Using Technology to Enhance Learning, Progression and Achievement in Higher Education

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Abstract

The efficiency of the use of technology in higher education teaching and learning has seen limited research which has been mainly theoretical in nature. The research aims to identify the effects of using technology to enhance learning, progression and achievement in Higher Education. The literature review identified a gap, and this study is situated here to provide a proposed solution to the identified problem. The approach taken is iterative, as it seeks to find a solution to a perceived problem. The research reviews the effect of Technology Enhanced Learning (TEL) on student case studies and establishes whether technology enhancement can be personalised for learners. The research comprises of three individual studies which form the research design and the construction of the pedagogical model is the result of three studies data. The first study investigates the strategic element of TEL implementation from a programme perspective. The second study gains the student voice on the implementation of TEL. The final study measures the effectiveness of TEL implementation at a module level with a focus on personalisation of learning resources. The methodology adopted is viewed through a pragmatist lens, which enables relevant research instruments to be used to find the solution through the use of mixed methods. The results from this research are used to produce a pedagogical model for the implementation of technology into teaching and learning for modules in HE programmes. The model production process identifies the impact of the major findings from the three studies and to assess the effectiveness of the proposed model before testing it statistically for acceptance. The proposed pedagogical model adds to the established research and gives guidance on the implementation of technology in taught modules in a strategic and consistent manner, offering a level of self-personalisation to support learning in the most effective way. The model and accompanying guidance add knowledge to the area, build on published research and will develop practice. The research will contribute knowledge to the area through a new way of looking at TEL pedagogy, manifested in the proposed implementation model.

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Definitions and Abbreviations of Key Terms

- Achievement – Student achievement is when the student passes an assessment in a module on a higher educating programme at the required pass mark.
- AIC – Akaike Information Criterion. This is a statistical criterion to assess the quality of the proposed model in relation to the dataset (Kline, 2015).
- BIC – Bayesian Information Criterion. A criterion by which a statistical model can be selected. A lower number is preferred in model selection, and it is based on the function of the model in relation to the data (Kline, 2015).
- E-learning – Electronic Learning. This usually involves the use of a computer to help deliver education either fully or a selected part of a taught, blended or distance learning programme.
- Engagement – Student engagement is the relationship between time, effort and other resources invested by all parties involved in the students Higher Education experience. The use of technology can help with this process, but it is not essential as engagement is intended to improve the students' learning experience and subsequent performance (Kuh, 2008 and Trowler, 2010).
- HE – Higher Education. This is an education level that is post-secondary education, and is an optional final stage of formal learning whereby a student studies a subject on a three-year degree programme.
- HEI – Higher Education Institute.
- HEPS – Higher Education Performance Scores. These are used to gauge the level of performance or quality of programmes at higher education institutes.
- Holistic/programme approach – This is when every module included in a programme uses the same layout or key principles when designing the online virtual learning environment presence.

- KPI – Key Performance Indicators. These are a group of statistical figures and indices that aim to provide an objective indicator of performance of a higher education institute.

- Learning – Learning is the acquisition of knowledge through the taught modules. The process of learning is the change of the knowledge from being surface to deep level. Deeper level learning means that the student can apply the ideas and concepts to different situations appropriately with confidence and accuracy. The journey to develop this deep understanding of concepts or ideas, is the learning process (Petty, 2004, Pitt & Norton, 2017; Ramsden, 2003).

- ILS – Index of learning style. This was devised by Felder and Soloman in 1997, and is a way of identifying an individual student's preferred way of learning. This can be in one of four categories; 1) Sequential or global, 2) Active or reflective, 3) Visual or verbal, 4) Sensing or intuitive (Felder & Soloman, 1997).

- Implementation – Is a direction and set of instructions for the use of TEL into module teaching in HE. These instructions and direction are derived from theoretical constructs and the findings of the research completed in this thesis.

- Modular Approach – This approach is when each module in a higher education programme uses its own layout and principles, regardless of any other module on the programme, to provide support online through the virtual learning environment.

- Non-traditional student. One who is not necessarily in full-time mode and whose study structure might not take that of the usual academic year or contact format.

- NSS – National Student Survey. This is an annual survey of all final-year undergraduate students, and it aims to gather their views on the degree course that they have been studying using a series of questions to gauge their satisfaction with the programme.

- Pedagogy – This is an approach or method of teaching in higher education. In the context of this thesis, this can relate to an approach to the use of TEL in module teaching and provides the constructs for the direction and instructions which make up

the implementation model (Beetham and Sharpe, 2013; Davies et al., 2017; Perry, 2013).

- Personalisation – this is a way to design or develop something to a specific set of individual needs. In relation to this thesis this is the design of learning resources to meet the individual needs of the students. These needs can be categorised by the use of learning styles but can also just be their individual learning preference (Bishop & Foster, 2011; Graf et al, 2007; Klašnja-Milićević et al., 2011).

- PLR – Personalised Learning Resource. This is a learning resource that has been tailored, often through the use of categories (like ILS), to give the learner a resource suited to their category, ILS or preference for learning. Such resources are usually provided through a virtual learning environment and may use technology to aid usability and accessibility. The range of resources available can be impacted by the student voice, as in this study, see self-personalisation.

- Progress – For the purpose of this thesis progress is when a student moves from one level of learning in a degree programme to another. The student would normally have to pass all of the modules on their Higher Education programme of study to progress, from for example level 4 to level 5.

- RSME – Root Mean Square Error of Approximation. This is a criterion for assessing a statistical model based on the dataset in question. It uses the difference between the hypothesised model and the optimal parameters for the given dataset. The measure avoids any issues of sample size of the dataset, through its methodology, and a score close to 0.00 is favourable (Kenny, 2015).

- Self-personalisation – similar to PLR but rather than the lecturer deciding how to tailor the learning resources for the students, a range of resources in different formats is made available. The students are then able to self-personalise their learning environment through their choice of resource from the range. As indicated in this research their choice might change depending on the stage of the module learning.

- SES – Sport and Exercise Science. This is a degree subject group at Middlesex University, providing the data and the students recruited to this study.

- Student Learning Environment -This is usually the physical location and culture in which students learn. This can be in a wide range of settings and may be an alternative to the classroom, such as an outdoor space.

- TEL – Technology-Enhanced Learning. This is simply the use of information and communication technologies in teaching and learning activities and sessions.

- TPACK – Technological pedagogical and content knowledge model. This is a theoretical framework to allow the identification of means to implement technology into teaching, whilst still indicating that subject and pedagogical knowledge is critical to successful implementation (Koehler et al., 2013).

- Traditional student – A full-time student who attends university face-to-face teaching sessions on a weekly basis as part of an academic year structure.

- VLE – Virtual Learning Environment. A system widely used in higher education, for instance Blackboard and Moodle. It uses web-based technology to allow students' learning to be structured and managed, and to make learning activities and content available. The module's digital elements, including assessments, can be delivered or collected and feedback released on the platform for students' ease of access (Jisc, 2016).

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Chapter 1 Introduction

This research seeks to address a gap identified within the research literature, namely that technology-enhanced learning (TEL) and electronic learning (E-learning) tools have yet to be investigated holistically from pedagogical, strategic and student perspective in higher education (HE). The literature review will highlight how, where it has been explored, it has been linked to blended learning and that that technology implementation models are theoretical in nature and do not necessarily offer practical guidance on using technology to personalise the students' learning experience. Moreover, they are based on limited research (Ginns & Fraser, 2010; Jennings & Kachel, 2010; Karamanos & Gibbs, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Mah-Ngee, 2012; Maor, 2017; Niess et al., 2009; Tai et al., 2015). No model has yet been established to guide the practical implementation of technology to provide a personalised, supportive learning environment for teaching and learning in HE.

1.1 Research context and rationale

The research is partly motivated by the researcher's passion for using technology in teaching and learning and the need to understand and discover the best approach to combining them (see appendices for researcher's own drivers). Like that of many young lecturers in HE, my initial practice in using the knowledge gained from education, for example the Postgraduate Certificate in Higher Education, was developed through trial and error from peer observation and discussions with colleagues on practice. The introduction of technology into HE teaching and learning, in the early stages, seemingly adopted the approach of 'Well, it's technology, so it must be better', rather than actually establishing the best use of the resources available to all in, typically, the main source of teaching and learning technology, the Virtual learning Environment (VLE).

Research by Browne et al. (2006) and Lingard (2007) indicates that lecturers do not use institutional VLEs effectively or with any consistency. The lecturers' knowledge and motivation to engage with the VLE are often cited as the reason for their lack of engagement and effective use of the VLE. Therefore, the rationale for this research was a desire for this approach to be changed and for evidence-based guidance to be given to

develop practice so that the knowledge held by staff can be accessed by the students in the most effective manner without any need for trial and error. The research aims to provide an evidence-based approach to using technology in teaching and learning in HE, with appropriate guidance for staff. The approach will help staff to create effective online environments to complement classroom sessions and support students' learning and development.

1.1.1 Changing scope of higher education

The current use of TEL and E-learning tools in HE is changing and the level of engagement of higher education institutions (HEI) is varied. Across the sector it can vary for a range of reasons and motivations. The cost of fully implementing technology can be a barrier to engagement, but can also be a motivation. As competition for student numbers increases, the perception of value for money, which the investment in technology can provide, is seen as a reason for investment in this area. The expectations of new students are not limited to their perceived investment in technology but include how it is used in their learning. The modern student is exposed to TEL at a very early stage in their education, therefore they have an expectation that it will continue when they attend HE.

These factors contribute to the changing scope of technology in HE teaching and learning. The rationale for the current study and the limited research in the area are identified in sections 1.1.3 to 1.2. This section will aim to identify the gaps and future direction needed in the area. The personalisation of learning using technology is a relatively new area of research, so the implementation of technology in this manner in teaching and learning in HE needs further guidance and development. The findings of the research will hopefully offer an evidence-based approach to personalising the student learning experience and a guide to further development in this area.

The research aims to guide practice in the sector to improve provision across institutions as it moves towards a more technologically advanced landscape. It hopes to provide evidence for the implementation of technology enhancing students' learning experience in a personalised manner, supporting their studies. This evidence will lead to the development of a guide on pedagogical strategies for TEL to enhance provision and further

engage students. The use of technology to personalise the pedagogical experience to improve students' academic performance is of interest to HE stakeholders. The development of a model for the implementation to personalise learning in HEIs will increase knowledge in the area and potentially enhance sector practice. The model may provide clarification in changing times for HEIs, and help to meet the expectations of the modern student whilst enhancing their learning environment and ability to achieve their goals.

1.1.2 Current technology use and enhancement

A traditional HE teaching model is one that students receive during contact in a lecture, tutorial or guide to additional reading and support to independent research through the library. Many universities now look to replicate and enhance this model through the introduction of a VLE. There is a multitude of systems and tools to create VLEs, which it is hoped will support the student outside of contact sessions. Current practice involving teaching and learning's utilisation of technology is varied, with no consistent evidence-based approach, as noted. The systems that universities in the United Kingdom favour to create a VLE to support their teaching and learning are Moodle and Blackboard, which contain a variety of E-learning tools including forums, quizzes, assessments, feedback and video, and which can act as a file store. The systems are accessed through a multitude of devices, including mobile phones, ensuring that course support and information are accessible virtually anywhere at any time, internet access permitting.

Technology at a very basic level is used through the VLE, as in the simple file storage to allow students to access information about their taught sessions. This basic use of technology may be a response to the perceived need to provide more support for students and the use of technology as a quick route to achieve it. Due to various policies surrounding Disabled Student Allowance (DSA) support for students, to produce an inclusive curriculum most lecturers' slides are available online before the session to support students both at this University and widely across the sector. A VLE allows for further technology to be used in the form of the usual E-learning tools (as noted above) to enhance the pedagogical experience of students and support them in their studies.

The use of online forums allows students and staff to interact on module topics to answer questions, develop thoughts and offer pastoral care, if needed. Others help the student to develop and test their understanding at their own pace. A VLE and technology may also be used during taught sessions, using mobile devices such as smartphones and tablets. The use of mobile devices can add interactivity to a taught session through the use of apps that allow questions to be answered during the session whilst the content is still being delivered by the lecturer, either individually or in groups. This type of technology allows students to interact with resources in real time. The use of mobile devices in this manner has been found beneficial to students' learning and engagement, as noted by Wilkinson and Barter (2016). The range of options for technology enhancement does not mean that strong implementation follows. The manner in which the technology is used in students' learning process to enhance their experience is, as noted, highly inconsistent, and mainly at the lower end of use; that is, as a simple file store for students to access information.

1.1.3 Impact of technology

The student body in modern HE is engaged with social media and is technology savvy, therefore there is an increased expectation for technology to be used in their education. Technology can have a major impact on a student's pedagogical experience in HE, which can be both positive and negative. The student experience is a part of HE that is increasingly under the microscope due to the inclusion of student satisfaction and learning experience scores in the Teaching Excellence Framework (TEF). Technology can be perceived to add value to the university experience, due to the value and the gravitas that the students feel it lends. Therefore, the use of technology in students' learning has to be purposeful and designed to enhance their experience and improve satisfaction. As noted in this study, when technology is used in a positive way it can help to engage students in their studies and help them to progress. Conversely, if technology is ineffective in its implementation it can become a barrier to learning and disengage the student from not only their studies but HE in general (Kent, 2015; MacKeogh & Fox, 2009; Rodriguez & Armellini, 2013; Thomas, 2012; Vayre & Vonthron, 2017). These themes are explored in more detail in sections 2.1 and 2.2 of this thesis.

