several digital technologies, such as Interactive Whiteboards, and iPads are increasingly being used in schools (Quniebi, 2016). Yet, even though 1:1 iPad is considered a technology-rich educational reform, there is little empirical evidence to support this claim (Bebell & O'Dwyer, 2010). Furthermore, teachers frequently change their instructional practices when using technology with students (Windschitl & Sahl, 2002), by affecting positively their teaching methods as they redesign their classrooms (Foote, 2012).

Several researchers have supported the view that technology promotes student-centred collaborative learning (Baker, Herman, & Gearhart, 1996; Mehlinger, 1996) and the application of technology stimulates educators to utilise more challenging activities in teaching (Means, 1994). However, how and under what specific circumstances such alterations occur is not clear. The current study aimed to trace teachers' perspectives on the use of 1:1 iPad in the classroom, and to track any changes they made to their pedagogical practices when implementing such technology. It therefore attempted to examine teachers' perceptions of changes in their teaching practice and what they think mediated these changes.

Method

Measures and Procedure

The study was conducted in collaboration with Doukas School, a private school in Athens, Greece, as it was the first school nationally to use 1:1 iPad (introduced in 2011). Two measures were used for the data collection; an online questionnaire and selective follow-up interviews. Twenty teachers participated in the survey answering the online questionnaire, while six of them, representing different disciplines, were invited to voluntarily take part in follow-up interviews.

Questionnaire

The questionnaire was administered by 'Survey Monkey', which provided convenience, flexibility and anonymity to participants. In the questionnaire, participants were given a small introductory statement and then they were asked ten questions (Appendix A). All the questions required one answer, apart from Questions two, three, five, and eight, where participants could choose up to three answers since one answer was not enough for them to provide their opinions adequately.

Interview

The second method was interviews, conducted to examine teachers' perceptions in their pedagogical practices when using 1:1 iPad. The interview began with questions regarding teachers' integration of 1:1 iPad in the classroom (Appendix B). Audio recording methods were chosen for the research, helping to improve the validity of the research and enabling the researcher to focus closely on the whole procedure (O'Leary, 2014). Also, the use of participants' quotations throughout the survey enhanced credibility and trustworthiness (Boyce & Neale, 2006).

Ethical Considerations

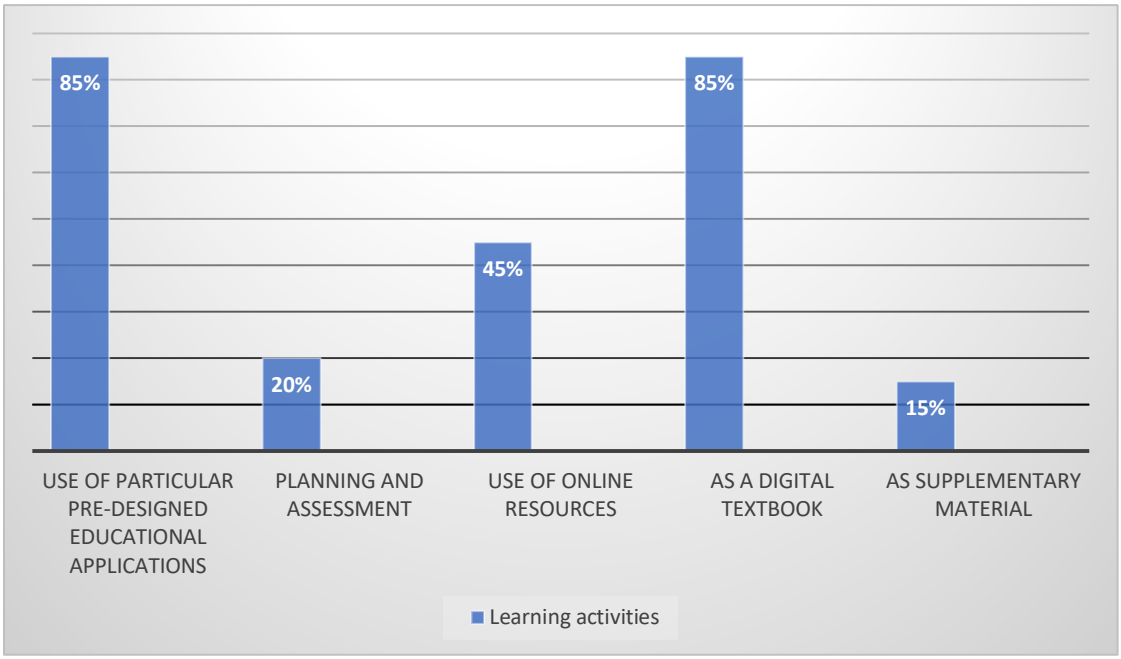
In an attempt to address ethical concerns, guidelines for ethical research from the British Educational Research Association (BERA) were followed. Ethical approval was given by UCL's Institute of Education MA dissertation ethical approval procedure. All participants were aware of their involvement in the survey as they completed an information sheet electronically at the beginning of the survey, and a voluntary informed consent form for interviews and questionnaires. Confidentiality was ensured through anonymising the questionnaire, and only asking the participants who agreed to be interviewed to provide their email address. Before the interview, participants were asked if they were happy to be audio recorded so as to aid the flow of the interview and to improve the accuracy of data collected. Finally, participants were informed of their right to skip questions, the option to withdraw any time (Longhurst, 2003) and their right to ask information about the results of the study.

Results

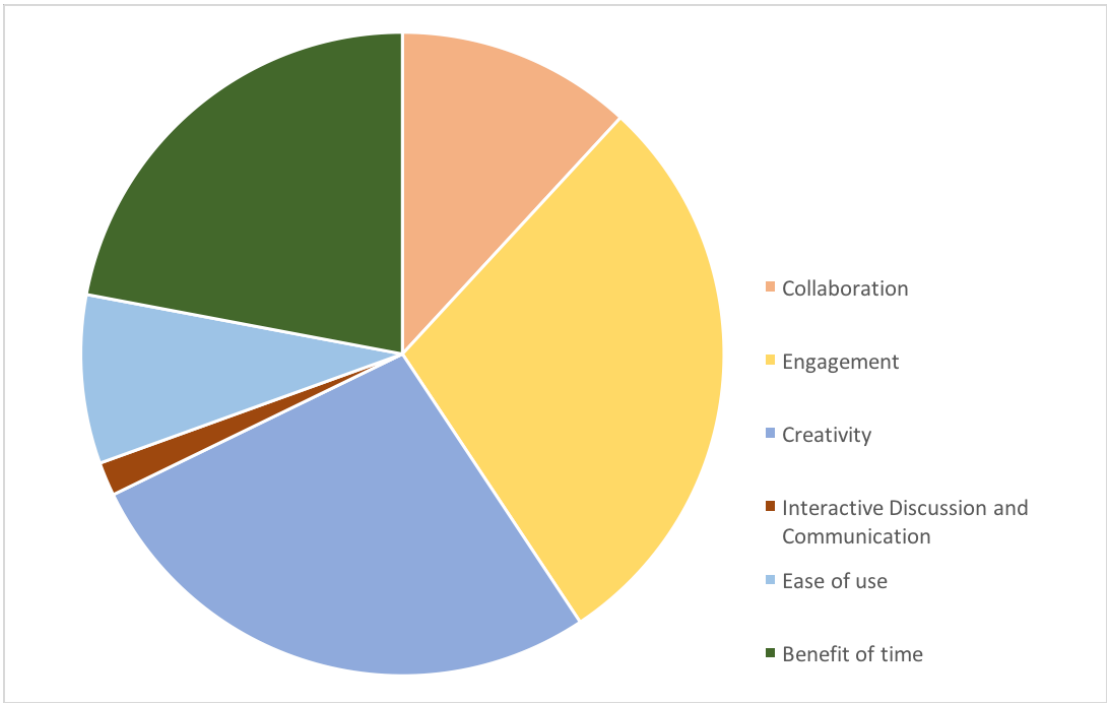
In this section, findings from the questionnaires (that were conducted to trace teachers' perceptions and changes in their teaching when using 1:1 iPad in the classrooms) and the interviews are presented.

Questionnaires

The 20 teachers (ten male and ten female) who filled in the questionnaire had been using 1:1 iPad for three or more years and had more than ten years of teaching experience. Bar Chart 1 shows the learning activities where the 1:1 iPad was primarily used. Eighty-five percent of the participants used particular pre-designed educational applications in the 1:1 iPad and twenty percent of them used it for planning and assessment of the course. Forty-five percent of the respondents stated that they use it for online resources and fifteen percent of them as supplementary material.



