Flipping Biomedical Science

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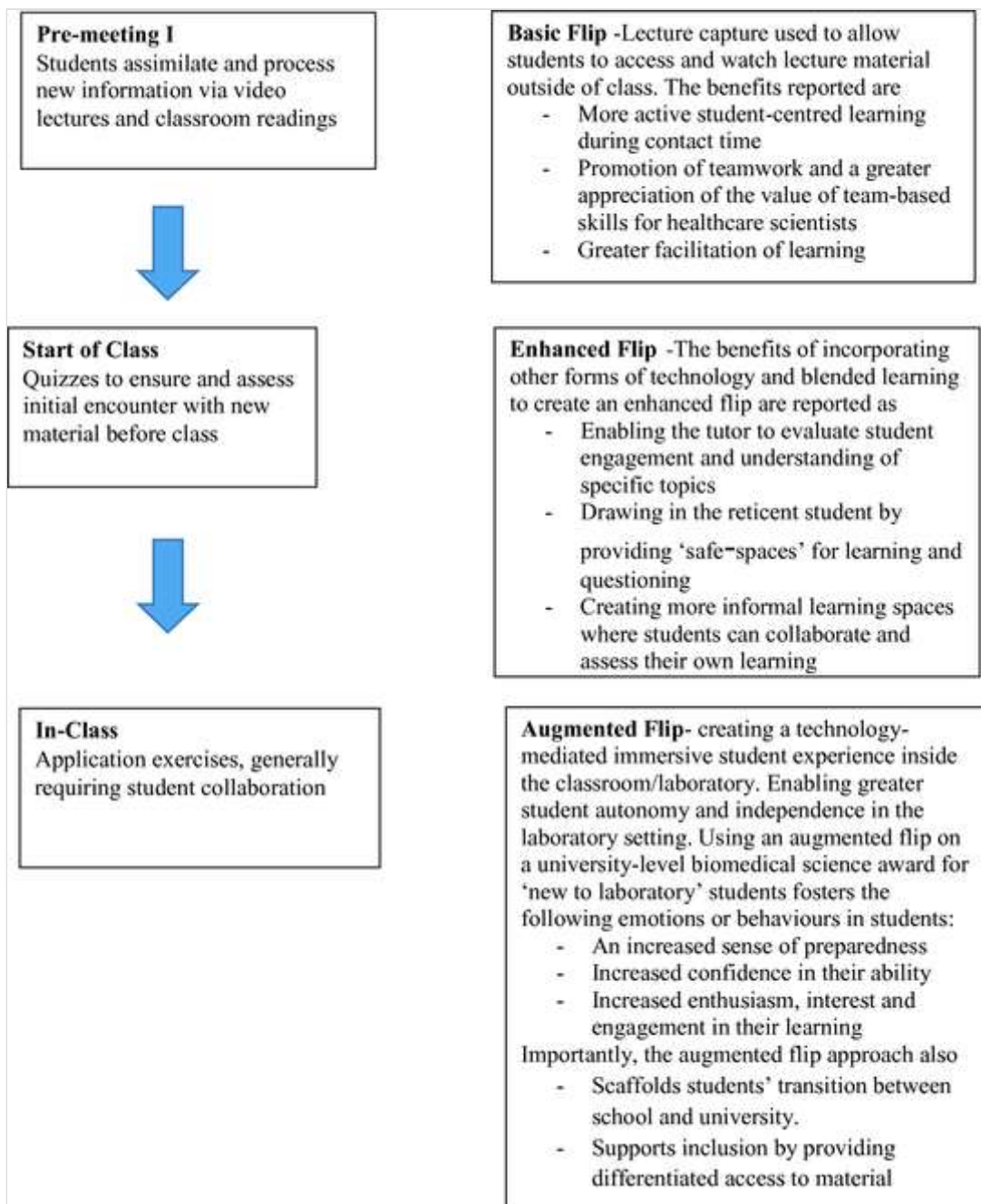
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Abstract Healthcare provision has undergone many changes over the past few decades driven by patient needs, advances in science and developing technologies. Within this framework, the role of individuals and the expectations placed upon the professions allied to healthcare have evolved. Supporting the development of these allied professions is the focus of this chapter. It is essential to have a highly skilled and flexible workforce to deliver the required healthcare provision, highlighting the necessity for programmes of study to support the development of the capable practitioner.