The use of technology holistically, at programme level, to maximise student learning is being investigated to add to the limited evidence base in the area. This study adds knowledge on a whole-programme approach to technology-enhanced classroom learning in supporting an online environment in a non-specialist population. Research has previously focused on TEL at the modular level, thus it may provide a short-sighted perspective that mirrors current practice in assessment. Practice is still highly focused on modular results and a change of assessment is seen as a way to change this, without looking at the overall impact of the change on the programme. TEL is often introduced in a modular manner, which can lead to a positive change in that module while the perceptions of other programme modules worsen due to their lack of TEL. With more emphasis on programme-level assessment, programme-level teaching TEL initiatives should be evaluated (Cavanaugh et al., 2008; Jennings & Kachel, 2010; Karamizadeh et al., 2012; Lu and Vela, 2015; MacKeogh & Fox, 2009; Stepanyan et al., 2013).

Research has looked at the effectiveness of online learning (Cavanaugh et al., 2008; Jennings & Kachel, 2010; Lu & Vela, 2015; Perry & Pilati, 2011), blended learning (EL-Deghaidy & Nouby, 2008; Geçer & Dağ, 2012; Karamizadeh et al., 2012; Wong et al., 2014; Wu et al., 2010), with little agreement across the research and, again, it was focused on a modular approach to TEL. Research into a holistic, coherent programme approach for a HE degree for TEL to assist students effectively in the classroom through providing support outside of taught contact sessions is needed to provide evidence and guidance on its use in HE.

1.1.4 Implementation models, guidance, current practice and what is known

The pedagogical approach to TEL implementation is continuously evolving in HE. Its efficiency as an approach to support learning is not fully understood and its use by staff is sporadic, and it is sometimes viewed poorly compared to traditional methods. Current guidance is limited, and institutions' focus emphasises meeting the Disable Students Allowances (DSA) requirements, in that lesson resources have to be online prior to the session in the appropriate format, rather than the potential enhancement of learning. The approach taken as a result of current guidance is one that encourages a VLE to be used as a file store rather than an extension of the classroom and tutors' contact time. Current

guidance and frameworks are varied and centre on one main theoretical model, the Technology Pedagogical Content knowledge (TPACK) model. This aims to help practitioners to ascertain the areas of strength and the areas that need to be improved in relation to TEL (Koehler et al., 2013).

TPACK does not offer any guidance or reference any specific TEL, but merely looks at the knowledge required and how it relates to the global picture of an educator's knowledge. There are examples of guidance being produced to help improve practice, but they often conclude with issues on student and staff engagement and the need to include the students' voice in the development of TEL (Beetham, 2012; Reedy & Goodfellow, 2014). Further review of the implementation models and associated guidance can be found in section 2.3. The findings from this research highlight a process through which the proposed implementation model is produced. The proposed model offers guidance on the implementation of technology in teaching in HE to support the contact session and provide a personal online approach.

Through the completion of three studies, this research has identified and provided evidence for new approaches to TEL in HE teaching and also an implementation model. The use of technology in students' learning should be a positive one, and the evidence provided by this research will demonstrate good practice and, through further development, become established sector practice. The inclusion of students' views on the development of the proposed approaches adds strength to the implementation. When a staff member opts to use technology to enhance, not replace, their taught session, evidence-based approaches should be available so that online support can be effectively designed by all, not dependent on the knowledge or preferences of staff. The development of a model for the implementation of personal learning resources could represent an interesting development of practice to support students outside of classroom contact for those with an interest in TEL and a way to make things more efficient for HEIs.

The empirical evidence is partnered with the feedback and views of students, putting the model in a strong position to change sector practice. In an environment constantly measured for performance, providing evidence to help lecturers to work efficiently and effectively will help to develop practice and assist the sector to deal with these challenges.

1.1.5 Future technology implementation

The use and implementation of technology in HE teaching and learning is constantly developing and becoming more prominent in the demands and expectations of modern students. Future development of its use could lead to a more personalised pedagogical experience and enhanced student learning environment. The ability to personalise a pedagogical environment using TEL in the classroom through traditional delivery to meet the needs of an individual student is under-researched; see for instance the approaches taken in Ginns and Fraser (2010), Klašnja-Milićević et al. (2011) and Krämer and Bente (2010). The quality of the student experience is very important in HE, especially in the modern climate where HEIs are measured by TEF. How the technology is personalised is currently not uniformly agreed or widely investigated. Work by Klašnja-Milićević et al. (2011) cites the use of learning styles as categories of the type of personalisation offered to students online, but does not give any guidance on how TEL can be implemented or its impact. Some research has been conducted on the use of learning styles, but not using the technology-enhanced approach (Bishop & Foster, 2011; Graf et al, 2007; Hong Lu et al., 2007; Santo, 2006). Personalisation using learning styles could give new direction to this area. Its use, in this context, is to categorise the content provided online. The impact of personalisation on students is an area for further research to ensure that it affects their learning positively and helps their engagement in the subject as a whole. The students' views on receiving content in this way are important when considering this approach to TEL and devising guidance on the topic.

Developing the specific research area of the use of TEL through this current research should allow for the development of an implementation model from the findings as guidance for the sector. The implementation model could move forward the area of the personalisation and implementation of TEL in HE.

1.2 Research contribution, aims, approach and structure

The research will contribute knowledge to the area through a new way of looking at TEL pedagogy, manifested in an implementation model. The model and accompanying guidance will add knowledge to the area, develop practice and build on published research

(Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009). The effectiveness of TEL has been researched by Cavanaugh et al. (2008), Jennings and Kachel (2010), Lu and Vela (2015) and Perry and Pilati (2011), and some have reviewed blended learning (EL-Deghaidy & Nouby, 2008; Geçer & Dağ, 2012; Karamizadeh et al., 2012; Wong et al., 2014; Wu et al., 2010). The findings have generally focused on module outcomes and not students' overall progress and achievement, and the students' views have not been considered. An incoherent and limited evidence-based approach to technology's use in HE teaching and learning is currently common practice, as noted by Browne et al. (2006), Heaton-Shrestha et al. (2007) and Lingard (2007). There has been limited research on the approach taken to TEL and the impact on higher education performance indicators (HEPIs) and none on investigating the impact of a consistent programme-based approach to TEL with a student perspective on the learning environment (Bakas & Mikropoulos, 2003; Cavanaugh et al., 2008; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Maor, 2017; Tai et al., 2015).

Technology is often used as a complementary tool for taught elements of a course, but its potential to be adopted in a more personal manner, as in everyday life, is yet to be explored in HE. Research into the personalisation of students' pedagogical environment has, to date focused on how to categorise support to offer a personal approach, including the use of learning styles to tailor and personalise the use of technology in the classroom (Bishop & Foster, 2011; Graf *et al*, 2007; Santo, 2006). The exact impact and identification of whether a personalised approach can increase overall effectiveness in the students' learning is not commonly known or researched. The development and adoption of the technology in HE teaching and learning require evidence-based guidance to ensure that the changes and systems being implemented are providing the best learning and pedagogical environment possible for the students.

1.2.1 Research aims

The aim of the research is to produce a model for technology implementation for use in HE programmes and module teaching to improve the student experience. In meeting this aim, the effects of using technology to enhance learning, progress and achievement in HE in a

holistic manner will be identified. The effect of TEL on student experience in case studies in HE will be analysed. Finally, whether technology enhancement can be personalised for the learner using their learning style will be identified.

1.2.2 Research approach

The current research is formed of three studies investigating the use of technology in student learning in HE. The measurement of technology implementation and the use of E-learning tools to then develop an approach for using technology to provide personalised learning resources is the key to this research. However, it is important before embarking on the research and establishing which research instruments to use to establish the paradigm under which the current research will operate. The research operates in the pragmatist paradigm, rather than the positive or inferential paradigms, as this allows the use of mixed methods. This methodology is critical to enable the use of the most appropriate data collection instruments to work towards a solution to the overarching problem in the form of a proposed implementation model. The findings are hoped to lead to enhancement and, by operating under the pragmatist paradigm, the students' views can be used with other data to co-create an agreed solution. From the research findings a model can be developed that may lead to an enhancement in practice.

The research is formed of three studies, providing the data and evidence to develop an implementation model. The studies use mixed methods in a longitudinal study and qualitative open-ended questionnaires with focus groups and blogs.

The first study looked at technology implementation in a chosen subject degree programme area. It investigated the impact of the use of technology in a holistic programme manner, using three implementation categories, on the student learning and pedagogical environment in terms of identified HEPIs, including students' assessment results, student attendance, student VLE time, student progress and achievement rates. The dataset was from the University record system, which included the last six academic years of the subject area programme's data. The three categories of technology implementation were as follows: foundation, which encompassed the lecture slides online plus electronic assessment and feedback; intermediate, which additionally used E-learning

tools to help support students' learning; and advanced, which additionally used a video of the lecture (further details can be seen in Table 4.3).

The second study aimed to investigate the effect of TEL on student experience in an HE case study. The findings aimed to add to the quantitative findings of Study one through qualitative methods, questionnaires and focus groups with students. The findings aimed to give the performance indicators a greater impact and depth of analysis by including student voice in the analysis, which contributed to the design of the approach taken in the final study. The questionnaire analysis was conducted on the free text comments from the NSS and module evaluation from the same period as the data in Study one. The focus groups were conducted using a semi-structured group interview approach to allow the themes from the questionnaires to be addressed and to explore other topics to increase the understanding of the impact of the changes.

The third study aimed to investigate the impact of personalising the technology used to support the students' learning, in and out of the classroom, using the learners' learning style (ILS) as devised by Felder and Soloman in 1997. The support inside and outside of the classroom, provided through the University VLE, was tailored to the students' learning style, as suggested in work by Klašnja-Milićević et al. (2011). The students were asked to upload a learning blog throughout the module intervention to gain their views on the personalised support, to be explored further in focus groups (Ebner et al., 2010; Garcia et al., 2015). The quantitative part of the final study helped to gauge the impact of personalised learning on the students' module performance and provide the evidence for the development of a model for the implementation of technology to personalise and support students' learning in practice.

1.2.3 Thesis chapter structure

The research presented in this thesis aims to demonstrate the impact of the implementation of technology on the learning of students in HE. The first chapter is the introduction, which sets the context of the research and identifies the research and theoretical space in which current research is completed. It identifies the aims and research questions and also the individual study questions, and then the key themes of the research:

the current use of TEL in HE sector; the impact of technology; the future use of technology; and technology implementation models.

The second chapter is the literature review, which outlines the key themes of the research area identified in the introduction. It examines literature on the use of technology in HE teaching and learning, and the approaches taken. It includes literature on students' usage of technology, why students choose to interact with technology and which approaches they value. The notion of an implementation model for the use of technology in teaching and learning in HE is discussed and critiqued in the next theme, particularly looking at the TPACK model. The final theme is the concept of personalising the students' learning experience and the use of technology to achieve this. Methods around this topic are discussed, including fully automated systems and staff-guided systems. The level of personalisation and how it interacts with the contact time are critiqued.

The third chapter is the methodology chapter, which outlines the ontological and epistemological positions of the research in relation to the paradigm in which the study operates in. The chosen data collection instruments for the studies in this research are discussed. Finally, the different types of data that were collected are discussed in relation to how they enrich each other to obtain the overall picture of this research to answer the aims.

The fourth chapter outlines the data collection procedures for each individual study, identifying the variables used, which protocols were used in the collection process and then how the data was analysed.

Chapter five is the results section, which goes through the data analysis in study order, identifying the key themes from the analysis for each study and answering its research question. The final section identifies the overall findings of the research and uses regression analysis for a proposal to be taken forward into the development of a model.

The sixth chapter covers the development of the implementation model, which is the product inferred from the data and its analysis of this current research. The chapter details the process of identifying the final model to be developed and the data to be used in this

process. The acceptance criteria are established to test the model at various stages of its development, before identifying the final model for acceptance.

The seventh chapter discusses what was found in each study and how this answers the study's question, and its relation to published research and the field. The implications for practice are discussed in relation to the findings from the studies and the overall research and in particular the proposed model with practical guidance.

The final chapter is the conclusion, which summarises the findings of the studies and the overall research in relation to the overarching aims and research questions. The limitations and recommended future work, based on the overall research, are outlined and, in particular, the work on further validating the proposed model. The impact of the current research on teaching and learning is discussed

1.3 Chapter conclusions

This chapter has outlined the context and rationale for the current research, identifying the research area and gaps that it aims to fill. The structure of the research has been outlined, along with the key terms. The main aims and objectives have been outlined and these areas covered in more detail.

The study constitutes seven chapters: current research in the area (Chapter 2); research methodology (Chapter 3); data collection methods (Chapter 4); research results (Chapter 5); model development (Chapter 6); discussion of the findings in relation to published research (Chapter 7); and finally, the conclusions, limitations and future work (Chapter 8). The appendices outline the researcher's personal research journey, the research questions used in data collection and practical guidance on the use of the proposed model.

Chapter 2 Literature Review

This chapter aims to review the literature on the implementation of TEL and E-learning tools in teaching and learning in HE to identify themes to focus the study's objectives. The modern HE landscape is one in which the student is portrayed as a customer, with full consumer rights over their investment in a degree, and a university as a business (Hannan, 2005; Kuh, 2012; Peña-López, 2010). The educational value of a degree is still seen as important in this changing landscape, but the nature of its delivery and progress, achievement and course resources are scrutinised in terms of value for money and overarching student experience (Catcheside, 2012; Hedberg, 2006; Renes & Strange, 2011). Students have started to demand more for their money rather than accept the generic usage of established systems and, as such, the use of technology in supporting students in their studies may form part of the solution for demonstrating this value for money.