Bar Chart 1. *Teachers' learning activities on 1:1 iPad*



Pie Chart 1. *Key teaching and learning benefits of 1:1 iPad*

Pie Chart 1 indicates the key learning benefits of 1:1 iPad. Particularly, thirty-five percent of the respondents chose "Collaboration" and eighty-five percent "Engagement". Also, eighty percent of the participants stated that 1:1 iPad boosts "Creativity", and five percent of them gave the answer of "Interactive Discussion and Communication" as a key benefit. Finally, twenty-five percent of the participants answered, "Ease of use", and sixty-five percent reported "Benefit of time" as an advantage. Finally, in terms of rating the usefulness of the particular technology, 19/20 of the participants characterised 1:1 iPad as "Very Good" and one of them as "Good". In a similar pattern, 20/20 participants answered that the use of 1:1 iPad has positively changed their views about technology for education.

Interviews

Teachers' opinions when using 1:1 iPad were collected in more detail through Skype interviews. The topics included: an overview of teachers' current contact with 1:1 iPad; teachers' background information for using

iPad; changes in their teaching; students' experiences; and advantages and disadvantages of using 1:1 iPad.

Six teachers participated in the interviews: three literature teachers, two mathematics teachers, and one biology teacher, all ranging from the fourth grade of primary school to the third grade of high school. They were confident and had a positive attitude towards the use of 1:1 iPad as they had used it for the past six years. All the teachers initially faced technical difficulties with the devices and although they wanted to provide students with new opportunities, they had issues with the hardware and the software. Particularly, participants mentioned several technical problems, such as the slow software or the bad condition of the touchscreen, as students had difficulty writing on it. However, these problems have now been resolved with the advancement of technology.

Secondly, several teachers referred to parents' attitude towards 1:1 iPad as an initial barrier as some parents were distrustful about integrating it into their children's school life; some parents preferred a more traditional concept of teaching such as reading from the book instead of the iPad. Moreover, all teachers, one year before the incorporation of 1:1 iPad, prepared the new material (collecting teaching material, visualising it, etc.). Some teachers supported that with the incorporation of 1:1 iPad they implemented the teaching material into another methodology and made it more interactive.

Furthermore, teachers listed the key advantages and disadvantages of using 1:1 iPad. As advantages, they stressed that students' perception of studying has been improved. They appeared to enjoy this educational tool, be more engaged in the classroom, which resulted in more learning time being available. Overall, teachers described how 1:1 iPad had brought beneficial changes in students' learning as they now study through self-exploration and use new resources for their learning. All teachers stated that because of the use of 1:1 iPad there is more learning time available in the classroom and so, they have the opportunity to dedicate valuable time to students as facilitators; in other words, they can guide and assist students in learning by themselves through picking apart ideas and forming their own thoughts about them.

Although all teachers highlighted that the advantages of 1:1 iPad outweigh its disadvantages, both features are worth discussing. They noted that their role changed after the introduction of 1:1 iPad and classroom

management became more difficult; it is harder to attract students' attention and interest as the iPad is a powerful information tool and they sometimes lose their focus. Moreover, some teachers mentioned that it is difficult to manage the plethora of online information. The teacher's aim is to make students active users of the knowledge they acquire by selecting the information critically, and therefore building students' confidence at a pace suitable to them.

Conclusion

The present research explored teachers' perspectives regarding the implementation of 1:1 iPad in the classroom. Overall, teachers were satisfied with such integration in their pedagogy and pointed out that this device is substantially beneficial for their learning activities and interaction with students. The findings of this study were an attempt to provide an insight into teachers' experiences of using 1:1 iPad and to contribute to this expanding field of educational research.

About the author

Olympia Christina Kalogianni holds a Bachelor's Degree in English Language and Literature from the National and Kapodistrian University of Athens. She has recently graduated from the Institute of Education, UCL where she completed her Master's degree in Education and Technology.

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Appendices

Appendix A: Online Questionnaire

Use of 1:1 iPad in the classroom

Thank you for filling out this questionnaire about the use of 1:1 iPad in the classroom. I am a postgraduate student at the UCL and I am writing my dissertation on tracing teachers' beliefs and changes in pedagogy when using 1:1 iPad in the classroom. I would be grateful if you could help me collect some data for my survey. Your answers of this questionnaire are completely anonymous and confidential. I appreciate your time and input!

1. **How long have you been using 1:1 iPad in the classroom?**

- I do not use it
- Less than 1 year
- 1-2 years
- 3 or more years

2. **What activities do you primarily use it for? (choose up to 3)**

- Use of particular pre-designed educational applications
- Planning and assessment of the course
- Use of online resources (e.g. videos, images)
- As a digital textbook
- As supplementary material (e.g. webpages, maps)
- Other (please specify)

3. **What do students primarily use the 1:1 iPad for in the classroom? (choose up to 3)**

- As supplementary material (e.g. webpages, maps)
- Exploring the Internet
- Use of online resources (e.g. videos, images)
- Do learning activities
- Use as a textbook
- Other (please specify)

4. **What is your overall opinion about this particular technology for teaching and learning?**

- Very satisfied
- Satisfied

- Neutral
- Hesitant
- Dissatisfied

5. **What do you think are the key teaching and learning benefits? (choose up to 3)**

- Collaboration
- Engagement
- Boost Creativity
- Interactive Discussion and Communication
- Ease of use
- Benefit of time
- Other (please specify)

6. **Do you think that 1:1 iPad has changed the way you teach your subject?**

- Yes
- No
- Not yet

7. **If yes, give one example of how you think that 1:1 iPad has changed your way of teaching?**

- Use of 1:1 iPad instead of textbooks
- Use of 1:1 iPad instead of blackboard
- More student-centred learning (students' action, engagement)
- Planning and assessment of the course
- Other (please specify)

8. **What kind of difficulties have you faced during your experience with 1:1 iPad? (choose up to 3)**

- Technical
- Knowledge/Training
- Students' denial
- Parental intervention
- Other (please specify)

9. **Overall how would you rate its usefulness?**

- Very good
- Good
- Neutral
- Limited

- Poor

10. Has the use of 1:1 iPad changed your views about technology for education?

- More positive
- More negative
- Neither

Appendix B: Interview Themes

A. An overview of teachers' first and current contact of 1:1 iPad.

- How did you feel about integrating 1:1 iPad into your teaching at the start?
- How do you feel about it now?

B. Teachers' background/training for using 1:1 iPad.

- Did you experience any difficulties when you first used 1:1 iPad? Can you describe these?
- What kind of instruction did you receive, if any? What would you have liked/needed?

C. Changes in teachers' teaching when using 1:1 iPad

- What learning activities do you do when using 1:1 iPad? Why did you choose these? Have these changed over the course of your use?
- Could you give me three main pedagogical changes that you made when you started using 1:1 iPad? How effective do you think these have been? Have you changed your lesson plans when you started using 1:1 iPad? What did you change?

Use of technology to support parental engagement and children's learning

Eliana Osorio Saez, University of Bath

Key Words

Parental engagement, technology and children's learning

Abstract

For more than fifteen years, The Learning Foundation has provided socioeconomically disadvantaged households with children in England with some kind of technological device (a tablet or a laptop) to use at school, and at home to complete schoolwork and homework. The 1:1 (one device per child) scheme has reached more than 1,000 schools, 400,000 parents and 250,000 children. This ongoing mixed-methods study examines the impact of parental engagement on children's learning by identifying patterns in the conditions under which the use of technology might be more effective in supporting parents to help children learn. My study has two stages: during the first stage, data from two surveys from more than 5,000 parents will be statistically analysed using structural equation models; during the second stage, new data will be collected from schools, parents, students and past project's participants to allow a longitudinal study.

Literature Review

The term deprivation will be defined in this research as the adverse economic circumstances in a child's family and/or local area (DCSF, 2009). We can perceive that compared to their economically advantaged peers, children in deprived context have worse outcomes on just about everything we can measure: personal, social, emotional, and physical development, as well as communication and language (Hackman & Farah, 2009).

In contrast to their peers with higher income, poor children are unprotected against negative family dynamics: they read less, and their parents tend to be less involved in their school life (Evans, 2014). In a recent government report, it is observed that the percentage of Free School Meals

(FSM) children achieving a good level of development at the end of the foundation stage has increased by about twenty-two percent between 2015 and 2017 (DfE, 2017). However, there is still a significant number of poor families that contribute to the achievement gap: the report by the Education Policy Institute (2017) shows that this gap in these disadvantaged children against their wealthy peers becomes wider (it is 24.3 months at the end of secondary school).

Children born into low-income families "face life-long penalties regardless of their abilities or effort" (Gregg & Macmillan, 2010, p. 260). The economically disadvantaged children tend to perform low in school (Cassen & Kingdon, 2007), they complete fewer years of schooling, they are more likely to be poor as adults (Lindley & Machin, 2012), they are less healthy, and they are more likely to commit or be victims of crime. All of these consequences of being born into a low income family has a negative impact on the national economy.

According to the Joseph Rowntree Foundation (2016), it was estimated that fighting back the effects of poverty and deprivation costs £1,200 for each person in the UK. Evidence from research shows that the aspirations, attitudes, and behaviours of parents may have an important part to play in explaining why poor children typically underperform at school and are at risk of never getting the social and cultural capital (Bourdieu, 1986) required for social mobility, overcoming poverty and becoming resilient.