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Healthcare provision in the United Kingdom has undergone many changes over the past few decades driven by patient needs, advances in science and developing technologies. Within this framework, the role of individuals and the expectations placed upon the professions allied to healthcare have evolved. A highly skilled and flexible workforce is essential for the delivery of the required healthcare provision, highlighting the necessity for programmes of study to support the development of the capable practitioner.

Pre-meeting I Students assimilate and process new information via video lectures and classroom readings	**Basic Flip** -Lecture capture used to allow students to access and watch lecture material outside of class. The benefits reported are - More active student-centred learning during contact time - Promotion of teamwork and a greater appreciation of the value of team-based skills for healthcare scientists - Greater facilitation of learning
Start of Class Quizzes to ensure and assess initial encounter with new material before class	**Enhanced Flip** -The benefits of incorporating other forms of technology and blended learning to create an enhanced flip are reported as - Enabling the tutor to evaluate student engagement and understanding of specific topics - Drawing in the reticent student by providing 'safe-spaces' for learning and questioning - Creating more informal learning spaces where students can collaborate and assess their own learning
In-Class Application exercises, generally requiring student collaboration	**Augmented Flip**- creating a technology-mediated immersive student experience inside the classroom/laboratory. Enabling greater student autonomy and independence in the laboratory setting. Using an augmented flip on a university-level biomedical science award for 'new to laboratory' students fosters the following emotions or behaviours in students: - An increased sense of preparedness - Increased confidence in their ability - Increased enthusiasm, interest and engagement in their learning Importantly, the augmented flip approach also - Scaffolds students' transition between school and university. - Supports inclusion by providing differentiated access to material

Introduction

Healthcare provision in the United Kingdom has undergone many changes over the past few decades driven by patient needs, advances in science and developing technologies. Within this framework, the role of individuals and the expectations placed upon the professions allied to healthcare have evolved. A highly skilled and flexible workforce is essential for the delivery of the required healthcare provision, highlighting the necessity for programmes of study to support the development of the capable practitioner. Capability is seen as an essential learning outcome that supports professionals to integrate enquiry and evidence into practice enhancement and professional development (Garrick & Usher, 2000). Supporting the student to

relate their academic studies to the world of work and ensuring that students are encouraged to engage and to develop their knowledge and capability can be a challenging task for tutors. For Biomedical Science (BMS) which is the focus of this chapter, added into this mix is also the need for tutors to introduce the new and potentially 'scary' environment of the medical laboratory. In such settings, there is limited scope for students to make mistakes and this creates a high-risk learning environment where students often become disheartened and otherwise disengaged.

AQ1

AQ2

This chapter starts by reviewing how flipping has been drawn upon as a tool to deliver and support teaching and learning in a range of settings for students studying healthcare-related undergraduate awards (see Fig This figure does not belong here and is not an example of the range of settings. The figure relates to how we developed AR resources and should be in the section below . 14.1). We introduce the current approaches adopted in this field to aid development of capable practitioners before discussing our own research on the BMS awards. Graduates from these awards, which are accredited by the professional body in the UK, usually progress to work in the healthcare setting in a clinical laboratory as registered biomedical scientists. Success in modern healthcare relies on the accuracy and efficiency of biomedical scientists. The constantly changing environment of the healthcare setting requires individuals who are able to 'think critically': actively apply both deductive and inductive reasoning along with synthesising information from a variety of sources to support capable practice (Benner, Sutphen, & Hughes, 2008). A capable person is more able to 'respond to the demands of a rapidly changing and ambiguous environment' (Hase & Davis, 1999, p. 298) if they have the ability to apply their knowledge to a range of settings. To ensure that individuals develop such skills and the ability to apply their knowledge to support practice, it is essential to design learning environments that assist them in fostering higher order thinking skills and not just focus upon gaining discipline-specific knowledge.

Fig Remove from here and place in correct section of chapter and linked into the text below . 14.1

Example of a resource generated with Aurasma image and QR code in student workbooks

Description of Technique	Image linked to Aurasma	QR code
Sugar Fermentation: Different organisms can utilise carbohydrates in different ways. In this assay, a purple colour indicates a negative result. Yellow indicates acid production. Gas may also be produced that will be captured in the small tube. Organisms can be gas and acid positive.		