Improvements in this area could help, and the advantage of this intervention and focus on technology is that it can increase HEIs' ranking and reputation through students' perceptions and the sector measurement systems and key performance indicators (KPIs). Technology alone may not be the solution, but the way in which it is employed could help: for example, taking a personal approach. Enabling technology to be used in this way could achieve these goals whilst enabling the HEI to compete in today's climate (Higgitt, 2012; Jones & Killick, 2013). Topics to be reviewed in this chapter are the use of technology in teaching and learning in HE, the breadth of TEL and E-learning, the student learning environment, current issues and potential areas in which further development could take place. The issues surrounding the models for the implementation of technology in teaching and learning will be reviewed with a focus on the most researched and supported model to identify areas for further model development. The final part of this chapter will review the research methodologies used in the area to inform the current research data and potentially highlight the direction for the research.

2.1 Subject background

New teaching strategies are increasingly important in HE as the landscape changes to embrace a digital world, which suits today's student; the drive by HEIs to be more modern

and efficient; and the demands from an increasingly discerning clientele. These changes are not free of risks and can cause tensions between all associated with HEIs, due to the impact on teaching and learning, and many have raised concerns over the quality of contact with students (Hedberg, 2006; Petit dit Dariel et al., 2013; Stepanyan et al., 2013). Catcheside (2012) discussed how traditional students, who are full-time students with a formal timetable and enrolled on a degree programme, still want quality contact with staff. The contact that students have with university staff is potentially under threat due to the change in approach to a more technology-enhanced teaching and learning strategy (Beldagli & Adiguzel, 2010; Goodfellow, 2011; Granić et al., 2009; Rose & Meyer, 2002; Voogt et al., 2013). Some authors (Hedberg, 2006; Petit dit Dariel et al., 2013) deem that technology can replace traditional contact and therefore save a university valuable resources in terms of staff contact hours and accommodation although, due to students wanting a personal engagement with staff, such a change may lead to staff having to foster such relationships asynchronously, increasing staff time. The impact of this type of change raises concerns over the impact on students' experience and KPIs, including those used in the United Kingdom, such as student satisfaction. This is currently measured through the National Student Survey (NSS), student progress and achievement, the Key Information Set data on contact time and, especially, the introduction of the Teaching Excellence Framework (TEF), which seeks to rank HEI providers on their teaching quality (Beetham & Sharpe, 2013; Davies et al., 2017; Higher Education Funding Council for England, 2017; Thomas, 2012).

The focus of the HEI is also considered important. As Hannan (2005) suggests, teaching and learning innovations, which can include technology use, could receive more support in an institution where, due to its focus, teaching and learning are held in high regard. The introduction of the TEF has moved teaching and learning quality to the forefront in all institutions' planning so, potentially, there may be a more universal need to show innovation and enhancement in teaching and learning through technology use, regardless of the traditional focus of the HEI (Hannan, 2005). The HEI strategic plan, which defines the overall focus of the institution, can affect research in this area, so this thesis should be mindful of this as the resultant outcomes may not be applicable to all universities.

2.2 Technology-enhanced learning

The use of technology in teaching and learning can be called technology-enhanced learning (TEL). Technology can be used to enhance teaching and learning in the classroom in HE, but the need for a sound theoretical basis is paramount. Without a sound underpinning pedagogy, the adoption of technology by both staff and students can be limited. Karamanos and Gibbs (2012) propose an adoption model for online interactivity, suggesting that the relative advantages of use and the complexity of the system are two of the important factors in its adoption.

Although this model was developed for online interactivity, the notion of complexity and relative advantage of use are issues for the use of technology to enhance teaching and learning in the classroom. If the system is too complex the staff and students are unlikely to adopt it and, likewise, if there is no clear advantage over the existing methods then its use will be decreased. The work by Beetham and Sharpe (2013) suggests that how technology and digital means are used to enhance pedagogy is often confused with the need to change one's personal pedagogical approach to teaching. Beetham and Sharpe (2013), Davies et al. (2017) and Davis and Roberts (2013) advocate a position whereby the need is not to change but rather to adapt to embrace the new technologies that are available to educators. The need for guidance on the adoption of new technologies and approaches is important for staff engagement, as noted by Beetham and Sharpe (2013) and Perry (2013).

Moreover, rather than individual tutor adoption, there is a need to ensure consistency in technology use, and the impact on the classroom would be better with a coherent curriculum approach to certain principles, whilst allowing for important subject specialism (Hannan, 2005; Juniu, 2011; Stepanyan et al., 2013; Voogt et al., 2013). A coherent approach should result in the student being able to use technology in their learning constantly, rather than a positive experience in one module due to tutor expertise and a poor experience in another, which can lead to confusion and reduced overall engagement with course technology (Coole & Watts, 2009; Kinchin, 2012; Land, 2000; Pemberton et al., 2006).

The work by MacKeogh and Fox (2009) highlights some of the barriers to embedding E-learning into the HE curriculum, but still identifies the potential to enhance traditional pedagogical approaches through a curriculum approach to technology use. The need to embrace the digital environment is increasingly apparent when students at educational levels below HE are experiencing varied and innovative uses of TEL and E-learning tools, as discussed by Kinchin (2012) and Hannan (2005). The expectations of these students when they progress to HE is that this will continue, and if it does not this it could lead to a negative perception of the HE learning environment. The use of E-learning tools and TEL needs to be implemented so that it enhances, rather than diminishes, the students' learning environment and the tutor's involvement in their learning. Catcheside (2012) reports that students still value and expect tutor contact. Nehme (2010) agrees and states that students require face-to-face sessions with the lecturer to maintain motivation and engagement throughout the course, and that this is often lacking on purely online courses due to a limited lecturer-student bond. Many (Catcheside, 2012; Coates & Dickinson, 2012; Shaw, 2012; Strijbos, 2011) have reported that the student-lecturer bond is held in high regard by students, as it helps to increase engagement in the learning process. Through this bond, the students often gain ownership of their learning and a joint sense of achievement can be achieved, as reported by Coates and Dickinson (2012), Coole and Watts (2009), Doolan (2010), Doyle and Jacobs (2013) Mikropoulos and Natsis (2011), Shaw (2012) and Strijbos (2011).

2.2.1 Student learning environment

A student learning environment is a physical space that helps to encourage and support students' acquisition of knowledge. At any level of education, a learning environment is essential, and within this it is important that students receive praise, guidance and clear goals in their feedback (Petty, 2004). This is a clear construct of a learning environment, as noted by Petty in his guide to teaching in HE, but can this process be enhanced by the use of E-learning? The construct identified by Petty could relate to a technology-enhanced 'E' environment. Technology enhancement and E-learning could enable feedback to be delivered to the student, quicker, so they can receive:

- Praise on the task completed
- Guidance on what the student needs to improve
- Goals for how and when they will achieve improvement.

Research suggests that the sooner the feedback is received after the submission date, the more effective it is in developing students' learning (Crisp, 2007; Petty, 2004; Pitt & Norton, 2017; Ramsden, 2003). Therefore, by using technology to increase the speed of feedback, learning environments may be enhanced. The use of the phrases identified by Petty (2004) is important, but student should still be encouraged to learn and achieve for their own internal reasons, which, combined with praise, can lead to greater success through the use of their personal goals as motivation.

Within any main group there are student cohorts that could suffer from a TEL approach, for example students who are unfamiliar with technology and E-learning, and this could create a negative culture early on. This may be affected by gender, thus could represent a problem in view of the gender split being 70% male to 30% female in the current research student cohort. A non-E-learning female could become very isolated quite quickly during the course due to the low proportion of women on the programme, if they did not seek additional support. Nehme (2010) discusses how different cultures and cohorts use technology and shows the potentially dramatic impact on a learner's motivation and resulting effect on their course achievement and personal success.

Case and Marshall (2008) discuss how students who feel isolated can often become demotivated yet will not want to admit to a problem with technology due to cultural pressure, simply saying 'it will be fine' 'I'll just hang in there', adhering to the 'no problem' discourse model. These students can create a negative course culture, as their perception of the course is linked to their ability to use the technology. Saadé and Kira (2009) believe that by working with these cohorts to improve their perception of the technology and its use as a pedagogical tool, which will benefit their learning, the course is then perceived to be accessible, creating a positive culture.

All cohorts need to realise the presence of technology in their teaching and learning environment, and potentially its value to their learning, through a variety of approaches. Nehme (2010) states that by monitoring these students and providing support where

needed, so they can see the value in the use of technology, their motivation can be altered and their learning improved, so they will achieve and be rewarded for their perseverance. The use of resources and E-learning tools to help cohorts who are not native users of technology in the learning environment is critical to reduce a negative culture and motivation. Goodfellow (2011), Nehme (2010) and Sharpe and Benfield (2005) conclude that to avoid isolating students this support needs to be used throughout the course, rather than just at the beginning. The support could help to increase their overall study skills in the modern HE technology-enhanced E-learning world, which in turn would help the them to develop and achieve their goals, and lead to a deeper level of understanding being achieved, as noted by Entwistle (2001).

2.2.2 Use of technology in a student learning environment

The importance of content, support resources and feedback is established to ensure that access is not an issue for any of the student groups within a programme cohort (Case & Marshall, 2008; Nehme, 2010; Reedy & Goodfellow, 2014; Saadé & Kira, 2009). The materials that are produced using technology and E-learning tools also have to be in a style that suits the student and in an appropriate context to allow for deep-level learning rather than just rote or surface-level understanding (Marton & Säljö, 1976; Pask, 1976). In order to achieve this and produce effective resources, the programme tutor must gain an understanding of how the students in their cohorts learn and develop information and ideas (Felder et al., 2000; Krämer & Bente, 2010; Mehanna, 2004; Pritchard, 2007; Rose & Meyer, 2002; Vrasidas, 2004; Yilmaz-Soylu & Akkoyunlu, 2009). Understanding the way students learn in HE is important, as cohorts often come to university from varying backgrounds and have different approaches to learning, and an individual might need different levels of support to use E-learning (Sharpe & Benfield, 2005). The motivation of the student and the design of the pedagogical environment and its resources have an impact, as noted by Marton and Säljö (1976). If a degree programme demands only that they recall information, then tutors cannot be surprised when students learn superficially and their ability to be analytical and develop their own ideas is limited. Work by Pask (1976) developed Marton and Säljö's (1976) findings to add further levels to their learning processes, as seen in Table 2.1. A levels map shows how assessments and course content

could be presented to students to enable them to develop a deep-level understanding of the subject. The map developed by Pask (1976) can be a useful guide when developing general course materials and student support resources.

Table 2.1 Approaches to learning and their outcomes (adapted from Entwistle et al., 1979: 376)

	PROCESS			
INTENTION	Approach / Style	Stage I	Stage II	Outcome
UNDERSTANDING	Deep approach / versatile	All four processes below used in alternation to develop a full understanding		Deep level of understanding
	Comprehension learning	Building overall description of content area	Reorganising and relating ideas to prior knowledge	Incomplete understanding due to globetrotting
REPRODUCING	Operation learning	Detailed attention to evidence and to its provenance	Relating evidence to conclusions, critically	Incomplete understanding du to improvidence
	Surface approach	Memorisation	Overlearning by routine repetition	surface level understanding
ACHIEVING	Strategic well-Organised studying	Any combination of the six above processes considered to be necessary in carrying out the perceived task requirements successfully		High grades with or without understanding

Marton and Säljö (1976) state that learning is not measured only by how much a student has learnt but by their depth of understanding and ability to formulate new ideas on a topic. The content given in a topic is also key, along with its design and feedback by the tutor. The use of technology to potentially enhance this should be carefully considered by the tutor at the development stage. As Entwistle (2001) states, understanding these processes and the importance of the approach, content and learning environment is crucial

in achieving deep-level understanding. TEL and E-learning tools, with careful planning and consideration, can be used to produce engaging and modern course content that can impact on this process and the resultant level of students' understanding. The link between the VLE and learning environment starts to become more important as not only can you improve the feedback given but, potentially, by using technology using the platform provided by the VLE, the teaching sessions and available subject support materials. If the students see a greater value in these, then their level of engagement may increase with, potentially, a positive effect on their learning (Bryson & Hand, 2007).

2.2.3 Technology use and engagement

Paulsen noted in 1995 that student engagement with interactions and process is vital to success in any pedagogical environment, whether this technology based or not. Trowler (2010) sees student engagement to be a relationship between the time, effort and other resources invested by both students and, in this case, the university, intended to improve student performance and learning experience. Student engagement is an important element in students' achieving their programme and personal goals. To reflect the importance of this and the views of Trowler (2010) and Paulsen (1995), a multifaceted approach should be considered to evaluate and monitor student engagement in modern HE where technology is heavily used.

Class involvement and overall achievement consists of several keys measures that include, in no particular order, attendance, VLE and resources interaction. Bryson and Hand (2007), Thomas (2012) and Kuh et al. (2008) support these views; rather than just multiply these factors together, they form part of the academic sphere of student engagement in HE. Work by Thomas (2012a) expands on this view by bringing the social and service aspects of university life into the engagement. The sense of belonging is important to a student, Thomas (2012b) writes, yet the impact of technology implementation and E-learning in HE is limited, outside of the academic sphere. Whilst this argument has some merit, this thesis contends that increasing the use of university systems in the academic sphere could result in an increase in engagement in a student's social sphere.