Parents do matter; they perform a crucial role in their children achieving better outcomes (Harrys & Goodall, 2008). Parental engagement goes beyond parental involvement. Parental involvement refers to the relationship between schools and parents and how parents can support the school's goals, especially academic achievement. On the other hand, parental engagement is connected with learning, a much broader concept. Parental engagement describes the relationship between parents and children towards learning, and it includes conversations, interactions, and discussions. Parental engagement describes how parents model and assume an attitude towards learning and the value of learning for their children, and how these models and attitudes support children's development, behaviour, and achievements (Goodall, 2016).

A home learning environment (Arnold, Bartlett, Gowani & Merali, 2007), is defined as any activity that presents learning opportunities to the children at home such as bedtime stories, library visits, and singing nursery rhymes (Goodall, 2017). Research has found a connection between a positive home learning environment and better achievements (Melhuish,

Phan, Sylva, Sammons, Siraj-Blatchford & Taggart, 2008). These activities are not necessarily connected with wealthy families; rather, they can also be performed in disadvantaged settings (Goodall, 2017).

Through the use of technology, this home learning environment might be strengthened. A significant number of charities in England such as Techknowledge for Schools and the Learning Foundation, provide children with some sort of one to one (1:1) technological devices and Internet connection. According to the report presented by Clarke and Svanaes, between sixty-eight and sixty-nine percent of children in England are currently using Tablets or laptops (Family, Kids and Youth research group from the University of Cambridge, 2014), therefore technology has a presence at school and at home.

Technology in education is often discussed in the teaching context, where it is used to support teaching and learning (Shank, 2007; Thorn, 2009). However, few studies have focused on how technology supports parental engagement and children's learning at home, in other words how the use of technological devices might help parents to create a home learning environment that may contribute to narrow the achievement gap.

Methodology

This is an ongoing mixed-method study, where quantitative and qualitative research will be combined. Quantitative data comes from two surveys carried out between 2016 and 2018. These surveys were filled in by more than 5,000 parents in England.

Data analysis in the first stage is being conducted by using advanced statistical techniques (Structural Equation Models) to identify patterns in the conditions under which technology is more effective in supporting parents' engagement.

Qualitative data will be collected by the researcher using interviews and focus groups. Current and former participants of the programme will be involved, in order to achieve a longitudinal study of impacts on parental engagement and children's learning.

Anticipated Contributions

This research may have implications for future research, policy, theory, and practice. It will add to the literature on parental engagement and the need to gather evidence: "While it is important to try to support parents to engage,

less is known about which methods are the most effective" (Barbour, Eisenstadt, Goodall, Jelley & Sylva, 2018, p. 3).

This mixed-method study will broaden the knowledge and understanding of how technology supports parental engagement and the creation of a home learning environment. In addition, this research will provide large-scale data from different areas across England, and will offer an overview of how England is placed compared to other regions in the world.

Moreover, it will provide an understanding of how parents observe the interaction with technological devices at home, focusing on their usage, learning potential, and home-school communications. Additionally, this study will reveal parents' opinions about the role of technology: beliefs, challenges, barriers, confidence, motivations, self-learning, collaboration and aspirations.

About the Author

Eliana holds a BA in Teaching Spanish and English from Universidad Popular del Cesar and an MA in Education: English Didactics from Universidad Externado de Colombia, both in Colombia. She graduated with a second MA in Education: Leadership and Management from Bath Spa University in England and is currently studying a PhD in Education at the University of Bath, in England. She has taught at all levels and is an author of textbooks and online courses. She has been a speaker and a teacher trainer in the fields of E-learning and ICT in Education, as well as a consultant for the public and private sector in Colombia, actively participating in educational projects for implementing e-learning and blended learning in public and private universities and high schools.

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Adult learners in online higher education: The complexity of students' transitional experiences of becoming a distance learner

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Key Words

Adult student, online learner, online higher education, diversity

Abstract

Online learning is a rapidly growing aspect of higher education. However, while this learning mode offers the flexibility and convenience required by non-traditional adult students who face competing social demands and obligations, various barriers still exist that threaten their academic success (Dziuban et al, 2006). Although a large body of research has focused on challenges for adult learners in online education, there is still a lack of in-depth understanding of the conceptual variations in the experiences and perceptions of adults as they embark on online education. This paper aims to emphasize the complexity of experiences of an adult student population in an online learning environment through a review of previous empirical research. The paper will stress the importance of looking at adult learners' transitions to online learning environments in more depth, with a particular focus on their divergent perceptions of learning processes.

Introduction

Adult students present the largest proportion of online learners (Ke & Xie, 2010; Moore & Kearsley, 2012). Openness, flexibility and accessibility of the online learning mode attracts adults allowing them to combine studies and other life responsibilities. However, in recent research the issue of students' transition into this new learning environment has emerged as an area of concern (Park & Choi, 2009). Drop-out rates from online programmes continue to be high (Simpson, 2013). Scholars recognise learners' experiences as a complex, dynamic, and context-situated variable (Park & Choi, 2009) and suggest variations

in adults' perceptions of their online learning. This paper aims to provoke a discussion on the differences in adult students' perceptions of their online learning, and highlight the need to examine the transitional processes of adults returning to universities as distance students with a particular focus on the diversity of their experiences.

Literature Review

According to Moore and Kearsley (2012), distance learners are primarily adults between the ages of 25 and 50 years. Online education can offer numerous advantages for them, including flexibility, accessibility, independence, and cost effectiveness. Ironically, it is the perceived benefits of online learning that usually create negative experiences for the majority of adult learners. Challenges, such as a lack of a sense of belonging to the academic community, insufficient course content and quality of teaching are commonly reported by adult online learners (Bourdeaux & Schoenack, 2012). Other factors that are actively discussed in the literature include physical isolation and the rarity of interactions (Phirangee & Malec, 2017; Kuo & Belland, 2016), inadequate support (Park & Choi, 2009) and challenges associated with technological adaptation (Beqiri, Chase, & Bishka, 2009; Pena & Yeung, 2010). Additionally, when adult learners face a dilemma between the course, and their competing life demands, they feel that they have no choice but to prioritise the latter (Thistoll & Yates, 2016). All of the above could lead to frustration and contribute to learners deciding to withdraw from the online course (Bourdeaux & Schoenack, 2012; Ilgaz & Gülbahar, 2015).

There are a number of assumptions associated with adult students rooted in the theory of adult learning (Knowles, 1984), according to which adults tend to be self-directed, require problem-centred learning and instant application of knowledge, and are internally, rather than externally, motivated. Scholars, however, argue that adults in online distance courses need as much guidance and motivation as their younger counterparts due to their weaker cognitive skills (e.g. Hashim et al, 2011). Adults' preference of self-directed learning does not always mean that they possess the necessary skills for successful learning in an online environment (Cercone, 2008). Moreover, Botha and Coetzee (2016) argue that there might be variations in adult students' level of self-directedness related to such individual characteristics as race, age or gender. Another common assumption is that older students may find online learning

difficult to adapt to (Dubois, 1996). Some scholars affirm that adults tend to feel insecure about their ability to succeed in distance learning, demanding more support services and additional technical training (Ke & Xie, 2009). On the other hand, there are findings suggesting that adult students are comfortable and satisfied with using technology in their learning (Ilgaz & Gülbahar, 2015).

I agree with those scholars who state that adult students have unique needs and expectations (e.g. Cercone, 2008), diverse characteristics, and life circumstances that impact on their learning (e.g. Boling et al, 2012; Loizzo et at., 2017), and argue that further in-depth research is needed to uncover the variations in the ways in which adult students experience their online learning.

Methodology

A systematic literature review was conducted with the aim of identifying gaps in the existing research. The Scopus database was used to search for relevant studies. Avariety of key words and word combinations, such as "adult student", "non-traditional student", and "online higher education" were used as search terms. Among identified studies only articles published between 2008 and 2017 in peer-reviewed journals were selected. Among other inclusion criteria that set the boundaries for this review were the student population (adult learners) and the study setting (online higher education). Only studies published in English language were reviewed. Additional studies of relevance to the phenomenon of interest were identified through a 'snowball' method by using reference lists of the selected articles (Webster & Watson, 2002).

Results and Discussion

The complexity of adults' online learning experiences

Appendix A presents an overview of findings reported in the extracted studies. There is no doubt that previous research has made a great contribution to understanding adults' online learning. Yet, although scholars have attempted to identify what affects adults' online learning experiences, there is no consensus among them on a single set of factors. Moreover, only a few studies focused on uncovering variations in how adults experience the same phenomenon with the aim to understand what the differences in students' perceptions of online learning processes are.