We discuss how we have drawn upon the concept of flipping to develop what we refer to as an 'augmented flip' as a tool to support laboratory-based sessions for first-year undergraduate students. These sessions are traditionally for large cohorts of students who have limited laboratory experience. Tutors are challenged to develop a learning experience for these students that is meaningful, developing the skills that these inexperienced students will draw upon as they move into professional practice, without being a procedural activity that only focuses upon individual tasks. We adopted an 'augmented flip' design to provide an environment that fostered a supportive experience where our students could be more confident when they entered the laboratory, allowing them to focus upon developing the knowledge and skills required for capable practice. We highlight from the tutors' perspective how flipping supported delivery of these daunting large cohort sessions of 'new-to-lab' students. We then conclude with our experiences of using flipping

to support the development of skills, knowledge and capability for practice, and make suggestions for further research.

Flipping on Awards Linked to the Healthcare Science Professions

In the past few decades, there has been a move to ensure that degrees are more applicable to the world of work. A need to reframe and enhance education for healthcare practitioners has been acknowledged in a range of disciplines, focusing upon approaches that result in individuals prepared for practice in the complex and rapidly developing environment encountered upon graduation (Clarke, 2014; Missildine, Fountain, Summers, & Gosselin, 2013; Peirce & Fox, 2012). The need to support understanding and skill development during students' studies is essential, but of equal or perhaps greater importance is supporting individuals' application of knowledge and skills to practice. A major challenge for tutors is enabling students to establish links between what they are being taught in the academic setting with 'real-life application' in practice, relating their learning and environment to the workplace to provide meaning and motivation. Hager refers to this as 'seamless know-how' or 'practical wisdom' (Hager & Hyland, 2003). A learning environment, both social and physical, that promotes a deep approach to learning and one that also encourages the student to take an active role in learning is more likely to support the development of this 'practical wisdom', helping students to question the assumptions that inform their development and capability (Lizzio & Wilson, 2004).

Increased classroom sizes and the reduced availability of relevant workplace experience challenge the development of flexible and learner-centred teaching to support the development of professional capability (Mehta, Hull, Young, & Stoller, 2013). As a result of these pressures, a range of courses linked to the healthcare professions have adopted a flipped classroom approach to support practitioner development and application of knowledge to practice.

A review of the literature identifies that innovative teaching approaches have employed flipping in a range of ways to encourage both active and critical learning in students. Many awards simply use technology to electronically capture lectures to allow time and space for the adoption of a more active approach to learning in the classroom—this could be termed the 'basic flip'. The use of pre-recorded lectures has been shown to encourage a more active, student-centred lecture style (Pierce & Fox, 2012). Additional reported benefits of this basic approach to flipping include students' perceptions that it facilitates their ability to learn

compared to the traditional delivery method (Tune, Sturek, & Basile, 2013); greater student satisfaction scores (Missildine et al., 2013); and the promotion of teamwork skills and the appreciation of the value of team-based skills in the healthcare setting (Clarke, 2014).

Other studies report on developing flipping further and embracing approaches that are facilitated by flipping, incorporating other forms of technology and blended learning to develop student autonomy and capability (Nerguizian, Mhiri, Mounier, Lemieux, & Dahmane, 2014). An 'enhanced flip' (Smith & Khechara, 2016) draws upon additional technologies during class contact time to support the 'basic flip'. Polling apps allow evaluation of student understanding of the flipped material at the start of in-class sessions. Question and answer sessions not only allow tutors to evaluate student engagement with the material and understanding of specific topics, but also allow students to ask questions of the tutors via their mobile devices. Incorporating flipping with additional technological approaches to support learning and teaching assists in 'drawing' the reticent student out of their shell by potentially increasing engagement with the flipped material and providing a safe space for them to ask questions and develop practice. Other studies have found that the use of more informal teaching spaces, moving away from the standard lecture theatre, is enabled through flipping (Baepler, Walker, & Driessen, 2014). These active learning classrooms can then be further supported by online resources to echo the learning conversations started in class.

In addition to the knowledge base, practical hands-on skills play a central role in healthcare professions, and flipping has been adopted for supporting the laboratory-based classroom. For example, short videos can be used to demonstrate how techniques are performed in the laboratory, providing students with an insight into what they will be required to do in class. Greater challenges exist when using this approach to prepare students for the hands-on laboratory class. Although flipping provides students with more time to complete tasks in the laboratory, a lack of engagement with material prior to class can lead to negative peer-to-peer interactions and students' inability to perform the required tasks in class (Mellefont & Fei, 2016). As a result, the approach may fall short of developing student capability and a deeper understanding of how the skills they learn in these sessions relate to professional practice.