The importance of the academic sphere of a student's HE experience, as noted by Thomas (2012), is vital to their success. If E-learning and technology enhancement could help to improve the academic sphere, then the overall effect on the student's HE life and journey towards their goals will be positive. Improving the academic sphere through the use of technology needs to be planned and implemented carefully: when students start HE, they have fears about the new ways to study, so an ineffective E-learning environment can create anxiety, affecting their engagement (Sharpe & Benfield, 2005). An important element of the academic sphere is programme teaching, so enhancing this through technology and E-learning tools is a logical development. The technology should not just facilitate and improve how programmes are currently taught; the support, the content, the feedback and the overall learning environment should also be improved, therefore the whole student experience could be enhanced.

The value that students add to the content provided online and the module support resources are important to the potential enhancement of the programme elements identified. MacKeogh and Fox (2009) note that technology and E-learning tools could realise these enhancements in a modern HE setting, providing an appropriate environment is created to support the curriculum in which the students see the value of the technology implementation. Fox and MacKeogh (2003) note that E-learning does not need to replace how we teach or take our role, but can be used to further engage the student population. As they become more digitally accomplished, this link is vital in HE. The use of technology has to be valued by the student, as noted above, and enhance the established taught learning environment that the student favours (Catcheside, 2012). If this technology enhancement and availability of course resources are valued by the student then their engagement in the module and programme as a whole could be positively enhanced, as noted by Kuh et al. (2008) and MacKeogh and Fox (2009).

The link between engagement, progress and achievement is an important one, as noted by Thomas (2012). However, the wider context of the student learning environment can also have an effect on their ability to achieve, as indicated in the social and services spheres of the engagement in this work. Whether these techniques to engage with students and potentially increase course performance indicators and are effective are issues that the research hopes to provide evidence for.

Kuh et al. (2008) and Bryson and Hand (2007) support Trowler's (2010) and Thomas' (2012), views on student engagement by stating that engagement involves the degree of effort and value that the student invests in educational activities directly contributing to the overall learning objectives. The definitions by Trowler and Kuh allow the measurement of engagement and the resultant assessment of their correlation with student performance. These viewpoints support the measurement of perceived value of the use of technology and the use of additional technology-enhanced course materials released through the VLE in module teaching. The perception of worth of the additional resources could be increased further using the VLE to provide personalised content, which could ultimately positively impact on the students' engagement in the subject and module learning (Bryson & Hand, 2007; Kuh et al., 2008; Paulsen, 1995; Thomas, 2012; Trowler, 2010).

If, through subject delivery and support, students' engagement can be increased, the effect on progress and achievement should be positive, as noted by Kuh (2008). The long-term effects of increased engagement in students' learning is an important factor to consider. It was noted by Thomas (2012) that many students are attending university not solely to gain a degree. Whilst that is a priority, there is other knowledge to be gained and a desire of HEIs is a passion for the subject in a student, leading to the creation of a lifelong-learning approach (Thomas, 2012).

2.2.4 Adding value and personalisation, using technology

The use of technology and the implementation of E-learning tools in a learning environment does not mean the replication of off-line sessions. Fox and MacKeogh (2003) noted that time can be better used by creating online environments that achieve the same desired outcome; virtual seminars, just requiring setup and monitoring. In order for this to occur, a framework within the subject curriculum needs to be established. The work by Fox and MacKeogh (2003) was largely based on online or blended delivery and therefore the need is apparent to investigate and measure the application of the findings to traditional delivery. The links between the individual learners' needs is a factor in the impact of the learning environment, which again is a factor not explored in previous work. Klašnja-Milićević et al. (2011) looked at linking the learning style of the learner to the E-learning environment, but did not link further, to the other performance indicators including

student achievement. Work by Biggs and Tan (2007) looked at linking students' characteristics to the teaching context (Presage) with learning activities (Process) with the eventual outcome students' learning (Product), as seen in Figure 2.1.

Serife (2008) discussed that identifying the students' learning style can lead to an improvement in students' deeper learning. The enhancement of the bridge between the learning environment and the identified learning/cognitive style can help. Therefore, matching their learning style to their E-learning and VLE needs could further enhance the teaching content element of the 'Presage' stage and support the student in the 'Process' stage to potentially improve students' learning in the 'Product' stage (Serife, 2008). The use of learning styles in this research is hoped to further investigate these links, as providing a VLE for students is only important if it is effective for the population of students in the provision that it is intended for.

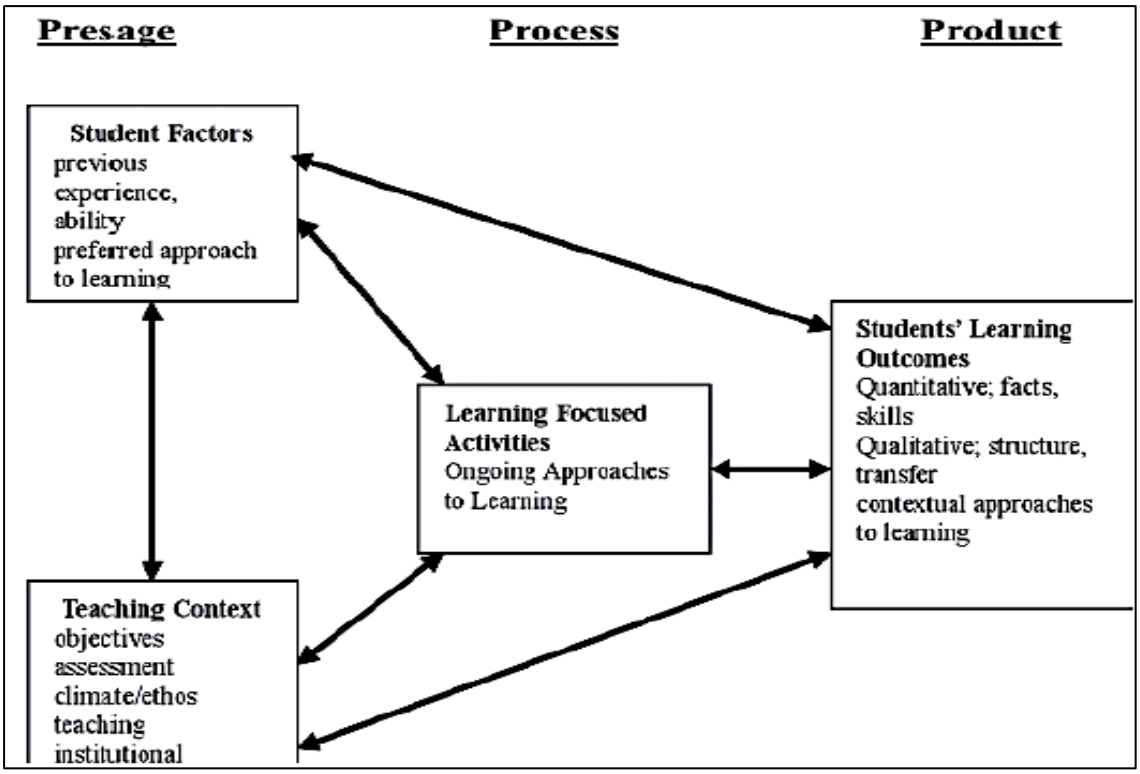

Figure 2.1 model of students' learning (adapted from Biggs & Tan, 2007)

Personalisation of the student experience to increase its effectiveness should lead to overall programme achievement, not just in a single module. But inclusion of social and services spheres must be embedded, as noted in work completed by Thomas (2012), and it is important to consider when reviewing what a student achieves from an HEI as a whole. The effect of a personalised environment will be negated if the learner cannot access the

technology in the first instance. The access to information presented through technology is vital, where access is the students' ability to find the content for their course using technology and in a timely manner (Kinchin, 2012; Ozkan & Koseler, 2009; Strijbos, 2011). The access to technology and therefore the required content is consistently changing as modern HEIs try to keep up with expectations of technology from experiences at lower levels of education.

The lack of consistency in provision and resources will affect student access and subsequently the impact on academic performance (Chen et al., 2014; Chen, 2010; Lo et al., 2012; Yuen & Ma, 2008). The environment could be deemed suitable for the students' personal learning style but, if they do not possess the skills to access this environment, then the impact is negative rather than positive. Monitoring of students' performance in technology interactions, both in and out of the classroom, to support their learning and create a positive experience is an important element of a dynamic pedagogical environment and facet of modern HE, as noted by Bryson and Hand (2007), González (2010), Hu and McCormick (2012), Thomas (2012) and Trowler (2010). If students are more engaged in the classroom and therefore seek further support online, outside of the classroom, this can lead to increased achievement, as noted by Halbert et al. (2011). Therefore, providing a personalised approach is complementary to the classroom content, and both should work to maximise this effect.

2.2.5 Personalised technology-enhanced learning

A dynamic system for a TEL environment could tailor the content to suit learners' needs and technology usage. Not all technology interventions will have the desired outcome. Pemberton et al. (2006) looked at the use of technology in the classroom to enhance learning in a module. The research focused on the use of simple technology, in the form of a basic VLE, which helped students to interact with the theory presented in the sessions. The outcomes suggested that, although the engagement of the students' increased, the results of the modules were not affected by the use of technology. The research noted limitations, including the isolation of subjects and the randomisation of technology use within a student group or cohort studying the module, suggesting that the technology use was not consistent, which may have affected the impact on the module results. Work by

Ginns and Fraser (2010), Hannan (2005) and Jennings and Kachel (2010) looked at enhancing the learning in sessions in a similar fashion to Pemberton et al. (2006), however they found a positive effect on the overall grade profile of module. One of the big differences in Ginns and Fraser's (2010) work was that they personalised the material given to the students in a format that was familiar to them. The format did not reduce the quality of the resource but matched it to the individual learner's needs, so for example a video might be used rather than a paragraph of text (Doyle & Jacobs, 2013; Land, 2000).

Personalisation of E-learning has been studied by Krämer and Bente (2010) and Graf et al. (2010), who suggest that using a personalised approach can help students' motivation and enjoyment. This personalisation of technology in learning raises the question of how to achieve this within the technological and staff constraints. Krämer and Bente (2010) investigated using non-verbal communication monitoring of students to influence the changes to their learning. A less automated selection is suggested by Karger et al. (2008), who developed a series of questions that changed the way in which the technology and systems that were used interacted with them, in response to their answers. Whether either approach could be taken in traditional delivery rather than a distance education mode is questionable, but the results do suggest that learner motivation and engagement are affected by a similar personalised approach. The needs of personalisation would be met by the use of learning analytics, so the resources attempt to match the learners' observed approach to technology use (Abbitt, 2011; Chen et al., 2013; Hannan, 2005). The development of this theme using a simpler analysis of the learners' needs and how they like to learn, to adapt the technology to a traditional delivery mode, would be a useful direction for research.

The links between the individual learner's needs and technology-enhanced education is a factor in the impact of a VLE, which again is a factor not explored in previous work. A simple and uniform way of analysing learners' needs is through assessing a learning style. One such measure is the index of learning styles (ILS) devised by Felder and Soloman (1997), based on earlier work, the Felder and Silverman's learning style model (FSLSM) developed in 1988. Although decades old, the ILS still has relevance for modern learners, and Felder and Spurlin (2005) noted that the ILS was a valid measure of learning styles in 2005. Again in 2011, Klašnja-Milićević et al. (2011) used it in their research for its validity. There are

multiple methods of measuring the learning style of students, and Honey and Mumford's learning styles questionnaire (LSQ, 2000), based on Kolb's learning styles model (Kolb, 1984), is a popular choice. The LSQ is an alternative to the ILS but not as conducive to linkage with E-learning environments (Klašnja-Milićević et al., 2011). Additionally, the LSQ in a study by Kappe et al. (2009) showed no predicative validity for established learning criteria, and has little correlation to Kolb's learning style model that it is based on, as noted by Sims et al. (1989). Felder and Solomon's model is more suited to the emerging E-learning environment, as the dimensions within the model can easily be aligned to the environmental components, as noted by Graf et al. (2007).

Klašnja-Milićević et al. (2011) noted that the measurement of learning styles could be used to develop and customise an E-learning environment to offer a personalised learning experience to students. The VLE could be personalised to suit their learning style, which would offer materials for the subject in a style to which a learner is receptive. If the learner had a preference for sequential material, for example, the information on their VLE would follow a logical order, whereas for learners who preferred a global approach and liked to see the whole picture at the start to contextualise it, the material would be in diagrammatic form (Doyle & Jacobs, 2013; Geçer & Dağ, 2012; Klašnja-Milićević et al., 2011; Zajac, 2009; Mestre, 2006).

The use of the ILS could give an insight into the suitability of the E-learning environment for students. The ILS identifies the style of learner by a 44-question multiple-choice questionnaire, formulating a score for the following conflicting categories: active vs. reflective; sensory vs. intuitive; visual vs. verbal; and sequential vs. global. Each category has 11 questions and is rated on a scale of -11 to 11, each answer scoring either +1 or -1. These link to what are called learning domains (Felder & Soloman, 1997), information processing, information perception, information reception and information understanding, which form the learning style model devised by Felder and Silverman in 1988.