The level of engagement and the sense of belonging to the academic community has been suggested to have an influence on students' learning satisfaction (Ke & Xie, 2009). In their study, Hashim, Ahmad and Ahmad (2011) emphasized that older students have lower academic performance due to their weaker cognitive engagement. This statement differs from findings presented by Conrad (2009) which demonstrate that adult learners possess good self-knowledge in their use of metacognitive strategies, and engagement in learning. Other authors have shown that adult students have mixed perceptions of engagement with online learning and suggest that adult students with a stronger sense of belonging to the academic community tend to have a higher level of learning satisfaction (Gravani, 2015; Ke, 2010).

Motivation was another factor that emerged from the literature. Scholars argue that lack of motivation could have an influence on students' academic progress (Kim & Frick, 2011; Nagelsmith, Bryer & Yan, 2012; Stoessel et al, 2016). Evidence provided by Kim and Frick (2011) further noted that the level of motivation may vary among adult learners across the study period. This suggests that there are not only variations in motivation among adults, but also that adults may perceive the same phenomenon – their learning process – differently at different times during their study.

Scholars have investigated the impact of learners' self-directedness on their study processes. Coetzee (2014), for instance, suggests that academic self-directedness has both an explicit and an implicit influence on students' sense of academic, personal and social responsibility. Botha and Coetzee's (2016) later findings also show that students' gender, race, and age are associated with the level of their self-directedness.

There have been other findings reporting learners' experiences in relation to their age and personal characteristics *(*Dwyer et al, 2013; I-Jan et al, 2013; Kao et al, 2013). Some researchers emphasize the challenge for older students related to the usage of technology for learning, suggesting that gender has no effect on adult students' preference toward online learning environments, while age does (Kao et al, 2013). However, Dwyer et al (2013) argue that female participants perceive distance education more positively compared to male participants. At the same time, Mohd Nor's (2011) study results indicate that mature learners tend to be strongly motivated individuals, with good time managements skills, and support from family. The latter finding therefore raises questions over the assumption that older students have more challenges in the online learning environment than their younger peers.

Prior studies have introduced some recommendations to overcome barriers and challenges reported by adult students. In order to encourage learners to become and stay involved in the online learning environment, Cheng et al (2011) and Boling et al (2012) proposed that teachers should integrate work-related tasks and real-world assignments into the lesson design. Ke (2013) points out that older students tend to prefer collaborative interaction in an online learning environment, rather than working individually, and suggests that learning arrangements which encourage learner-learner interactions should be prioritised as they enhance the level of interactivity and collaboration in learning. By contrast, Kuo and Belland (2016) advocate learner–content interaction, showing that it has the strongest correlation with Internet self-efficacy. Loizzo, Ertmer, Watson and Watson (2017) argue that learners have a variety of expectations within their online learning, and that while some learners value discussions and instructor engagement, others prefer to have limited interaction and focus solely on the course content via videos, readings, and assignments.

Conclusion

The scientific discussion on the diversity of adult student accounts and differences in their perceptions, experiences and needs of online learning environments has recently emerged in the literature (see, for instance, Kim & Frick, 2011; Baloyi, 2013; Kuo & Belland, 2016, Waller, 2006). However, acknowledging these differences is one thing, but taking the divergence principle into account is another. This principle could be implemented into the research design by selecting the study sample that reflects the diversity of the adult student population, and by choosing the appropriate research methodology that aims to uncover variations in students' learning experiences. As Waller (2006) emphasized, 'mature students are a diverse and heterogeneous group, with the 'reality' of their experience(s) being [too complex and individually situated]' (p. 120). Therefore, I would argue, that research that is specifically designed to examine the variations in the experiences and perceptions of the adult student group is needed in order to create a more complete picture of the phenomenon of adult online learning. Understanding the range of student experiences in online programmes is crucial because those learners who feel frustrated, lost or unsupported during their studies are more likely to discontinue their enrolment (Bourdeaux & Schoenack, 2016).

About the Author

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Appendices

Appendix A: Adult Learners' Experiences in Online Higher Education

Author	Year	Approach	Sample size	Findings
Meyers & Bagnall	2017	Qualitative Phenomenography	10 students	Authors suggest a model of variations in adult students' prior knowledge and skills in relation to the use of computers or the Internet.
Loizzo et al	2017	Qualitative	12 students	Study results show that adult students express a variety of reasons to enrol onto online programmes. Those range from personal enjoyment to career development; have different expectations within a MOOC; and show various preferences towards levels of interactions and engagement.
Shapiro et al	2017	Mixed-method	26 students	The results demonstrated that participants with lower levels of formal education are more likely to feel lost and frustrated in their studies. In addition, the findings showed stronger resilience and optimism in students from less developed countries. Lack of time, previous bad classroom experiences, inadequate background, and lack of resources such as money, infrastructure, and Internet access, have been identified as common barriers.
Bourdeaux & Schoenack	2016	Qualitative	22 students	The study findings suggest that students expect clarity, respect, and intentional design from their online instructors, and experience a feeling of frustration if instructors do not meet their expectations of teaching.
Kuo & Belland	2016	Quantitative	167 students	The results of the research showed the strong correlation between learner satisfaction and performance. The data analysis showed the positive correlation of Internet self-efficacy and learner-learner, learner-instructor and learner-content interactions. Learner–content interaction proved to be the most important predictor of student satisfaction.
Botha & Coetzee	2016	Quantitative	1,102 students	The findings showed that there is a significant difference among learners in the level of their self-directedness in relation to gender, race, and age groups.

Stoessel et al	2015	Quantitative	4,599 students	The study results suggest that older students are generally stronger motivated.
Malinovski et al	2015	Quantitative	198 students	Adult students' satisfaction with online learning is influenced by the ease of participation and appropriateness of teacher-student interaction and is predicted by students' motivation to attend similar trainings.
Ilgaz & Gülbahar	2015	Mixed-method	2,334 and 2,288 students	Findings suggest that the participants' satisfaction was generally affected by instructional content, level of communication and content usability, as well as by the teaching process and learners' time management skills.
Gravani	2015	Qualitative, phenomenography	16 students, 8 educators	Study findings indicate the complexity of adults' online learning experiences, and suggest that adult student's experience might be influenced by personal, social and contextual factors that interconnect and can either support or impede learning.
Coetzee	2014	Quantitative	1102 students	Results indicate that academic self-directedness of the participants was positively influenced by their scholarship, global/moral citizenship and lifelong learning attributes. Authors emphasize that the influence of scholarship attributes on academic self-directedness is significantly mediated through global/moral citizenship and lifelong learning attributes.
I-Jan et al	2013	Quantitative	178 students	Authors suggest that gender does not have an influence on adult students' preference towards online environments, while age does. In addition, the findings show that younger adults have more confidence than older adults in using technologies in their learning.
Ransdell	2013	Quantitative	52 students	The results of the study showed that baby-boomers often interact with learning software with more meaningful engagement.
Lee & Choi	2013	Quantitative	169 students	The findings of the study showed that persistent students had higher levels of academic locus of control and metacognitive self-regulation skills compare to dropout students.
Dwyer et al	2013	Quantitative	97 students	Study results showed that the participants viewed distance learning as the best opportunity to gain their degrees. According to findings, female participants

				had significantly more favourable attitudes towards distant learning than the male participants. The opinions in regard to benefits of online programmes were different among students of different gender.
Ke	2013	Mixed-method	463 students	Findings showed that a design of online discussions with a balanced inclusion of three types of interactions (student-student, student-content, student-instructor) promoted the most self-reflection/ self-regulation oriented online discussions. Findings also showed that older students perform less online discussions which may denote individualistic knowledge construction or surface learning.
Nagelsmith et al	2012	Quantitative	297 students	Findings showed that there are strong relationships between motivation, volition, and academic success.
Ismail et al	2012	Quantitative	182 students	The study results indicate a positive and active attitude in learners' readiness to use e-learning.
Boling et al	2012	Qualitative	10 students, 6 course instructors	Findings reveal that in online courses with little or no interactions, students often feel disconnected. Communication with fellow students and completing real-world assignments that required interactions with others has been reported as a favourable aspect of online learning, while learning through memorisation was reported as a negative aspect. Another negative aspect mentioned by students was the learning experience when peers' lack of activities during the collaborative work and group projects influenced their own grades.
Carnoy et al	2012	Quantitative	29,700 students	Study findings suggest that adult students' age does not influence the online course completion or duration of enrolment, while number of children does.
Hashim et al	2011	Quantitative	169 students	The findings of the study showed that cognitive engagement in online learning processes is rather weak for adult students, suggesting that adult learners need as much guidance as their younger counterparts.
Cheng et al	2011	Mixed-method	12 students	The study results show positive effects of perceived learning support, as well as perceived support for promoting a norm

				of cooperation, on students' intention to use e-learning system. The perceived support for enhancing social ties had a negative effect on employees' behavioural intention.
Mohd Nor	2011	Mixed-method	5 interviews, 72 questionnaires	Author suggests that older adults are strongly motivated to learn, health conscious, possess good time management and social skills, have support from family and no financial difficulties. Challenges faced by older adult learners are related to the usage of a computer and the stress of study.
Kim & Frick	2011	Quantitative	368 students	The study findings inform that the best predictors of motivation during self-directed learning are the perceived quality of instruction and learning, and the motivation to begin.
Ke	2010	Mixed-method	16 students	The study results indicate online instructional design and teaching elements that are crucial prerequisites for a successful online higher education experience for adult students. The author also discusses the relations between online teaching, cognitive, and social presence.
Ke & Xie	2009	Quantitative	51 students	Findings suggest that age does not predict adult students' learning satisfaction and performance. Findings of the study indicate disadvantages of close-ended discussion tasks in supporting students' online learning success and emphasize the benefits of the integrated course model to promote learning satisfaction, and a Content +Support course model to reinforce knowledge–constructive online interactions.
Kim	2009	Qualitative	12 students	The study results show that the lack of extrinsic motivators in self-directed e-learning could have both positive and negative impacts on the learner's motivation. In addition, results suggest that adult students' individual differences affect preferences in e-learning, and motivation in terms of the individuals' need for achievement, locus of control and anxiety.