A study looking at the role of tutor-narrated videos identified that by combining the approach with compulsory pre-laboratory tests, a flipped approach can support greater independent learning. Ensuring that students had to engage with the videos

prior to class helped them to maintain active cognitive engagement throughout laboratory sessions, possibly due to the reduction of cognitive overload during these sessions (Teo, Tan, Yan, Teo, & Yeo, 2014). The use of pre-laboratory exercises and questions reinforced the tutors' expectations of commitment and engagement from the student, thus ensuring that flipping enhanced the laboratory experience. Flipping allowed the student to be more confident when entering the laboratory environment having viewed the activities in advance (Teo et al., 2014). The authors suggested that students engaged more meaningfully with the tasks—an essential aspect for supporting the development of healthcare practitioners. Flipping can move the student experience away from just following a set of instructions as a trivialised activity to gain grades to gaining an understanding of application to practice and the development of professional capability (Teo et al., 2014).

We decided to build upon the approaches adopted by other studies to introduce flipping to a first-year undergraduate science laboratory session. First-year students' initial encounter with the university science laboratory can be a daunting experience for them. Students are required to contend with complicated equipment and rules of conduct, and are expected to follow very precise instructions about something they may not have encountered before. In such settings, there is limited scope for students to make mistakes and this creates a high-risk learning environment where students often become disheartened and otherwise disengaged. We wanted to ensure that this initial experience for students was one which built confidence and encouraged teamwork—an essential skill for healthcare practitioners. Our own experiences of delivering the sessions suggested that for many students, it is often not a good experience; many students stand back and do not take an active part in the sessions, merely watching their peers or even becoming totally disengaged. This lack of engagement hinders student development, their future experiences in the laboratory setting, and the development of the skills required for practice. We therefore addressed whether a flipped approach could support delivery of the taught practical content in a busy undergraduate teaching laboratory by drawing in those students who normally fail to engage, supporting their confidence at-the-bench. As we knew that not all students would engage with the flipped content or pre-laboratory exercises prior to attending class, we considered how to best negate the negative impact this would have on their learning experience and skills development. Could we take the flipping further and not just provide short videos showing students how to perform tasks and use equipment prior to entry into the laboratory, but also link these videos to the specific tasks in the laboratory through the use of augmented reality (AR)?

AR can be created by using and connecting a range of innovative technologies such as mobile devices, smartphones, and immersion technologies. As such, it can be applied to any technology that blends real and virtual information, overlaying 'real world' information with context-relevant virtual information (Klopfer & Squire, 2008). AR can thus provide a technology-mediated immersive experience in which real and virtual worlds are blended, thereby augmenting user engagement. Using AR, virtual objects or demonstrations can be superimposed onto physical objects or environments to enhance users' experience (Clark, Dünser, & Grasset, 2011). Research has demonstrated that the use of AR in the classroom increases student motivation, understanding of the topic area, and satisfaction with their course (Serio, Ibenez, & Kloos, 2013). A range of different approaches to AR has been adopted in the literature to support learning in many different areas (Lee, 2012). However, the value of AR in education is less about the types of technology used and more about how it is employed and integrated to support both formal and informal learning for students.

AQ3

Methodology—Development of 'Augmented Flipped' Instruction

As practitioners, we continually employ an action research approach (McNiff & Whitehead, 2011) to develop new pedagogical methodologies that address the variety of challenges we encounter when delivering our awards. These include the need to meet the demands of a range of professional and regulatory bodies in the UK as well as the rapidly developing world of professional practice in the healthcare setting. We wanted to develop an approach to laboratory-based teaching that embeds a blended and more supportive methodology into the curriculum, in order to enhance student experience and ensure a learning environment that supports the development of capability for practice.

Methods

An interpretative approach was adopted for this study. As practitioner researchers, we drew upon aspects of action research (Elliot, 1991) in order to develop a better understanding of students' current perceptions of laboratory-based learning and the barriers they felt existed around engagement in this environment. The approach involved an initial fact-finding stage, the development of interventions based upon this initial stage, an intervention stage and finally an evaluation of the impact of the

interventions employed. The methods and findings from each stage are presented separately below to reflect the cyclical nature of the study.