ILS is not a universally accepted model for learning styles in the TEL environment. Work by Yilmaz-Soylu and Akkoyunlu (2009), Gurpinar et al. (2010), Kappe et al. (2009) and Kolb and Kolb (2005) questions the application of ILS scores and resulting learning dimensions to TEL environments. With the questions in their basic form, Yilmaz-Soylu and Akkoyunlu (2002),

Kappe et al. (2009) and Santo (2006) ask whether focusing on learning styles has an effect on the achievement of students in today's modern learning environments and whether they stay on the same learning dimension throughout a course. Yilmaz-Soylu and Akkoyunlu (2009) state that the timing and the placement of learning style-focused material are more important to the achievement of the students than the type of material. The use of the students' personal preferences and level of knowledge, in conjunction with their learning style, is also important when personalising a pedagogical environment (Klašnja-Milićević et al., 2011).

Work by Graf et al. (2007) expands on the dimensions used in the ILS to provide more detail on the creation of technology-enhanced resources. The ILS questions were ranked in terms of their importance to each dimension of the model. For active reflective learners, it is stated that the question about whether you prefer to try things out is more important than whether you prefer to study in a group or individually (Graf et al., 2007). Alternatively, for sensing/intuitive learners, concrete theory is more important than applied information (Graf et al., 2007). The work by Graf to add more depth to the ILS enables it to be used for the integration of technology into a modern teaching environment, which is supported by many published researchers (Klašnja-Milićević et al., 2011; Kolb & Kolb, 2005; Mupinga et al., 2006; Wu et al., 2010).

Matching students' learning style to their E-learning and VLE needs could then further improve the technology-enhanced teaching content, leading to the students seeing greater value in the classroom sessions, which, as noted, is critical to seeing an enhancement of their learning. The support that such systems could lend students in the classroom initially, and then outside of formal sessions through the VLE, could lead to a more authentic learning environment, with students actively engaged and taking responsibility for their learning (Bishop & Foster, 2011; Chen, 2010; Krämer & Bente, 2010; Zajac, 2009; Mupinga et al., 2006). Paulsen noted in 1995 that student engagement in the interactions and responsibility for the process are vital to success in any pedagogical environment. Trowler (2010) sees student engagement to be a relationship between the time, effort and other university resources invested by both students and the institution to improve students' performance and learning experience (as discussed in section 2.2.6). A tailoring of the

systems associated with this engagement by means of their learning style seems a logical direction for research.

The support offered to the student needs to be personalised to have a positive effect on the students' understanding of the subject for a variety of reasons, as discussed previously (Beldagli & Adiguzel, 2010; Buzzetto-More, 2007; Charles et al., 2009; Jennings & Kachel, 2010; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009; McKim et al., 2013). If the student seeks additional material to help in their learning and this is ineffective, it could have a damaging effect on the level of learning achieved in both the subject and programme (Kinchin, 2012; Krämer & Bente, 2010; Moore, 2007; Sahin et al., 2013). If the material is generic in nature and does not match the needs of the student, rather than help them it will bolster their conception that the subject is difficult. The matching of material to the needs of the student should increase the likelihood that their resulting subject knowledge is increased and achievement improved (Bakas & Mikropoulos, 2003; Jennings & Kachel, 2010; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Liu, 2007; Zajac, 2009; Santo, 2006).

Enjoyment of a subject can also be increased when learning is accessible, which can lead to both increased passion for the subject and engagement (Coates & Dickinson, 2012; Huang et al., 2012; Krämer & Bente, 2010). The level of learning that the student gains from a subject could be greater if this environment can be created, which ultimately leads to greater achievement overall in the degree programme and potential lifelong learning.

2.2.6 The impact of academic staff on implementation

Another group critical to the use and implementation of technology and the engagement of the students is the academic staff. The staff have needed to adapt their own teaching methods to some degree to operate the programme modules they are teaching, using the required level of E-learning. Even if the adaptation is only to the extent of using online assessment submission and marking, they have adapted to meet these changing demands. The way in which the delivery has altered can also be matched, to a degree, to the ability or willingness of the staff to engage with new ideas and methods.

In research by Espositio (2013), academics were interviewed about scholarship activities in the digital environment, and it was found that once an understanding of the terminologies involved had been established many felt comfortable to use the new methods. Until then, the need for change or adoption was not seen and the methods were negatively perceived (Espositio, 2013). The findings contrasted with research by Beetham (2012), who reported that the use of digital technologies in HE was seen only as a positive development, and the only drawback the potential reduction of face-to-face teaching and learning activities. One of Espotitio's (2013) findings was a consensus that clear guidance was required from the institution on the terms and usage of digital technology to fully achieve an understanding of the digital terms and therefore increase engagement by academics. Although Espositio's research (2013) had a small sample group and the views were from a single institution, it does offer a useful insight in terms of how new technologies can be implemented to engage staff and create a positive learning environment. Beetham (2012) and Espositio (2013) both noted the need for training and guidance from the HEI to increase staff engagement and resulting usage of the new technologies.

Learning in the workplace informally can motivate staff and therefore further engage them, and be the most important process for staff development and implementation of new methods, as noted by Eraut (2004). Beetham (2012) also found that informal adoption of new technologies was the key to staff engagement and motivation to change teaching and learning practices. The need to allow this informal learning to occur with guidance is critical to ensure that any staff concerns around digital adoption are allayed so the student learning environment, engagement and subject culture are not negatively affected (Beetham, 2012; Eraut, 2004). The need to engage the staff is paramount to the success of a programme-wide implementation of E-learning (Beetham, 2012).

Unpublished conference proceedings from a study entitled 'The digital literacy project' (Barter et al., 2015; Zoubir et al., 2015) supports the findings of Espositio (2013) and Beetham (2012). The understanding of the terminology involved in the use of technology in HE teaching and learning is often the biggest barrier, for staff. The research found that staff used many E-learning tools without knowing that they were such or could be used further in their teaching. Once the barriers were overcome, there was a willingness among staff to engage with the process and use the new technologies. The overall acceptance of

technology use in HE teaching was found in unpublished research (Barter et al., 2015; Zoubir et al., 2015) to be varied, many seeing it as a time saver rather than a change to their pedagogical approach. Education and training are paramount, with the use of an evidenced-based model for the implementation to further engage staff with the merits of technology use and E-learning tools in a modern HE programme curriculum.

Digital literacy is a modern term used to encompass all educational technologies used in modern learning environments, and Sharpe and Beetham's 2013 model is now the established common ground. It can help with the explanation and clarity of terminologies to aid in adoption. The digital literacies literature also explores the digital impact on traditional literacy constructs, which are important for using modern tools academically in HE, as noted by Gourlay, Hamilton and Lea (2013). The need for clarification and guidance in programme implementation and staff engagement is clear and often requires a realignment with established traditional norms, suggests Hinrichsen and Coombs (2013). One of the outcomes from this research is such guidance in the form of a model to aid programme enhancement through technology implementation.

2.2.7 Effect of technology on key performance indicators

As highlighted, the introduction of technology-supported education is contentious, as it can be seen as a mechanism to reduce contact time. Clegg et al. (2003) argue contention that technology use is part of the globalisation of HE and is not generally used with any pedagogical reasoning. Its use, it is suggested, is to support the management agenda rather than enhance the pedagogical environment. A lack of a holistic model for technology implementation can add to this debate about the merits of its use. A holistic approach should value all elements (including student and staff experience; student performance; technology use; engagement; and personalisation) equally to enhance the adoption by all involved, and therefore the success of the technology implementation. Kinchin (2012) explores this further, stating that there is widespread staff dissatisfaction in HE due to the mixed reasons for and methods of technology adoption. The negative effect on the student learning environment through staff barriers to adoption not being resolved can result in a "non-learning" environment being created. Whilst this is at the extreme end of the adoption of TEL, it does highlight the need for a clear overall strategy and pedagogical basis

for its use in teaching and learning prior to implementation, as suggested by Davies et al. (2017).

The need to be strategic in the implementation of technology in teaching and learning is supported by a plethora of researchers (Beetham & Sharpe, 2013; Chen et al., 2013; Davies et al., 2017; Delamarter, 2006; Granić et al., 2009; Murray & Pérez, 2014), who suggest that an understanding of the current academic practices, level of staff expertise, the level of technological support, agreement on what is TEL and the student engagement in technology is critical. Understanding the skill set of the institution staff and therefore the required level of support is crucial, as is an understanding of how technology could be used. Likewise, the engagement from students can be linked to enjoyment, ease of use and importantly the value of the technology to their learning, as suggested by Ozkan and Koseler (2009) and Karamanos and Gibbs (2012). If these issues are not tackled, technology use could be ineffective, at best, and at worst create a non-learning environment due to the resources provided being ineffective and not coherent.

Taking these thoughts further, the TPACK framework suggested by Mishra and Koehler (2006) identifies three core components in the development of technology-enhanced teaching and learning. The framework could help to overcome any barriers and ineffective technology use. The three core areas of knowledge in the TPACK model are pedagogical, technological and content (Mishra & Koehler, 2006). The focus on these three core areas equally is, however, contested. Chen et al. (2013), Mestre (2006) and Yuen and Ma (2008) agree that these three areas are important yet that the success of TEL is not solely dependent on them, as the impact of accessibility to technology and the tutor-student relationship in the learning environment are other area that have an impact. The three core components (pedagogical, technological and content) are stated as being equal in the TPACK model, however Clegg et al. (2003) suggest that the development of technology-enhanced teaching and learning should ensure that it does not lose sight of the most important relationship, that of the teacher and the student, rather it is enacted in a different more holistic way, encapsulating all involved to maximise adoption and success (Clegg et al., 2003). The approach taken with technology must benefit all parties to truly enhance the HE teaching and learning environment. The implementation of technology

needs to be implemented at a curriculum level, with sound pedagogic reasoning, for the desired impact to be achieved (Beetham & Sharpe, 2013; Davies et al., 2017).

2.3 Models of technological implementation in learning and teaching

With the importance of implementing technology into teaching and learning in the most effective manner to achieve the aims of all involved, as discussed in section 2.2, models have been developed to offer guidance. The pedagogical content knowledge (PCK) model developed by Shulman (1986) is the one that the TPACK, discussed below, is based upon. Many argue that this is an unsure basis on which to design a model (Angeli & Valanides, 2009; Chai et al., 2013; Cox & Graham, 2009; Graham, 2011; Guerrero, 2010; Koh et al., 2014; Rosenberg & Koehler, 2015). The debate centres on the broad definitions used in PCK, which are difficult to define theoretically. The difficulties of the definitions can lead to multiple interpretations (Graham, 2011; Lee et al., 2007). The inability to define the theory and the multiple interpretations of the PCK definitions have made the measurement of the model difficult, as noted by Baxter and Lederman (1999) and Kagan (1990). The design of the TPACK model adds complexity to the PCK framework and therefore researchers argue that PCK needs to be fully understood before completely measuring the effectiveness of TPACK (Gess-Newsome, 2002, 1999; Magnusson et al., 1999).

The Universal Design for Learning (UDL) model, developed by Hitchcock et al. (2002, 2002b), suggests a set of principles to ensure that the integration of technology into teaching and learning enables learning to be achieved and does not erect barriers. These principles are to provide multiple means of representation, action and expression and engagement (Moore, 2007; Ralabate, 2011; Rose & Meyer, 2002). The debate and potential confusion with other models highlights that there is no single model for all circumstances, and educators and teachers need to integrate technology to the benefit of the subject matter and not the other way around (Benton-Borghi, 2013; Chai et al., 2013; Koehler et al., 2013; Krämer & Bente, 2010; Tai et al., 2015; Voogt et al., 2013; Yeh et al., 2014).

The TPACK model encompasses the knowledge that teachers use to improve the quality of their teaching to help students' learning (Mishra & Koehler, 2006). The model is based on constructivism theory, whereby users formulate ways to cope with ICT integration in learning and develop knowledge through their own perception of their resultant

experiences. Hannafin and Land (1997), Koh et al. (2014), Land and Hannafin (1997) and Mikropoulos and Natsis (2011) suggest that this is the case for five reasons. First, using ICT in learning is active; secondly, as students reflect on their work to gain an understanding of their actions it is constructive; thirdly, the student has to complete real-world problems and tasks, which make it authentic; fourthly, students set their own learning goals so their personal learning is intentional; and finally, through some of the tasks the students had to complete, they work collaboratively and therefore the task is a social process (Koh, Chai & Tsai, 2013).

2.3.1 Technological Pedagogical Content Knowledge model

The TPACK model is the most widely researched and used for technology integration, so the next sections give more detail and critique on this model. TPACK is based on four central components (see Table 2.2), which are incorporating technology in teaching, knowledge of students' understanding of subject area, knowledge of technology-enhanced curricula and knowledge of teaching methods using technology (Niess, 2013).

Table 2.2 TPACK's four central components (adapted from Niess, 2013)

TPACK components
1) The level of knowledge that teachers have and believe in, the how students learn their subject area and how this can be supported with technology.
2) Students' understanding of the subject area that they are studying, what they need to learn to be successful in the subject and how technology can be used to enhance this.
3) To enable the effective integration of technology in teaching, knowledge of curriculum is required to produce a structured and organised approach.
4) Knowledge of pedagogical approaches to help students to achieve in the subject area is required for these to be potentially enhanced by technology use.

The resulting TPACK model is derived from the overlap of content knowledge, pedagogical knowledge and technological knowledge, referred to as TPACK. The use of this intersection is encouraged in modern teaching to employ available resources appropriately and raise the quality of sessions (Yeh et al., 2014). The model has been developed further through work by Mishra and Koehler (2006) and Thompson and Mishra (2007) to form several subsets/ constructs:

TK – Knowledge of technology

CK – Knowledge of the subject being taught

PK – Knowledge of methods of teaching (pedagogy)

PCK – Knowledge of teaching based on taught content

TCK – Knowledge of using technology to present content

TPK – Knowledge of methods to use technology in teaching

TPACK – synthesis of teaching elements, content, pedagogy and technology required to integrate technology into teaching.