Park & Choi	2009	Quantitative	147 students	Authors conclude that individual characteristics have little influence on the decision to drop out from an online course, while external factors (e.g. family and organisational support), learning satisfaction and course relevance have a significant influence.
Conrad	2009	Qualitative	18 students	Study findings show that learners are able to acknowledge the importance of the affective domain to their cognitive successes in learning. Learners demonstrated insightful self-knowledge in using metacognitive strategies. Results also indicate that external support systems are fundamental to learners' ability to continue to learn after their absence from the study.

Mapping pre- and post-exclusion trajectories using Tiki-Toki Desktop Timeline software

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Key Words

Exclusion from school, technology, Tiki-Toki Desktop, trajectories, interdisciplinary

Abstract

Drawing on findings from the Excluded Lives project: '*An Interdisciplinary View of Permanent Disciplinary Exclusion in Oxfordshire*', this paper will explore the use of Tiki-Toki Desktop Timeline software in plotting the pre- and post-exclusion trajectories of 43 pupils who were permanently excluded from school in Oxfordshire in 2012/13. We will describe how this technology enabled us to map data from the Education and Social Care records held by the Local Authority for each of the pupils, helping us to build a detailed picture of their school, exclusion, intervention, and service-use histories. We will explore both the methodological advantages and limitations of utilising the Tiki-Toki Desktop Timeline software to explore school exclusion as a multifaceted process, and outline the potential implications for both researchers and practitioners.

Introduction

The recent rise in the number of fixed period (FEX) and permanent (PEX) exclusions from school in England has sparked national concern (Department for Education (DfE), 2018). A FEX involves a pupil being temporarily removed from school, whereas a PEX means that the pupil is

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prohibited from returning (DfE, 2017). Policymakers, academics and practitioners are increasingly concerned with understanding pupils' pre- and post-school exclusion trajectories to both inform policy reforms and ensure that adequate needs-led provision is provided.

Research has shown the associated costs that school exclusion can have for pupils, families and wider society (Pirrie, Macleod, Cullen & McCluskey, 2011; Daniels & Cole, 2010; Gazeley, 2010), yet many of these studies have focused on single levels of analysis from specific disciplinary lenses – highlighting the individual, familial, institutional, or societal causes and consequences of exclusion – and/or conceptualised PEX as an isolated critical incident in a pupil's life (Carlile, 2009; Silver, 2007).

The aims of the Excluded Lives[1] project: *'An Interdisciplinary View of Permanent Disciplinary Exclusion in Oxfordshire'* were to: (1) overcome the criticism of previous research and develop an interdisciplinary methodology for studying PEX as a multi-faceted process over time; and (2) provide Oxfordshire County Council (OCC) with a detailed analysis of the ways their departments interact and use their data to support excluded pupils. In this paper, we will reflect on the use of Tiki-Toki Desktop Timeline software (referred to throughout as Tiki-Toki) to achieve these aims.

Research Questions

1. To what extent were there similarities and differences in the pre- and post-exclusion trajectories of pupils excluded in 2012/13 in Oxfordshire?

[1] Excluded Lives was originally a collaboration between different academic disciplines within the University of Oxford (Education, Criminology, Law, Social Policy, Psychiatry and the Internet Institute) who were seeking to develop an innovative interdisciplinary methodology, with a strong theoretical underpinning, for examining the complex and multifactorial causes and experiences of permanent school exclusion. The team has since expanded to include colleges from other universities across the UK. By understanding how different disciplines can work together and how different databases can be collated, it is hoped that the Excluded Lives Research Group will be able to see how different factors found to affect excluded young people inter-relate.

2. What does the Local Authority (LA) data tell us about potential causes and consequences of PEX?

Method

OCC Education and Social Care records were sought for all permanently excluded pupils in 2012/13 in Oxfordshire. The year 2012/13 was chosen in order for both pre- and post-exclusion data to be available for analysis. Forty-three out of 44 records were obtained. Ethical approval for the study was granted by the University of Oxford's Central University Research Ethics Committee, and a data sharing agreement arranged with OCC.

To map the pre- and post-exclusion trajectories of the pupils, their records were manually entered into Tiki-Toki Timeline Maker which allows for the creation of 2D and 3D timelines (Webalon Ltd, 2018). The desktop rather than web-based version of the software was purposefully chosen to adhere with data protection policies and ensure confidentiality, namely that the data was stored locally rather than digitally.

Computer Assisted Qualitative Data Analysis Software (CAQDAS), such as Atlas.ti could have been chosen for the analysis as it has the capability to collate multiple sources of data in a timeline format. However, the timelines produced in Atlas.ti are static and single level, rather than being interactive and layered. CAQDAS packages are also often expensive and inaccessible to practitioners, therefore we sought a different software for our analysis. Tiki-Toki was selected for two reasons. First, it enabled us to create moving timelines and look at data from across services through time, and second, it had the potential to be translated and used in practice. Many library guides recommend integrating timeline software, such as Tiki-Toki, into research (University of Michigan Library, 2018; Harvard Law School Library, 2017). It has been argued that timeline software can appear visually clearer than pure text, helping researchers make connections and recognise patterns in data (*ibid*). However, empirical examples of using the software, and its potential benefits, are not well documented in academic literature.

To ensure the anonymity of the participants in the study, we have created a fictitious/composite example timeline – see *Figures 1* and *2*. The same 'category' levels from the original analysis are represented by the different colours. Individual entries on the timeline are referred to as 'stories'. Each

story box expands when clicked on to provide further information, and an overview of the 'full' story can be added and appears when the timeline is opened.

Analysis

Data analysis consisted of three steps: (1) collating the data using Tiki-Toki, (2) writing narratives based on the timeline, and (3) conducting a thematic analysis of the narratives (including calculating the prevalence of timeline patterns across the dataset, i.e. how many times does a pattern appear across different narratives and extracting important instances in relation to the research questions). By collating timelines for each pupil, Tiki-Toki enabled us to visualise exclusion as a multifaceted process rather than a single critical incident (Carlile, 2009; Silver, 2007), and look across different levels of analysis to explore individual, familial and institutional factors that may have contributed to the pupils' eventual PEX. The timelines can be read horizontally to look at a single level of analysis over time (e.g. OCC service history) or vertically to look across different levels of analysis at a single moment in time. During the analysis process attention was paid to the period when each event took place in the pupils' lives, the order of events, and the duration of time between the different events. This provided us with an understanding of the possible reasons behind being permanently excluded.

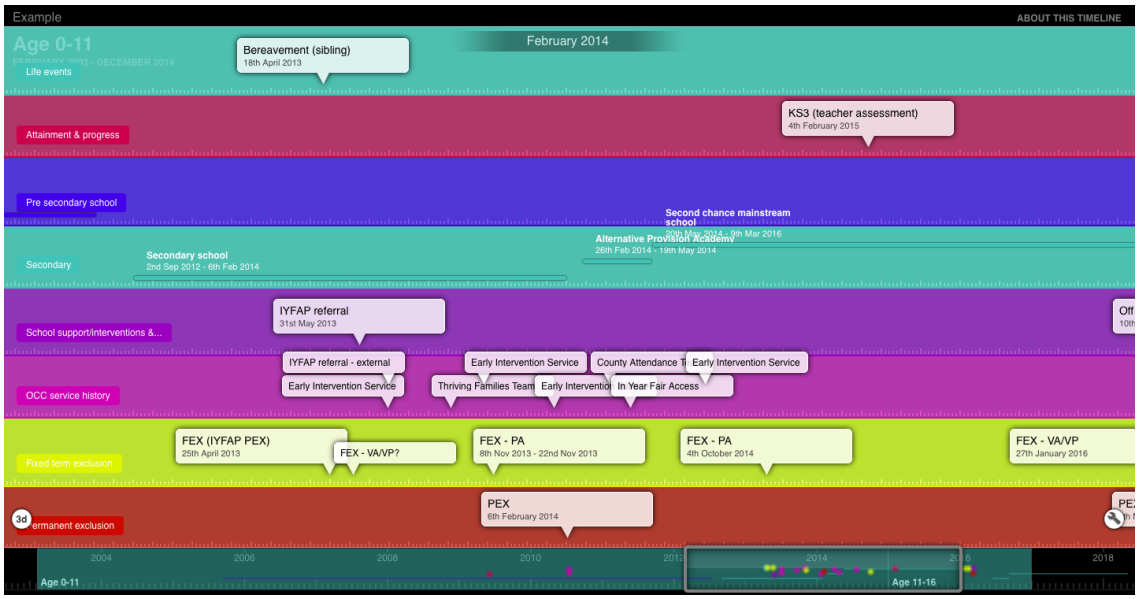

Figure 1. 2D example timeline[2]