Method 1: Fact-finding stage. Initially, a focus group discussion involving five final-year undergraduate students was held to identify the nature of the current situation. It was used to gather perceptions of barriers to learning and engagement and the understanding of class content in the laboratory. We also looked at students' perceptions of the quality of teaching in these larger spaces. Additionally, their perceptions of the role of technology in supporting learning and its potential value were gathered during the focus group, to identify possible areas where technology could support both delivery of material and student learning. The focus group discussions were recorded and transcribed *verbatim*. Thematic coding was used to identify key themes within the data.

Result 1: Fact-Finding stage. Several key themes were identified from the coding of the transcripts. Open coding was used to develop codes describing, naming or classifying concepts within the transcripts through the use of simple words or a short sequence of words. Focus group discussions highlighted that students thought the size of teaching groups impacted their learning. Further questioning revealed that due to the large number of students in the class, when unsure about something they either did not ask questions or found that a tutor was not available to assist them:

yeah you are just standing around waiting … and you think ah if someone was available I could have done this a few minutes ago and carried on but .. (Participant 1)

The excerpt above describes how students often found themselves waiting around for support to understand how to perform a task, or to receive additional information that would allow them to move on to the next stage. Students suggested that this provided quite a barrier to their progression and resulted in them losing motivation during the practical class. Being lost led to a lack of engagement in activities and in subsequent classes. As we unpicked this feeling of being lost, we realised that feeling lost or not knowing what to do next led to a lack of support for autonomous learning and for progression within tasks.

In trying to understand how we could address this barrier to autonomous learning, discussions with the students identified that they wanted '*just-in-time*' support that was specific to the area in which they had become 'stuck'. Rather than having to go back through the flipped instructions, they wanted the answer to their problem

delivered to them immediately. This was clearly articulated by one student in his suggestion of a possible means of additional support:

if there was a barcode say on the bottom of a chemical and you held your phone up to it and it gave you the safety information that you needed. (Participant 4)

Another student commented on the range of equipment that they encountered and how a lack of knowledge about how it worked made them nervous about using it. Being able to access specific instructions as and when needed would help reduce anxiety:

I think because with biomedical sciences we do have a lot of machines, like PCR machines so like if we went over to it and held our phone over it and it actually tells us how it works itself – that would be pretty interesting and really help. (Participant 3)

Again, the students acknowledged that if appropriate information could be delivered as and when required, this would overcome some of the barriers they were encountering. There was agreement from the group that to be of value, any form of AR introduced would have to be easy to use and accessible. In addition, they made it quite clear that video clips should be short and delivered clearly what was required:

a couple of minutes – nothing more than a couple of minutes….. you don't want anymore. (Participant 2)

They were not really concerned about the format the AR was produced in, as long as it supported them while they were engaged in a task and made the experience a little more realistic for them:

anything that could make it seem that little bit more realistic - to help you kinda immerse yourself that little bit more into that situation. (Participant 1)

Other commen ters   comments not commenters

Thanks   suggested that short recordings of tutors demonstrating the techniques to be used in the class or additional relevant information would be beneficial—short, concise, relevant to each topic, and easily accessible when needed was the take home message. The intervention stage which was embarked on next drew upon this

information to deliver a range of 'augmented flipped' resources that addressed each of the areas highlighted by the focus group.

Method 2: Intervention stage. Two approaches to AR were developed for use in a first-year microbiology laboratory class that had an enrolment of 240 students. The first AR tool was created using quick response (QR) codes. These barcode-like patterns provide access to digital content through a reader application (app) on a suitable mobile device. Digital information was attached to images on workbooks, reagents, and equipment (see Fig This is what the figure relates to and should be added here so that it is in context - thanks . 14.1). When students held their mobile device over these markers, they could access the digital information superimposed over the real environment which augmented the information available to them.

A second, more advanced approach to AR was also employed. A freely available app, Aurasma (www.aurasma.com), enabled the generation of dynamic AR content through the creation of trigger images (called Auras), which were then linked to designated overlays using an online interface. By simply pointing their mobile device (on which they had downloaded the app) at the trigger image, students could discover and access videos demonstrating the appropriate technique. This enabled their real world to be augmented by the additional information. Instead of just reading about the technique, they could watch their tutor perform it. The trigger images in the students' workbooks allowed them to access these demonstrations prior to entering the laboratory class so that they could familiarise themselves with what they would be doing (see Fig. 14.1).