The TPACK model aims to be multifaceted and complex (Mishra & Koehler, 2006), so a definition for the constructs has a measure of openness, yet some precision over the constructs of a model is fundamental to a coherent theory (Angeli & Valanides, 2009). If the definitions are too open to interpretation then volumes of findings could be collected by research into the theory without meaning, due to the absence of agreement on the nature of the constructs (Burkhardt & Schoenfeld, 2003). Koh et al (2014) investigated the links between the age/experience, technological knowledge and pedagogical knowledge of the educator to the constructivist-oriented model. They further looked at the influences of the constructs of the model above and, in particular, how these impact on the teacher as the profession becomes more ICT oriented. Benton-Borghi (2013) continued to look at the influence of the TPACK model and question its complete acceptance by today's education system. The article views the 'one model fits all' approach as inappropriate, ultimately leading to populations of learners being side lined (Benton-Borghi, 2013).

2.3.2 TPACK design

The components of the TPACK model listed above are open to debate and interpretation, for example a piece of technology might be used for a specific construct, such as PowerPoint for the TCK (how to use technology to present content) but, equally, could be used in TPK (knowledge of methods to use technology in teaching). Chai et al. (2013) and Mishra and Koehler (2006) state that the TPACK model was multifaceted, complex and situated, upon launching it into the education research community. The model attempts to be parsimonious in its design, as it is simply the interaction of three major educational research knowledge domains (pedagogical, content and technological). However, to be a 'catch all' model, it also needs to be comprehensive and this causes discord over its foundation on PCK, as previously discussed, and the lack of specificity in the model constructs (Graham, 2011). In Cox and Graham's investigation into the model's construct definitions (2009), the findings are that there were 89 distinctly different definitions of TPACK in the research that they sampled. One of the major differences is the addition of technology knowledge to the PCK framework, and this is fundamental to its coherency. The definition used by Mishra and Koehler (2006) should be concise to enable testing of TPACK in relation to PCK and its validity as a model, however it is broad and represents the root cause of several debates surrounding the model, as noted by Angeli and Valanides (2013), Chai et al. (2013), Cox and Graham (2009) and Whetten (1989).

Some people's notion of technology for teaching and learning should lead to a definition based on its perception as modern, digital computer-assisted technology. Alternatively, the perception in the current definition allows for inclusion of simple chalkboards or flipcharts, or any tool used for teaching (Koehler & Mishra, 2008; Mishra & Koehler, 2006). This has led to some (Angeli & Valanides, 2009; Doering et al., 2009a, 2009b; Doering & Veletsianos, 2008; Lee et al., 2010) to redefine the technology aspect of their own research. However, Cox (2008) takes perhaps the most appropriate approach, simply defining technology as either transparent (pen/pencil, flipchart) or emerging (digital technologies), and the transparent is restricted to PCK. Emerging technologies are, then, those being introduced into the learning environment and forming part of the TK, TPK, TCK, which are added to PCK to form TPACK.

This simple change, proposed by Cox and Graham (2009), is ideal as it allows the constructs to use and be used without the need for a major addition to the overall TPACK model. Another issue relating to the model is whether it is integrative or transformative in nature, whether it is the intersection of a combination of the three major dimension or whether it is a synthesis of new knowledge (Angeli & Valanides, 2009; Gess-Newsome, 1999). Many researchers (Doering et al., 2009b; Doering & Veletsianos, 2008; Guzey & Roehrig, 2009) have taken the view that TPACK is another name for the integration of technology and taken an integrative approach to the knowledge dimension. Angeli and Valanides (2009) agree with this approach, but suggest that the underlying boundary issues with constructs needed to be resolved to define whether TPACK is integrative or transformative. For the purpose of this research, the integrative approach will be taken in agreement with work by Doering et al. (2009a, 2009b), Graham (2011), Guzey and Roehrig (2009) and Koehler et al. (2007).

2.3.3 TPACK validity

The body of TPACK research to validate its approach has increased at a relativity fast pace since 2009, with 20 papers published compared to only four between 2002 and 2009 (Wu, 2013). The majority of research was found by Wu (2013) to be non-domain specific (66.7%), with the two most popular subjects being maths and science. The methods used to review the model have changed since before 2007, when the focus was a quantitative approach, and now qualitative and mixed methods are beginning to be used to assess the model (Wu, 2013). Critique of the model is centred on not only the integration of the individual component knowledge basis but the actual definition of the categories. The definitions of these categories and their application to technology in education is questioned by Angeli and Valanides (2009, 2013), Graham (2011), Whetten (1989) and Yeh et al. (2014). These authors argue that, due to these validity issues, the model is merely a collection of knowledge sets that could be replaced with hybrid domains (Yeh et al., 2014). However, if you look at the model as a whole rather than the separate constructs, then you can view TPACK in two ways, transformative and practically. The question of who is the model for is often debated, and from a transformative approach this debate is partially answered by suggesting that the model is there to help teachers to customise subject-specific curricula to both learners and the context, through the use of technology (Yeh et al., 2014). The

practical side of TPACK helps with this question by taking into account the experience of the teacher and valuing this as a knowledge base for the model. The base, rather than remaining static, will adapt and grow as both new and experienced teachers gain knowledge to help the implementation of technology in learning (Yeh et al., 2014).

Having covered the implementation models and explored the TPACK model in greater depth, it is important to review some of the key issues surrounding the implementation of a model, including subject-based approaches, the experience of teaching staff and the systems in place at the educational institution.

2.3.4 Subject-based approaches

The use of such models as TPACK, UDL and PCK can vary between subject disciplines due to the specific traditional approaches taken in the field. A science-based discipline and traditional STEM subjects could find the integration of technology into their teaching and learning approach easier, due to the finite answers to questions and the established theories. A particular computer-based technology use, it could be argued, is more suited to science-based subjects as systems generally operate in a 'right or wrong' paradigm where there is no middle ground. This approach to support materials and assignments is suited to technology enhancement due to the limited outcomes available in current technologies. The work by Niess et al. (2009) concludes that TPACK could be used in STEM-type subjects for the enhancement of assessment and the effectiveness of support material. Guerrero (2010) supports this viewpoint and has researched the use of technology in mathematics in particular, highlighting the impact that the potential effectiveness of this approach to technology implementation could have on the delivery and support of mathematical content.

Limited research has been conducted on the enhancement of teaching and learning practice in non-STEM subject areas, as noted by Niess et al. (2009). Subject areas such as the humanities and social sciences encourage debate and engagement with the meaning behind decisions in a rational manner. The notion of using technology to enhance the development of these skills is still not established, partly due to the technological limitations.

Hammond and Manfra (2009) conducted a literature review (n=121) on the use of technology in social science teaching and found that practitioners established how they wanted content to be delivered, then reviewed the use of technology to enhance the process. The nature of the content, it was felt, did not always allow or need the integration of technology for its enhancement. The systems in use in today's HE in some cases simply cannot test, support or display the skills required for investigations into the meaning of events to any degree of effectiveness, at present. The very nature of this work is that there are many possible reasons, formed from a myriad of sources, and this produces far too many combination systems in use in HE (Hannan, 2005; Petit dit Dariel et al., 2013). Juniu (2011) states that technology should be integrated on the basis of the value that it can add to a teaching and learning approach; attempts to fit subject teaching and learning approaches to the latest technologies should be avoided.

Voogt et al. (2013) investigated the literature on the integration of technology into subject domains and found that there had been very little research in this area; a total of seven papers had been published on this topic and the overall use of TPACK. The view and beliefs of practitioners are an area that has been much researched with regard to TPACK, and over 60% of the articles reviewed in Voogt et al.'s study (2013) are this area. The level of research into this facet indicates first the need for acceptance, not just access to technology, to enhance teaching and learning and, secondly, increased usage of TPACK as a model. Practitioners still have core educational values, and the choices that they make in their professional approach are in keeping, to the benefit of HE (Juniu, 2011; Voogt et al., 2013). The content that practitioners provide is critical to the success of the technology implementation as, without it, the pedagogy of the teaching cannot be enhanced (Archambault & Barnett, 2010; Chai et al., 2013; Graham, 2011; Juniu, 2011; Voogt et al., 2013).

2.3.5 Experience of teachers

Work by Lee et al. (2007, 2010), Nilsson (2009), Perry (2013) and Shulman (1986) discusses the experience of the teacher or educator as a factor in the adoption of new approaches to teaching and learning. These authors' suggest that inexperienced staff at the beginning of their careers often seek knowledge that has a practical impact, so they can immediately

enhance their own practice. Nilsson uses Shulman's pedagogical reasoning framework as a basis to understand the decisions made by such staff on the introduction of new approaches. The lecturer needs to first understand their own subject matter and the interconnections within the area before experimenting with the delivery mechanics (Nilsson, 2009).

This approach is similar to the usage of technology for the delivery of subject knowledge, as noted by Koh et al. (2014). Knowledge of all the common elements of the models, including subject content, pedagogy and technology, needs to be enhanced to enable lessons to be efficiently designed when incorporating technology in the delivery of subject material (Chai et al., 2013; Koh et al., 2014). Although the level of experience of the educator is a factor in this process, it is not solely an issue for technologically inexperienced staff, as noted by Perry (2013). Of paramount need is the continuation of learning about the incorporation of technology to enhance their own practice to create environments for students to learn, irrespective of the lecturer's personal level of experience (Perry, 2013; Perry & Pilati, 2011). TPACK uses these themes as part of one of its core components in a more integrated fashion than other models. The personal development of staff is essential to the development of a holistic programme approach to TEL. If a programme team has staff who are 'laggards', they can become the weakest link in the enhancement of the student environment and lead to some of the issues noted in sections 2.2.1 and 2.2.6.

2.3.6 Integration of technology in educational systems

Sahin et al. (2013) suggest that there is a significant relationship between the knowledge components of the TPACK model, including technology, pedagogy content and intersections. This may also be seen, to a degree, in the models of technology implementation discussed above. Sahin et al. (2013) found a significant relationship between these components and a teacher's self-efficacy in technology usage in education. From this one might conclude that if teaching using technology is to be successful the practitioners must have an understanding of the three elements of subject content, pedagogy and technology. Their level of understanding will affect their personal self-efficacy and therefore their confidence to use it in their teaching efficiently. The importance of this relationship in these areas is critical to the success of TEL in HE.

Technology should be used only with a sound pedagogy, to enhance a specific subject's teaching session (Sahin et al., 2013). The TPACK model is seen by Tai et al. (2015) to be a comprehensive approach to enhancing educational programmes with technology, if these areas are taken into account. The conclusions from sections 2.3.2 to 2.3.4 indicate that the TPACK model incorporates a wider set of components and values. The high volume of research on the model suggests a greater degree of acceptance in the field, therefore it seems appropriate to discuss this model in more detail to identify areas on which the proposed model might build.

2.3.7 Implementation model conclusions

TPACK has its faults, as stated above, but its fundamental aims on guidance for the integration of technology are apparent. The use of technology, in addition to technological knowledge, should not be without pedagogical and subject-based knowledge. With all three knowledge dimensions being considered, the learning environment that is created could be supportive, productive and personalised, allowing the student to achieve well in the given subject (Graham, 2011). The notion of personalisation is a potential addition to the model, in the creation of a proposed new model. The inclusion and consideration of a more practical approach to technology implementation is also an area for development. Both of these areas are within the scope of this research and should be considered when developing the final model.

2.4 Research area methodologies

The standard approaches reported to TeI and E-learning and research on technology implementation, to date, are focused on distance learning or blended learning. MacKeogh and Fox (2009) looked at embedding E-learning into courses to promote higher learning, but from the approach of reducing staff's workload rather than an individual student-centred approach. Paulsen (1995) looked at applying pedagogical techniques to computer-based courses so, in effect, was taking the reverse approach. The results from MacKeogh and Fox's (2009) research showed that in blended learning drop out from courses was reduced, and in Paulsen's work the effects were unclear but the impression was that the quality of teaching on the programmes improved. Herrington (2009) reported that the use

of E-learning can create innovative and authentic learning, but the exact impact needed further research (Granić et al., 2009; Hedberg, 2006; Karamizadeh et al., 2012; Lu & Vela, 2015; Mehanna, 2004; Ozkan & Koseler, 2009; Petit dit Dariel et al., 2013). The current research aims to provide evidence of the impact of the implementation of technology and E-learning tools into a taught HE curriculum. The current research will then aim to develop this further to investigate the use of these tools to provide personalised resources to support students in module teaching whilst examining the holistic effect on the main stakeholders, involving the student body. The existing body of research has flaws, as discussed above. The current research will seek to extend the research agenda to include taught provision in the knowledge base.

The holistic effect on the students is as important as technology, and E-learning tools are used not just for assessments in the students' journey; they form an integral part of their whole experience at university and their engagement with their chosen programme of study. Students' receive online access to pre-induction material as soon as they confirm their university place and receive their school examination results. This first stage involves materials for pre-reading and important information that they need prior to the start of the course. This process also helps students to start to understand how their online learning environment works and how they can use it. Once they start, the integration of E-learning and technology into the course becomes more apparent, with individual module pages indicating session information, resources and tasks designed to support their learning.

The next stage in the journey is the submission of assessments online, and feedback is also given on this platform. The feedback process is important not only at a module assignment level but also at course level through the board of studies. The feedback and outcomes of other instances are published through the VLE. This enables the students to see that their views are being considered and acted upon, where appropriate. The final stage of the students' E-learning journey is the evaluation stage, where they can access their grades on the module and therefore their progression options, along with module and course feedback questionnaires, which are completed online.