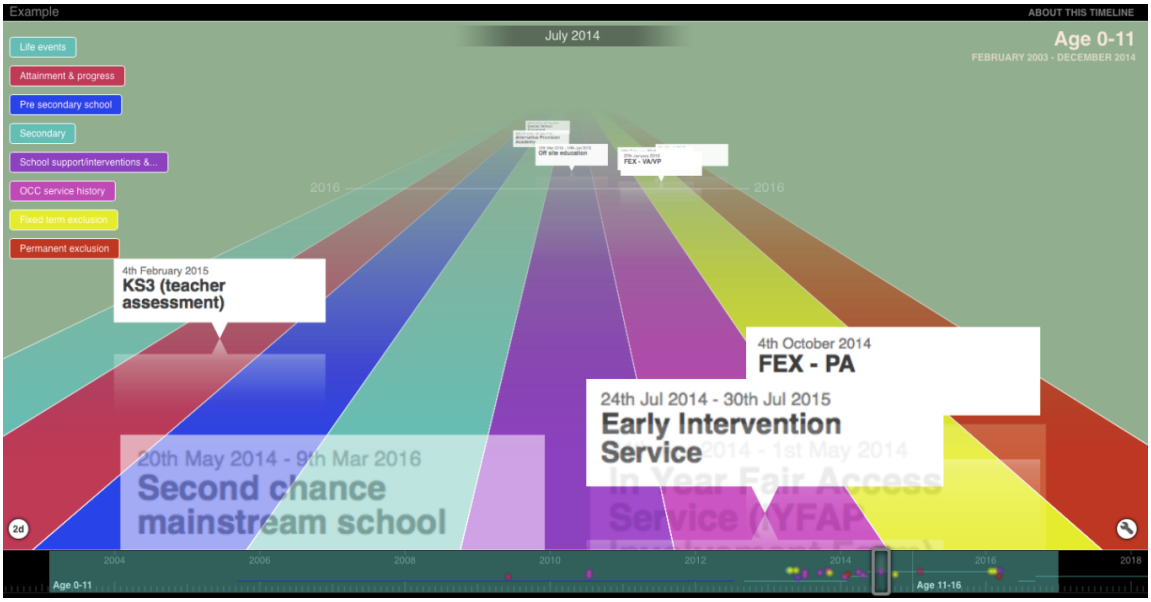

Figure 2. 3D example timeline

The short narrative accounts were written by one researcher based on the timelines. They represent narratives 'told' by the LA records, and mediated by the researcher, rather than accounts provided by the excluded pupils themselves. Consequently, they offer a nuanced way to understand school

[2] The box at the bottom of the timeline indicates the time period being shown on the screen.

exclusion experiences. Braun and Clarke's (2006) six-step guide to thematic analysis was followed to code the narrative accounts.

It is important to note that rather than moving in a linear way from the timelines to the narratives and then to the thematic analysis, we engaged in a reflective iterative analysis process, whereby the original data were revisited in relation to the emerging themes, progressively leading to refined focuses and understandings. *Figure 3* provides a visual depiction of the analysis model.

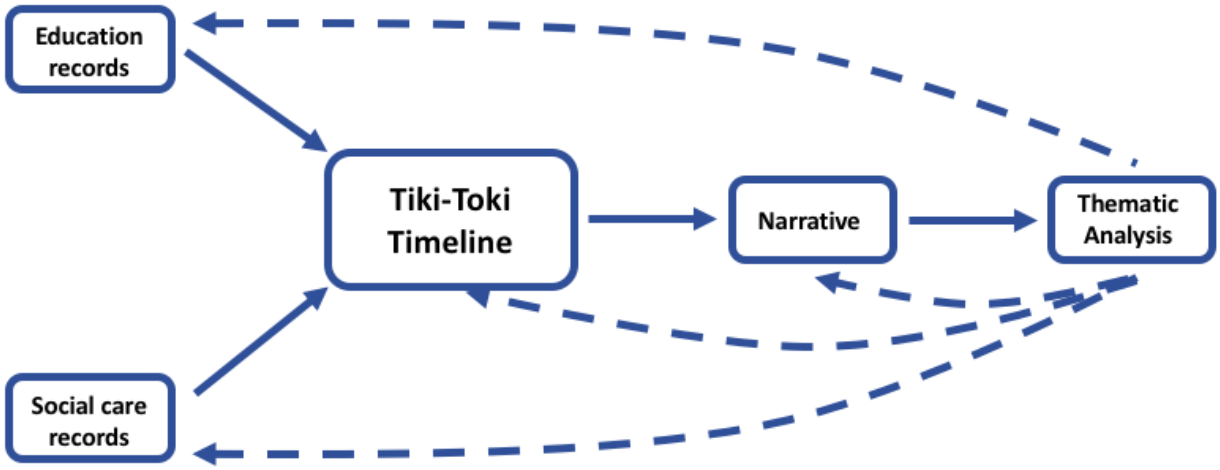

Figure 3. Data analysis flowchart

Preliminary Findings

As the main focus of this paper is to outline the benefits afforded by the use of Tiki-Toki in our ongoing analysis, the preliminary findings will only be briefly reported.

Four main themes were identified from the timeline patterns (see *Figure 4* for additional details). As many of the patterns from the data were across different levels of analysis and highly time-related, it would be difficult to explore them without the help of Tiki-Toki. Taking the theme 'multi-agency working' as an example, across timelines it was found that clusters of interventions were often delivered by different LA teams, with each team being called in response to a single FEX and targeting one single problem (e.g. in one case, within six months, the pupil was involved with specialised teams who targeted autism, non-attendance, and parent domestic abuse, separately). While the clusters of interventions and FEXs possibly

indicate inter-related risk factors at the individual and familial level, at the institutional level these ad-hoc interventions indicate the need for holistic analysis and joined-up multi-agency working between LA teams.

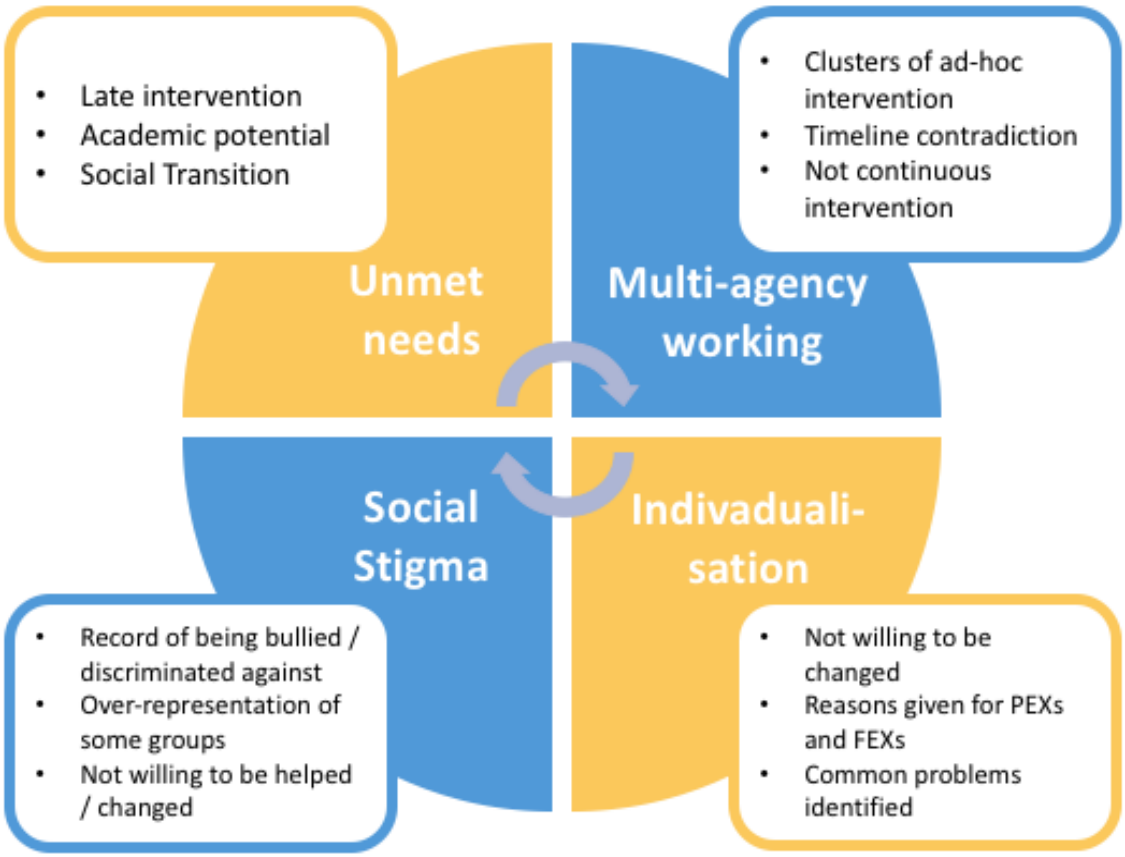

Figure 4. Preliminary themes

Implications for Research

Tiki-Toki may be a helpful resource in similar trajectory research, due to its effectiveness in collating different data sources into clear timelines. However, the software does have limitations. By virtue of its simplicity, the software lacks more sophisticated features that may be found in other programmes (e.g. the ability to open multiple timelines simultaneously). Moreover, as the data has to be manually entered, inputting numerous sources at once can be time consuming and labour-intensive.