To allow for issues of health and safety as well as the use of personal mobile devices in the laboratory, QR codes were further linked to the same video demonstrations and held on the university virtual learning environment (VLE) (see Fig. 14.1). QR code readers were then installed on institutional tablet devices so that students could access the same demonstrations whilst they were in the laboratory class performing the techniques themselves, without the use of their personal mobile devices.

Signage on entry and exit points was set up to inform students that the laboratory space was 'QR code or Aurasma enabled' as appropriate, and provided students with additional information about how to access the meta-information available.

On completion of laboratory classes, a mobile polling app (Socrative) was used in an asynchronous fashion to gather free-text responses to a set of questions. With their own mobile devices, students could log in using the access code provided and

respond anonymously to the questions. Responses could be as short or as in-depth as students preferred. A questionnaire approach was used since it is an appropriate method for gathering data about abstract ideas and concepts that are otherwise difficult to quantify, such as opinions, attitudes, and beliefs (Artino, Rochelle, Dezee, & Gehlbach, 2014). Students were familiar with the polling app since it was used to support formative assessments during lecture sessions. Since many students text on their phones regularly, the use of this medium to deliver a questionnaire proved to be surprisingly appropriate for gathering rich data, which was analysed qualitatively.

Besides the student responses, tutor observations had previously identified that students were reticent to engage in practical activities during their laboratory-based classes. For comparison, tutors were asked to reflect upon student behaviour during the AR-enabled sessions and to comment upon their observations and their experiences in supporting the classes during informal five-minute interviews which were transcribed and separately analysed. The five-minute interviews were undertaken at the end of each laboratory session.

Result 2: Evaluation of intervention stage. The use of a mobile response app (Socrative) to pose questions to students proved to be an exceptionally valuable way to gather responses. Although the response rate was only 20%, the responses were a richer source of data than we had anticipated. While generalisations cannot be made with the sample size obtained, the student feedback provided valuable insight into their perceptions of the role of 'augmented flip' in a laboratory setting, meeting the aim of the study. Questions were posed to elicit students' perceptions of whether and how the availability of 'augmented flip' impacted their preparation for the practical sessions, their experiences during the sessions and their post-laboratory assessment. The text responses were downloaded to a spreadsheet in Microsoft Excel, then coded. Six key themes were identified from the students' responses, as summarised in Fig. 14.2.

Fig. 14.2

Interrelated thematic codes obtained after analysis of free-text responses from an asynchronous mobile response quiz

All of the six key areas are interrelated. However, as discussed below, as we started to unpick the student responses it became evident that by supporting the development of the five key areas in the outer circle in Fig. 14.2, we provided a much more inclusive environment for students.

Acceptability. The introduction of a new approach to supporting student learning needs to be acceptable to those involved for it to be successful. Acceptability is linked to both ease of use and recognition of the value of the intervention (Selim, 2007). Student responses revealed an acceptance of the introduction and use of 'augmented flip' in their learning spaces. They thought it was a useful adjunct to their studies, and their comments made it obvious that a majority of the students

had embraced its introduction and used it to support them in class and in preparation for class:

it is very helpful and useful would like to use it in the second year… (Student 1)

The added value of 'augmented flip' was highlighted by students' requests for it to be embedded into other areas of the curriculum. The initial focus group identified how students perceived the large class size and resultant low availability of tutors as barriers to learning. In contrast, the use of 'augmented flip' appears to start to lift this barrier since students could '*access the* [relevant] *video when in doubt*' (*Student 5*); it was thus viewed as an acceptable alternative to waiting for a tutor to come over and explain. Students accepted the use of 'augmented flip' as an extension to the role of the tutor rather than a replacement. They acknowledged that the approach afforded more time for tutors to support them when they did encounter problems. Tutors did not have to continually explain the basic concepts and next steps to students since AR enabled a greater workflow, so tutors had more time to engage more meaningfully with students.

Although there was overwhelming positivity around the role and value of 'augmented flip', we did encounter accessibility issues that impacted the student experience. We would highlight this as an area for additional consideration when adopting new approaches. Some students did not have access to smartphones and so could not make use of the QR codes and Auras linked to their workbooks prior to the laboratory class. However, by enabling students to access the QR codes using the tablets in the laboratory and ensuring that the videos were also made available on the VLE and accessible without the need of an app, we provided students with solutions, allowing them to accept this approach to supporting their learning. Even with these issues, the overall consensus was that 'augmented flip' was a valuable learning tool, which links to the second theme of being prepared.