Concurrently with the academic elements of the students' journey, there are social parts, supported throughout the above stages through social media platforms. From the outset, E-learning and technology have an impact on their learning environment at each level of their university journey. Whether this interaction can be further enhanced using technology to provide personalised support materials for module teaching is a development for this model that this research will explore. The exact impact on the whole student journey and on their own learning and resultant achievement on their degree programme needs to be further explored in an appropriate way. A range of methods needs be used to successfully explore and capture both the data-driven impact on a course and student KPIs and the students' views and feelings on the use of technology to enhance KPIs and their university experience.

2.5 Chapter conclusions

In summary, it is important to state my own position, which is that E-learning is a collection of tools that should form part of a modern students' learning environment and that offers support. Rather than replace or replicate, this support runs in parallel to face-to-face teaching, and could be personalised to enhance students' ability to achieve in their chosen subject. The work by Beetham and Sharpe (2013) on digital pedagogy highlights the need not to change our approaches to learning but to adapt to embrace the new technologies that are at our disposal as educators. The work by Fox and MacKeogh (2003) highlights some of the barriers to embedding E-learning into HE curriculum, but still identifies the potential to enhance traditional pedagogical approaches, not replace them. The need to embrace the digital environment is increasingly apparent when students at levels below HE are experiencing varied and innovative use of E-learning (Beetham & Sharpe, 2013; Davies et al., 2017; Davis & Roberts, 2013; Moore, 2007). The expectation of these students when they progress to HE is that this will continue, and if this does not it could lead to a negative perception of the HE teaching and learning environment.

The use of E-learning and technology needs to be correctly implemented so it enhances rather than diminishes the learning environment and tutors' involvement, as Catcheside (2012) reports that students still value and expect tutor contact. The technology, as noted by Klašnja-Milićević et al. (2011), exists to enhance an individual student's learning

environment in a personal fashion. A personalised environment, whether in part or whole, could then create an opportunity to further connect with the student and increase their engagement. Therefore, it is contended that E-learning and technology enhancement should be implemented in a way that enhances the learning environment and individual students' experience. The use of technology in teaching and learning in HE should provide each individual student with the opportunity to access a personalised approach to their learning to support their learning on the degree programme. It is hoped that the current study can provide evidence for the personalisation of learning technology to help to engage students and thus potentially increase course KPIs. The approach taken with these aspects on modern teaching and learning in HE should be modelled to offer a practical guide to the implementation and personalisation of technology, based on this study's evidence.

The literature in this chapter is largely supportive of the use of TEL to help to engage students in their learning, enhance the pedagogical experience and help universities to show value for money. However, there are gaps in the literature: how TEL should be implemented with practical guidance; the efficiency of using TEL in student learning; a coherent programme approach to TEL implementation; the use of TEL to help students to engage with their studies; and potentially to offer a personalised approach to TEL. The research aims to fill these gaps by adding to the knowledge on TEL in HE teaching. The findings will produce a model and guidance for TEL to be used at programme level for implementation in each module and demonstrate the potential impact on the student learning environment. The development of TEL pedagogy, through the development of an implementation model with guidance from the current research, will add to published research (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009).

Chapter 3 Methodology

Chapter 2 reviewed the current literature relevant to this study and identified that, whilst agreeing on the use of TEL and E-learning, it had some areas of limited research. The current study aims to add to the knowledge on the holistic effect of E-learning and TEL from a pedagogic, strategic and student perspective. The literature indicates that models for technology implementation in HE teaching and learning are theoretical in nature and do not completely consider the personalisation of student environment using technology, which is another area that this current study aims to add to.

Before undertaking the research and establishing the methodological approach leading to the data collection methods, it is important to establish the paradigm in which the studies will be operating. The current study is operating in the pragmatism paradigm, for the reasons discussed below. As stated by Guba (1990), the paradigm can be characterised through the ontology – what is its reality?, its epistemology – how is knowledge established? and its methodology – how do we discover knowledge?

The ontological approaches used in this research are discussed in section 3.1, which takes particular consideration of the positivist and interpretative paradigms, as described in the literature (Boote, 2008; Christ, 2014; Creswell, 2013a; Crotty, 1998). The epistemological positions of this current research, taking work by Creswell (2013a), Crotty (1998), Gialdino (2009) and Wallen and Frankel (2011) into account, are discussed in section 3.2. The overall research design and how this is affected by the epistemological and ontological approaches in the current research will be discussed in section 3.3. The establishment of how each dataset will inform and enrich each other to achieve the research aims will be discussed in section 3.3. The individual studies forming this research, which lead to the development of a model for the implementation of TEL, are discussed in section 3.4. The procedures and the instruments to gather the data and information for the current research will be discussed in section 3.5, and an outline of how the data will be analysed leading to the production of the implementation model in section 3.6. The ethical considerations for this research are considered in section 3.7, and the intended outcomes from the research and their impact are discussed in section 3.8.

3.1 Research ontology

Ontology is concerned with the nature of the reality in which we exist and therefore in which the research is conducted. As noted by Cresswell (2007), as in Table 3.1, this reality can be subjective, reflected by the multiple viewpoints observed in the research. Most research falls within a spectrum from positivism to interpretative, but pragmatism is also increasingly being adopted due to the use of mixed methods (Table 3.2).

Table 3.1 Philosophical assumptions, with implications for practice (adapted from Creswell, 2007)

Assumptions	Question	Characteristics	Implications for Practice (Examples)
ONTOLOGICAL	What is the nature of Reality?	Reality is subjective and multiple, as seen by participants in the study	Researcher uses quotes and themes in words of participants and provides evidence of different perspectives
EPISTEMO-lOGICAL	What is the relationship between the researcher and that being researched?	Researcher attempts to lessen distance between himself or herself and that being researched	Researcher collaborates, spends time in field with participants and becomes and "insider"
AXIOLOGICAL	What is the role of values?	Researcher acknowledges that research is value-laden and that biases are present	Researcher openly discusses values that shape the narrative and includes his or her own interpretation in conjunction with the interpretations of participants
RHETORICAL	What is the language of research?	Researcher writes in a literary, informal style using the personal voice and uses qualitative terms and limited definitions	Researcher uses an engaging style of narrative, may use first-person pronoun and employs the language of qualitative research
METHODO-lOGICAL	What is the process of research?	Researcher uses inductive logic, studies the topic within its context, and uses an emerging design	Researcher works with particulars (details) before generalisations, describes in detail the context of the study, and continually reviews questions form experiences in the field

In the positivism paradigm, the reality in which the research is carried out is a definite singular reality, where the research investigates the causes of certain measured outcomes

(Sparkes, 2009). This construct could apply to the current study, where the students are enrolled on a module, which is a learning journey, which is real and has a definite, singular start and endpoint. However, education could be argued not to have a singular starting or endpoint, as each student will take their own path through the journey, resulting in a different reality. The students' own reality would be constructed around their own personal past learning and learning experiences. The research questions for this current research will be measuring certain interventions and their effect on the students' outcomes, which is whether they gained the knowledge required to pass the modules and programme (Creswell, 2013a; Crotty, 1998; Punch, 2011).

The interpretive viewpoint is that there is no single reality but rather a reality constructed by individuals or groups involved in the research (Sparkes, 2009). Operating in this paradigm is an assumption that there is no single truth and that knowledge is created by individuals in groups involved in the research, which will create a new reality (Hickman & Alexander, 1998; Morgan, 2014; Ormerod, 2006). In relation to the current research, rather than the students being treated the same, as one group on a learning journey with a definite beginning and end, as in the positivist paradigm, the students' views whilst on this journey are considered in the interpretive paradigm. Adopting this alternative paradigm to positivism enables the students' subjective options of the reality to form a common viewpoint (see Table 3.1).

In the current research the students' views on the impact of the interventions imposed on the students' learning journey would be gathered if this research was completed in the interpretive paradigm. This approach would add depth to the understanding of the phenomenon observed and the knowledge that will be created. The current research is not only investigating the impact of E-learning tools and technology implementation in teaching and learning, but also the impact on the subjects, the students. Operating in the interpretive paradigm enables this impact on the students' learning and the teachers to be captured and used in creating the new knowledge and reality. Evaluating the work of Hickman and Alexander (1998), Morgan (2014) and Ormerod (2006) suggests this approach with the current research would allow the impact of the intervention on the participants to be considered and help to create a whole picture of the phenomenon.

The research involves the use of technology to enhance the student environment. The nature of technology would suggest that its use is more suited to the positivism paradigm as there is a fixed endpoint with a measured outcome and reality, as discussed earlier regarding the work by Sparkes (2009). Due to the consistently changing nature of technology, the reality could be renegotiated or interpreted in relation to its usefulness, in this instance to improving the learning environment (see Table 3.2, based on Crotty, 1998). A different paradigm of thought, pragmatism, allows for the constant renegotiation of the reality as the study evolves (Morgan, 2014). This is a useful approach to take with this current research as it allows for change and provide solutions for, in this context, the use of technology to improve students' learning in the form of an implementation model.

The way the current research is designed (see section 3.3) benefits from operating in the pragmatist paradigm. Each of the studies, as part of the overall research aim, informs the development of a model for the implementation of technology in teaching and learning. The views from each study inform the model development and some of the aspects of the following study in the research (Ormerod, 2006). The current research viewpoint can be developed and constantly renegotiated to consider the impact of technology and the students' views of its implementation. Operating in the pragmatic paradigm allows the use of mixed methods, which means the whole picture of the observations of the phenomenon can be captured, as previously discussed. Mixed methods allows the views of the students and researcher to co-create an agreement, which would not be relative but a good enough truth to find a solution. A model can be deducted from the agreed solutions and potential change can potentially be instigated. Therefore, a pragmatic approach is suitable for the current research to help to provide solutions or the impact of the use of technology in teaching and learning in HE (Morgan, 2014; Moxley, 2002a, 2002b; Ormerod, 2006; Peirce, 1905, 1998).

Table 3.2 Research paradigms (adapted from Crotty, 1998)

Assumptions	Ontology	Epistemology	Theoretical Perspective	Methodology	Method
Positivism	There is a single reality or truth (more realist)	Reality can be measured and hence the focus is on reliable and valid tools to obtain that	Positivism Post-positivism	Experimental research survey research	Usually quantitative, including: Sampling Measurement and scaling Statistical analysis Questionnaire Focus group Interview
Constructivist/ Interpretive	There is no single reality or truth. Reality is created by individuals in groups (less realist)	Therefore, reality needs to be interpreted. It is used to discover the underlying meaning of events and activities	Interpretivism (reality need to be interpreted): Phenomenology Symbolic interactionism Hermeneutics Critical inquiry Feminism	Ethnography Grounded Theory Phenomenological research Heuristic inquiry Action research Discourse Analysis Feminist Standpoint Research, etc.	Usually qualitative, could include: Qualitative interview, Observation Participant, Non-participant Case study, Life history Narrative, Theme identification, etc.
Pragmatism	Reality is constantly renegotiated, debated, interpreted in light of its usefulness in new unpredictable situations	The best method is one that solves problems. Finding out is the means, change is the underlying aim	Deweyan pragmatism research through design	Mixed methods Designed-based research Action research	Combination of any of the above and more, such as data mining expert review, usability testing, physical prototype
Subjectivism	Reality is what we perceive to be real	All knowledge is purely a matter of perspective	Postmodernism Structuralism Post-structuralism	Discourse theory Archaeology, Genealogy Deconstruction etc.	Autoethnography Semiotics, Literary analysis Pastiche, Intertextuality, etc.
Critical	Realities are socially constructed entities that are under constant internal influence	Reality and knowledge is both socially constructed and influenced by power relations from within society	Marxism Queer theory Feminism	Critical discourse analysis, critical ethnography action research ideology, critique	Ideological review, Civil actions, Open-ended interviews, focus groups, open-ended questionnaires, open-ended observations, and journals

The current research design allows for the creation of an environment where knowledge can be formed and solutions to problems generally found. The use of a mixed methodology allows for the creation of this environment and provides the constructs for the subject's views to add a depth of understanding to the quantitative data analysis from the studies to create generally agreed outcomes. The multiple sources of data from the mixed methods approach also allow for triangulation to validate the agreed outcomes (Fesmire, 2003; Hickman & Alexander, 1998; Howe, 2012; Johnson et al., 2007; Morgan, 2014; Sleeper, 2001). The epistemological position of the research and the resulting selected appropriate methods for the current research study design, to enable the aims of the research to be achieved, will now be discussed.

3.2 Research epistemology

The epistemological position of the research is one that identifies the most appropriate methods for establishing a reality and leads to discovering a solution to the research problem. The positivism paradigm states that the reality can be measured, resulting in research tools that are reliable and valid and normally quantitative in nature. The interpretive paradigm states that there is no single reality, rather one that is created by groups. The research tools being used to interpret this reality in this paradigm are qualitative in nature to discover the underlying reasons for the phenomena. Operating in the pragmatist paradigm allows an epistemological approach, which can be tailored to use the best research tools available to find solve a problem. The data in this paradigm is only viewed to complete the overarching aim of change, and the use of the research tool helps in discovering a solution for the problem to instigate this change. The pragmatist position allows the use of both qualitative and quantitative research tools if they are the best way to find a solution that meets the aims of the current research.