Despite these limitations, the timelines have the potential to serve as a support during subsequent data collection phases (e.g. as a visual cue in an interview) or in the analysis phase. For example, the narratives 'told' by

the official data could be used to supplement interviews with other stakeholders to build holistic pupil case studies.

Implications for Practitioners

The accessibility of the software means that it also has the potential to be integrated into practice and have instrumental impact. Our research, and subsequent conversations with OCC officers and local teachers, have highlighted the possible benefits that utilising the software could have for practitioners, including the ability to create a unified data storage system, take a more forensic approach to investigate how 'at-risk' pupils move through the education system; reflect on their decision-making processes; and appropriately meet the needs of 'at-risk' pupils through early intervention by identifying patterns in behaviour, or links between different level factors (individual, familial and institutional). By sharing access to the created timelines with all practitioners working with 'at-risk' pupils in LAs and schools, there is increased potential for communication across departmental silos, and multi-agency working. In contrast to researchers who may be faced with inputting large amounts of data simultaneously, practitioners could enter events in real time. As such, integrating the use of Tiki-Toki into their practice may not be overly demanding.

Conclusion

Our research has shown that exclusion from school should be recognised as a process that can only be examined from multiple professional and disciplinary perspectives, and by looking across different levels of analysis over time. By employing Tiki-Toki, we were able to begin to design an interdisciplinary methodology, that could be extended in subsequent projects, to fully understand the multifaceted nature of pupils' pre- and post-exclusion trajectories. As well as having methodological value, the software also has the potential to be used in practice to help practitioners to understand how their departments interact and how they can more efficiently use their data to support 'at-risk' and excluded pupils.

Notes

This research was supported by the John Fell Fund. Thanks must also be extended to Oxfordshire County Council and members of the Excluded Lives Research Group, particularly Susila Davis and Sarah Cox for their work on the Tiki-Toki timelines and narrative reviews.

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Alice Tawell is an ESRC DPhil candidate, co-supervised by Professor Harry Daniels in the Department of Education, and Dr Rachel Condry in the Centre for Criminology, University of Oxford. Alice's DPhil thesis broadly focuses on the enactment of school exclusion policy in England. Alice is also a member of the multidisciplinary Excluded Lives Research Group, and lead Research Officer for the projects: *An Interdisciplinary View of Permanent Disciplinary Exclusion in Oxfordshire* and *Disparities in Rates of Permanent Exclusion from School across the UK*.

Eszter Saghy is a penultimate year undergraduate student studying for a BSc (Hons) in Social Policy at University of Bath. Eszter is also a research intern for the multidisciplinary Excluded Lives Research Group for the 2017/18 academic year.

Zening Yang is a penultimate year undergraduate student studying for a BA (Hons) in Education with Psychology at University of Bath. Zening is also a research intern for the multidisciplinary Excluded Lives Research Group for the 2017/18 academic year.

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Use of a three dimensional virtual environment to teach anatomy

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Key Words

3-Dimensional, Virtual Reality, anatomy, pharmacy, teaching and learning

Abstract

This study examined whether three-dimensional technology improves student engagement compared with traditional lectures using two-dimensional graphics. Ninety-three students participated. Student attitudes towards three-dimensional sessions were examined by a five-point Likert scale questionnaire. Results indicated a strongly positive student experience with seventy-five percent of students feeling that the sessions improved their understanding of anatomy, and sixty-three percent reporting increased enjoyment of the course. These data support the use of a three-dimensional teaching environment as a useful tool for enhancing the teaching and learning of anatomy alongside traditional teaching methods.

Introduction

Pharmacy students need to understand anatomy and physiology; this presents a teaching challenge as organs are three-dimensional (3D) in nature, their structure and connections to other body systems are not easily illustrated by two-dimensional (2D) graphics and are difficult to explain in lectures.

Although individual researchers have access to software and hardware allowing 3D visualization, this technology is not widely used in pharmaceutical/medical science education limiting attempts to evaluate its pedagogical effectiveness (Oloruntegbe & Alam, 2010). 3D technology is effective in the study of drug/receptor interactions (Richardson et al, 2014), and an increasing body of evidence suggests that this technology has

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benefits for pharmaceutical sciences and medicine (Peterson & Mlynarczyk, 2016; Brazzina, 2014). Results are not clear-cut; some studies indicate this technology has specific benefits, e.g. improvements in spatial ability while not improving learning over all (Hoyek et al (1), 2014). Meta-analyses conducted in 2015 and 2016 each came to a different conclusion (Yammine & Violato, 2015; Azer & Azer, 2016). Evidently this is a field that requires further evaluation if the pedagogical effectiveness of 3D Virtual Technology (VT) in pharmaceutical science education is to be understood.

3D anatomy teaching was evaluated at the University of Lyon (Hoyek et al (2), accessed 2014); results indicated that 3D technology did not improve students learning, however two critical points were made: (1) Sessions were short, and (2) required students to master the technology during the session, either of which could have skewed the results. Improved spatial ability in anatomy students who experienced a 3D animation compared to those who had only experienced a 2D version has also been reported (Hoyek et al (1), 2014).

The Keele Active Virtual Environment (KAVE) at Keele University in the United Kingdom provides hardware and software that allow students to view molecular or anatomical structures in an interactive 3D environment. This pilot study examined whether 3D technology improves student engagement and understanding compared with traditional lectures, and whether it enhanced their learning experiences.

Methods

Students experienced the same teaching methods, which form part of an accredited MPharm course. No additional ethical permission was required other than obtaining informed consent to use anonymised data for the purpose of this study.

The learning outcomes for these sessions were to: (1) recognise the position of each organ in the body; (2) recognise the placement of each organ in relation to others; and (3) gain an understanding of how the organs interact to maintain normal physiological function. Each session covered a set of related organs, e.g. gastrointestinal tract also covered pancreas, liver and spleen.

Participants were in year two of an accredited MPharm programme. Students had previously been examined on anatomy and physiology during examinations conducted at the end of their first year of study after they had followed a course of didactic lectures. The students experienced three teaching sessions in the KAVE covering: muscle structure, the

cardiovascular/circulatory systems, respiratory system, urinary system, gastrointestinal tract, brain structure with emphasis on the hypothalamus/pituitary gland, and reproductive systems.

Keele Active Virtual Environment (KAVE)

Four Mirage S+3K projectors (Christie, Wokingham, England) project separate stereoscopic 3D images onto the left, center, and right walls. A projector in the ceiling projects onto a mirror, which in turn casts an image onto the floor. The images are synchronized to create one larger image spread across all four screens, the user's shadow is cast behind and away from the image on the floor to avoid occluding the projected image.

Five computers running a Microsoft Windows operating system, controlled the KAVE with a "master" computer communicating with a video matrix switch. Students wore liquid crystal display shutter glasses stimulated by an infrared emitter associated with each screen to view the 3D image. Stereo synchronization was orchestrated by the computers and a controller head graphics unit. Organs were visualized using the program CyberAnatomy.

Evaluation

Prior to the KAVE sessions students completed a quiz to evaluate their understanding of anatomy. Students completed a second quiz to evaluate whether the sessions had improved their knowledge and understanding of the material following the 3D sessions.

Additionally, students were asked to fill in a feedback questionnaire administered as an electronic survey, rating the following statements:

- The 3D sessions improved my understanding of anatomy
- The 3D sessions improved my understanding of positional anatomy
- The 3D sessions improved my enthusiasm for anatomy
- The 3D sessions were enjoyable

Each statement of the survey was rated by the respondents using a five-point Likert scale with one being "strongly disagree" and five being "strongly agree".