Prepared. The theme 'prepared' is used to capture how students felt on entering the laboratory class for the first time. The students in the study had not undertaken laboratory-based classes at the university prior to these sessions. Data gathered during the focus group had highlighted how students often felt poorly prepared for certain classes and unsure about what they would be doing. Interestingly, respondents suggested that 'augmented flip' allowed them to feel more prepared for what they would be doing during laboratory sessions and also stimulated their interest. Being able to access instructions that were directly linked to each stage of experimental procedures was highly valued:

It was much more stimulating as I enjoyed knowing what was happening in the lesson before the lesson started so that I was prepared. (Student 3)

The excerpt above emphasises how the students took pleasure in feeling more informed, which then ensured that they felt prepared for the class. This feeling of being prepared links to the other key themes as it supports confidence building, facilitates interest in the topic, and enables an easier transition from school to university—the three other key areas in the outer ring of Fig. 14.2.

Confidence. A lack of confidence around what needs to be done in practical sessions and in their own ability to perform tasks was highlighted by students in the initial focus group as being a barrier to learning. In contrast, the analysis of questionnaire responses identified that 'augmented flip' in the laboratory learning environment increased students' enthusiasm for the topic area and afforded more confidence. Anecdotal observation of first-year students by tutors during the module had also identified that the students needed a little more guidance and encouragement to promote engagement and provide them with the initial confidence to see that they could succeed in the tasks that they were given to complete. The use of an AR-based intervention seemed to do just that and students commented that they were quite enthusiastic about taking part in the class rather than apprehensive, since they had more confidence that they knew what to do:

It made me much more willing to look at the content and try to grasp the concepts and I'm sure it is the reason for my passing this module. (Student 6)

Students also thought that the 'augmented flip' intervention was a useful addition that helped to further extend any explanation provided in class. One student remarked:

Some of the content is very complex and without the AR the practical would have been very difficult as I felt the written instructions were just not enough the AR was a major help. (Student 7)

These comments highlight how having additional information and videos that linked to the text and specific stages of the experiment aided understanding and developed student confidence, allowing them to tackle tasks that they perceived as complex. Having greater confidence to tackle the more complex activities also seemed to support a greater interest in the module on the students' part.

Interest. How much a student is interested in their work impacts how engaged they are in what they do (McCoy et al., 2016). This could be engagement in the task at hand alone or engagement in the module overall. We identified that the introduction of 'augmented flip' into the laboratory learning environment had a direct influence on students' perception of their task engagement. They recognised that the use of 'augmented flip' increased the flow in their work by allowing them to continue with tasks without having to wait for a tutor to demonstrate certain aspects or provide additional information. The videos and additional information provided greater relevance to the tasks being performed and stimulated their interest. The interactive nature of the augmented approach was much more interesting than being provided with a set of written instructions and watching tutor demonstrations at the start of each class. The *'just-in-time'* learning facilitated through the AR approach supported this impact by increasing students' level of interest. A good example of the responses gathered is highlighted by this comment:

The use of AR made the module that I was studying much more interesting as there was help whenever needed through the scanning of a simple barcode. (Student 1)

Findings from the initial focus group highlighted issues with students standing around waiting for support or being unwilling to ask for additional support or information. The analysis of student responses showed how AR helps to address this barrier in the laboratory. This in turn supports improved engagement and interest in the tasks being performed.

Transition. Transition from the school environment to the world of higher education is often daunting for students and has been acknowledged as an area which needs careful attention, particularly for retention and progression (Dinning, Magill, Money, Walsh, & Nixon, 2015). Our study involved first-year students who were being introduced to a university laboratory environment for the first time. We had not initially anticipated the impact that using 'augmented flip' would have on their transition into this new learning environment, nor that the students would identify that the AR technology could help them to bridge the gap between school and university, assisting them in developing the skills for practice:

I felt more motivated to make the step from school to independent learning, more willing to learn even some harder aspects and more confident about my knowledge and ability. (Student 10)

The comment above demonstrates how students are aware that learning at university level requires a different approach to that adopted in school. It also suggests that there may be an unwillingness to *make the leap* since they perceive this transition as difficult and may not have the skills required. Drawing upon AR to aid students in learning a new topic area and developing new skills appears to support this transition, providing the students with tools to bridge-the-gap. This is an extremely interesting finding and one which requires further research to develop a better understanding of how 'augmented flip' can be employed to provide a learning environment that facilitates development of an independent learning approach and skills for the workplace. Students need to be supported to make the transition into new ways of learning and developing skills—it does not simply happen from being placed into the new environment.

Inclusion. Development of an inclusive curriculum and consideration of the diverse needs of students are required of all higher education institutions, especially a widening-participation university such as the one at which this study was undertaken. Often, an inclusive curriculum can be achieved simply by giving students different ways to interact with their learning material. In this study, students identified that using 'augmented flip' provided them with a choice. They could access the text, the augmented content, or both. 'Augmented flip' was seen as a useful adjunct by some students that made things easier for them to understand. One student commented:

Watching a video is always going to be easier for me to learn a skill from than reading or just listening to instructions… also the videos linked to the task and I could watch as many times as I needed to at different speeds. (Student 7)

Having instant access to instructions in a range of formats and being provided with autonomy in directing their own learning and learning approach were identified as invaluable, especially for those students with additional educational needs. This approach allowed students to be able to link the demonstrations to the text and, more importantly, be equipped to learn and progress at their own speed. In addition, providing an acceptable learning tool that supports student transition and class preparation automatically promotes an inclusive approach to curriculum delivery.

Other findings. Finally, the tutors who were involved with the AR-enabled sessions reported on what they referred to as a calmer environment in the laboratory. The availability of additional information linked directly to chemicals, equipment or procedures for the students to access in a step-by-step guide appeared to support

independent progression and increased engagement in activities for most students. Tutors felt that students were asking fewer questions and that there was less demand for their time. They felt that they were able to move around the sessions to check student progress instead of constantly explaining and demonstrating while moving from one group to the next.

Discussion and Conclusion

In this chapter, we have discussed our approach of drawing upon the concept of augmented reality to deliver 'augmented flip'. The aim of this study was to address how we could increase student engagement and motivation during laboratory-based classes and to develop the essential skills required by those working in healthcare professions. Our findings indicate that 'augmented flip' can influence students' perceptions of their course and that the use of AR in the laboratory learning environment increased engagement and stimulated student interest in the subject matter. Moreover, it also increased levels of satisfaction in the overall module. It is clear from the responses gathered that students not only thought that 'augmented flip' was a successful way of improving their learning experience, but also that the autonomy that it provided them within these sessions by having content at their fingertips, when they wanted it and under their terms, gave them a sense of independence and thus boosted their confidence about achieving success in tasks and the module. This in turn led to a greater willingness to actively take part in the module, developing the essential skills required for practice in a healthcare setting. Importantly, the technology also provided a way of bridging the gap between school and university for these first-year students. 'Augmented flip' made the laboratory experience less daunting for the students, decreasing the fear they felt about the unknown entity of the university laboratory class.

Removing or providing a way to bypass the barriers that students encounter when they enter the science laboratory also provided a more inclusive learning environment—options were provided. Students could access the additional supporting information if they needed it, via whichever platform they felt most comfortable with. Students using the technology did not see it as a replacement for staff but merely as a useful addition to the instructions given, and did not seem to care if instructions were in-person or via video. The use of 'augmented flip' afforded tutors more time during class sessions to interact and support students, ensuring that they were undertaking procedures correctly and appropriately applying their knowledge to the techniques being performed. From a tutor's point of view, the sessions were much easier to deliver and less demanding of individual

tutors' time during the sessions, and also enabled them to ensure that students achieved positive outcomes in their individual experiments.

Initial findings about the role of 'augmented flipping' have been extremely positive. However, we need to develop a greater understanding of the potential benefits of 'augmented flip' in supporting engagement and developing motivation in a laboratory-based class, as well as its potential role within an inclusive curriculum and for supporting student transition from university to the workplace. To allow for further developments in this area, the practical implications of a wider rollout of an 'augmented flipped' approach across a curriculum or an institution need to be addressed. Evaluation of potential scalability along with the impact of providing support for tutors and students using the technology is required. Finally, issues around accessibility of appropriate devices and the use of AR systems that allow institution-wide adoption of 'augmented flipping' must be tackled. Our findings highlight that university IT infrastructure often does not offer appropriate flexibility that allows different practices to be adopted; the *technology* needs to be compatible with the '*teachnology*'.

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