Results

Seventy-two of the 93 students attended and completed the pre- and post-3D session quiz. Prior to the sessions, students mean score on the quiz was twenty-eight percent (SD ±17.1; see *Figure 1*). Following the 3D sessions, mean sore on the quiz increased to sixty percent (SD ±17.3; see *Figure 1*). It is likely that the lack of statistical significance can be attributed to the small cohort size.

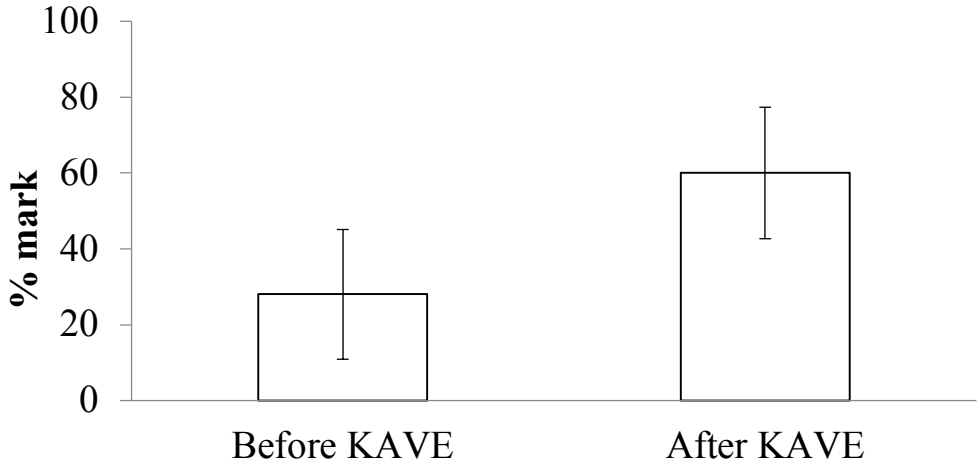

Figure 1. Mean quiz scores before and after 3D teaching sessions in the KAVE. Standard deviation of the mean is represented by vertical bars

Twenty-five of 93 students completed the questionnaire. *Table 1* shows the average Likert scores, *Figure 2* shows a summary of the data. Seventy-point-eight percent agreed or strongly agreed that 3D sessions improved their understanding of anatomy (see *Figure 2*), seventy-nine percent agreed or strongly agreed that 3D improved their knowledge of organ position. Just over half of the respondents (50.7%) agreed or strongly agreed the 3D sessions increased their enthusiasm for the course, compared to sixteen-point-six percent who disagreed or strongly disagreed, while thirty-three-point-three percent of respondents selected neutral. Finally, sixty-two-point-three percent of students agreed or strongly agreed that the 3D sessions were enjoyable.

Table 1. Pharmacy students' perceptions of their participation in an interactive 3D environment in anatomy

Statement	Average Likert score (SD)
The 3D sessions have improved my understanding of anatomy	3.8 (0.8)
The 3D sessions have improved my understanding of positional anatomy	4.2 (1.1)
The 3D sessions have improved my enthusiasm for the anatomy material	3.5 (1.2)
The 3D sessions were enjoyable	3.8 (1.1)

1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

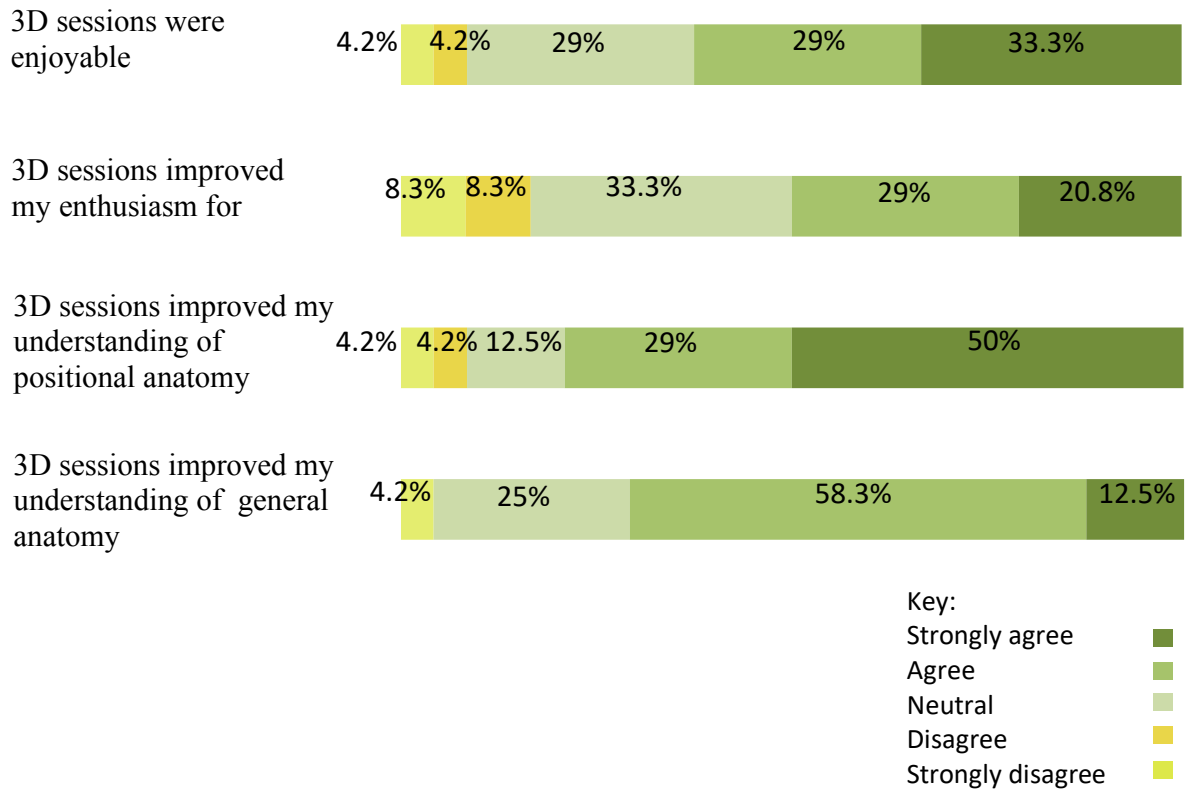

Figure 2. Summary of responses to five-point Likert questionnaire

Students were given the opportunity to provide free text comments. The majority were positive with students feeling that the sessions had supported their learning. One student commented that sessions were much more useful than they had anticipated, and that it highlighted where their positional anatomy knowledge was weak. One student commented that although the KAVE was useful for some subjects they felt that it was not as effective for supporting their learning in anatomy as sessions in an anatomy suite would have been, where they could have 'hands on' experience.

Discussion

Students studying pharmacy need a sound knowledge of anatomy and physiology in order to understand the processes that occur in health and disease. This presents a teaching challenge as organs are 3D in nature and not easily illustrated by 2D graphics. The development of virtual reality (VR), augmented reality (AR) and 3D learning environments have added new, powerful tools to the range of educational technology available (Kamphuis, 2014, Craig & Georgieva, 2017; Moro et al, 2017). This study investigated whether 3D presentation of organs in the body improves students understanding of anatomy compared to didactic lectures alone when used as part of an MPharm course.

The results reported here show improvement in student understanding of the material (*Figure 1*), which while not statistically significant is still an important finding that supports previously reported data (Yammine & Violato, 2015, Nicholson et al, 2006).

Students felt their understanding of anatomy improved and that their enthusiasm for the course was enhanced (*Table 1, Figure 2*). 3D teaching sessions were not favoured by all students, with some preferring illustrative examples while others favoured logical, analytical styles (Churchill, 2008). Those who preferred illustrative examples to reinforce their understanding would benefit from the interactive, visual nature of 3D teaching sessions, however those with a more analytic learning style may find it less beneficial.

The current study is limited by the cohort size, with only 25 of the 93 students who experienced the 3D teaching sessions completing the questionnaire. It is possible that the current data overestimate how useful students found these sessions. Since the completion of this pilot the KAVE has been decommissioned and a much larger 3D teaching installed. We intend to repeat this study with new cohorts utilising the new 3D health cinema facility. It is hoped that this future work will allow us to optimise

the use of 3D technology in the teaching of anatomy in pharmacy and other health sciences.

A significant drawback of using technology such as KAVE is the initial financial outlay to acquire the system and gain licences for the software required. This cost can be justified when the technology is used to teach other subjects. In addition, 3D technology is not just confined to large expensive systems, in the past few years Lewis et al (2014) evaluated some of the 3D anatomy software applications currently available for tablet computers, identifying several which could prove to be powerful teaching aids in anatomy education. Further work is planned to evaluate the potential benefits of this technology in the teaching and learning of anatomy more fully, and to expand on the data presented here.

About the Authors

Dr Carolyn Voisey is a Lecturer in Physiology in the School of Pharmacy at the University of Keele and has a keen interest in how students learn, and in the use of teaching technologies.

Mr. Daryl Kerr is the Faculty Learning and Technology Officer for the Faculty of Natural Science at Keele University.

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