The methods used in positivism paradigm are chosen in an attempt to prove a hypothesis and theory for the research, so they will be selected as they are a valid way of measuring that reality. The tools are usually employed in an experimental fashion and enable the production of numerical data, which can be statistically analysed to provide an answer to

the hypothesis. The problem with operating with the approach in this environment is that the picture captured is often incomplete. Moreover, the statistical findings might not have any real value in relation to the learning environment, regardless of statistical significance (Creswell, 2013a; Punch, 2011; Teddlie & Tashakkori, 2006). The environment in which the current research will be conducted, the value of the research to the students is important, since it is their learning, which any proposed solutions as a result of the research will affect. Not capturing their views in the production of a solution seems inappropriate in this context, as the proof of a hypothesis without students' views or approval will not lead to a long-term solution or engagement from students.

Operating in the interpretive paradigm, to produce a theory or hypothesis inductively allows for the use of mixed methods, and this helps to discover the meaning of a phenomenon. The methods allow for interpretation of the reality and the individuals involved in it. Qualitative tools such as interviews, blogs and focus groups create data in the form of words that can be analysed to understand common themes and reasons for the outcome of the phenomenon (Moran-Ellis et al., 2006; Punch, 2011; Sommer Harrits, 2011; Tashakkori & Teddlie, 2003). As discussed in section 3.2, the views of the students involved in the environment are important and the outcomes and proposed solutions of the research will affect their learning environment. Conversely, to operate in an interpretive way to propose a potential solution based entirely on the views of the students, regardless of the overall measured effect on their module learning, could also lead to an ineffective outcome (Castro et al., 2010; Creswell, 2007; Teddlie & Tashakkori, 2006).

Establishing a paradigm that rejects the need to make choices about research tools and methods and allows for the adoption of whichever tools achieve the answer to the research question being posed. Through the early work by Peirce (1905), Sleeper (2001) and Mead (in Cook, 1993), pragmatism allows for mixed methodology (Peirce, 1905). Tashakkori and Teddlie (2003) and Maxcy (2003) developed this idea to suggest that the research question is the most important aspect of the research, not the choice of method or paradigm. The research question influences the methods selected to find an answer to the question (Punch, 2011). The approach means that the range of research methods that can be used in a pragmatic paradigm is increased if it is rationalised to be suitable to find an answer to

the research question. The use of both quantitative and qualitative methods in this approach will allow for a more detailed answer and solution to the research questions of this study (Johnston, 2014; Teddlie & Tashakkori, 2006).

One of the critical issues surrounding the establishment of appropriate methods and the knowing of the reality is the position of the researcher in the study (Boote, 2008; Burkhardt & Schoenfeld, 2003). The positivism and interpretative paradigms have a viewpoint on the position of the researcher and whether it influences the findings through the research process. The relationship of the researcher to the subject and resultant data is a clear difference. In the interpretative approach, knowledge is maximised when the distance between the inquirer and subject is minimised and the groups are treated as subjects rather than objects (May, 2011). The positivism paradigm maintains that increasing the distance between the objects and the researcher will maximise the knowledge gained from the resultant data and singular truths from the research. In the case of this study, the removal of the researcher from the data collection process completely would be extremely difficult. The depth of understanding gained from the students on the implementation of the technology and E-learning tools would also be limited by the researcher not being present in the environment and the research tools used in this paradigm being quantitative, thus would not allow the understanding of a phenomenon to be captured.

The current research involves an environment in which it will be easy to position the researcher in a manner that would have an influence on the research, due to the nature of teaching and learning (Wallen & Frankel, 2011). The delivery of the sessions in which technology and E-learning tools are being used will be carried out in part by the researcher, which could influence the research results. The interactivity gained by the researcher's position in the research could mean that the findings would be more far reaching, as delivery of the sessions could be controlled and produce a dataset that has a more complete picture of the observed phenomena (Creswell, 2013a; Punch, 2011). The position of the researcher could result in the distance between the researcher and the subject being decreased due to the nature of the teaching and learning environment in which the research will be conducted. If the position of the researcher is closer to the students, as in this case, it could give the dataset added depth by including the views of the subjects (the students), therefore the reality can be altered and renegotiated as the research progresses,

which would make it more interpretative. The potential of the researcher to influence both the input and the outcome of the research, through this approach, needs consideration to ensure that the repeatability and authenticity of the findings are not negatively impacted (see section 3.6 for more on being an insider researcher).

The pragmatism viewpoint on the position of the researcher is that it should allow the phenomena to be observed to find a solution to the problem. To this end, if positioning the researcher in the learning environment close to the students allows for a complete picture of the phenomena, as noted by Creswell (2013b) and Punch (2011), then surely this is the approach to take to formulate a solution. The research design of the proposed research (see Figure 3.1 below) indicates smaller studies feeding into a larger end product. With this design, the need to renegotiate the reality after each study and to be flexible with the research tools to let the best possible solution be discovered suits the pragmatic epistemological position. Adopting this approach and potentially using qualitative tools with a quantitative data analysis of the learning environment, providing this helps to achieve the aim of a solution, would seem to be the most acceptable and potentially best approach (Morgan, 2014; Tashakkori & Teddlie, 2003; Feilzer, 2010).

The choice of methods appropriate to answer the research question and provide a solution and proposed model are important issues that have been discussed. The position of the researcher and its impact on the data being collected, in addition to the need for a constantly renegotiated reality, have also been. This suggests that this research is situated in the pragmatism paradigm and, considering all of the above and the surrounding issues, the use of mixed methods would seem a sensible approach to take to capture the entire phenomenon and provide a solution to the research problem in the shape of a implementation model (Lattal & Laipple, 2003; Morgan, 2014; Mounce, 1992; Moxley, 2001, 2002a, 2004).

3.3 Overall research design

Having established that the current research operates in the pragmatist paradigm and from an epistemological position, the use of mixed methods is the most appropriate to find a solution to the current research aim. This section will identify the overall research design

(section 3.3) and leads onto the individual study designs (section 3.4) and then the research instruments used in the study are discussed (section 3.5). The design shown in Figure 3.1 indicates how the research is made up of a series of smaller studies. Each part of the overall research will form the basis of the next study and add a deeper layer of understanding. The research will be evaluated using a mixed-methods approach in an explanatory sequential design, as described by Creswell (2013b) and in keeping with the chosen ontological and epistemological position. The study design allows for the reality to be considered at each point before commencing the next. The findings from the first study will inform the second study and, through the epistemological approach chosen, mixed methodology will allow the students to add to the reality from the first study and renegotiate it through their views. The renegotiated reality from the first two studies then ensures that the third is conducted in the most appropriate way to produce the data for the implementation model. The end of the third study is another point at which reality could be considered to incorporate the qualitative and quantitative findings to ensure that the implementation model is an acceptable solution, in keeping with discussions above (sections 3.1 and 3.2).

The data analysis (as discussed in 3.6), to be undertaken as part of Study one, creates an evaluation of the impact of TEL, E-learning tools and technology implementation on the Higher Education Performance Scores (HEPS). The outcome of the data analysis informs the renegotiation of reality and the design of the next study. The data sampled from the qualitative instruments as part of Study two, as discussed in 3.5.3 and 3.5.4, provides an additional and deeper layer of interrogation to add an in-depth explanation of the experience associated with the quantitative data collection in Study one. The quantitative section will aim to identify any relationships between the identified variables, whilst the qualitative analysis will aim to identify how they occurred (Cohen et al., 2011; Punch, 2011). This approach and design will allow the views of participants to be explored and help to portray a picture of the journey and reality of the research, ready for the final study. The approach, in line with the paradigm and epistemological choices, ensures that the findings from the final study in the research can be used to produce the most appropriate implementation model as a best fit solution to the research problem.

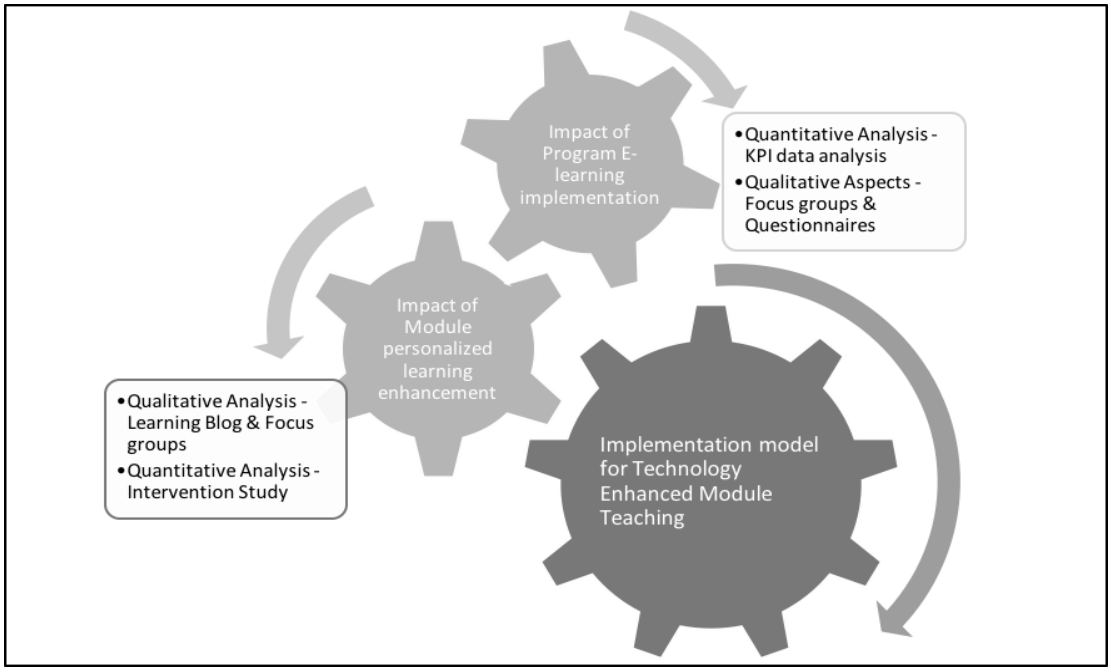

Figure 3.1 Overall research design

As can be seen in figure 3.1, the studies in the current research interlink to create the implementation model. The first study investigates the effect of TEL at a programme level, with the findings feeding into the approach taken in the intervention used in the third study. The second study engages with the students to gain their voice in the changes that have occurred in their learning environment in relation to TEL. The student voice will also feed into the choices made for the intervention used in the third study and in the development of the implementation model. The final study considers the findings from the first to studies to collect data on an intervention on a personalised use of TEL in module teaching. The findings from study three aid in the development of the implementation model by outlining which components of TEL are the most effective in module delivery in this research. The approach taken with this research design means it encompasses, strategic programme level TEL findings, the student voice on TEL and TEL implementation in module teaching in its outcomes in addition to the implementation model.

The first study will include the quantitative section and identify any relationships between the chosen variables, whilst the qualitative section in the second study will aim to identify how they occurred (Punch, 2011). This approach and design will allow the views of the

participants to be explored and paint a picture of the journey of the whole programme in terms of E-learning and technology implementation in the learning environment.

The final study combines the methods used in the first two studies to investigate the use of personalised learning materials. It will use a quasi-experimental approach (see 3.5.2) to gather quantitative data and individual student module performance data, whilst the weekly learning blogs uploaded by the students and the follow-up focus groups (see 3.5.1 and 3.5.3) will provide the qualitative data.

The implementation model is constructed from the quantitative findings from the final study using structural equation modelling (SEM) (see section 4.4). The quantitative findings from the first study, in combination with the qualitative findings from the second and final studies, inform the development of the model and acceptance of the final version. By incorporating both quantitative and qualitative findings, it will be a best-fit negotiated solution to the problem, in keeping with the chosen paradigm.

The chosen design (see Figure 3.1) will allow exploration of potential relations rather than focusing on one approach. The research will be focused on one student group, the SES students, due to the positionality of the researcher. The student group are not representative but within the group they had a range of learning styles.

The qualitative aspects of the research through the use of questionnaires, learning blogs and focus groups will allow the students' views to be fully explored and collected. The depth of the collected views is important when trying to answer the research questions and conducting research in education, as discussed by Cohen et al. (2011) and supported by Buzzetto-More (2007), Creswell (2013a) and Crotty (1998). The data involved in educational research is student data, and to focus on only one element would miss vital reasons underpinning their existence and relationship to the whole student-centred environment, emphasising the importance of qualitative aspects to complete this picture, as discussed by Burkhardt and Schoenfeld (2003), Cohen et al. (2011), Creswell (2011, 2013b) and Hannan (2005).

The quantitative elements of the current research are based on a theory construction-theory testing method (Creswell, 2013a; Hannafin et al., 1997). The 'research' - that is, the

alteration of the curriculum and embedding of the E-learning tool and technology, coupled with the literature exploration - comprise the theory construction stage. The resultant studies will test the theories using data from the programmes and modules that have seen an implementation of E-learning tools and technology. The findings from this testing will provide a basis for the renegotiation of the established reality and theory. The qualitative aspects will then add depth to the reality and interpret its usefulness, which will lead to the development of the design of the next studies (Creswell, 2013a; Punch, 2011).

3.4 Individual study designs

For the first study, technology and E-learning tools' implementation in a chosen HE subject programme cluster will be assessed. This will be carried out by looking at the impact on the student learning environment in terms of identified HE performance scores. The HEPS are: student assessment results, student attendance, student VLE time, student progress and student achievement. This will be a cross-sectional study, as the collection period encompasses all the identified performance indicators (outlined in Table 4.1) for the whole subject student cohort over six academic years for the module identified in Table 4.2. The study will be exploratory in nature, because it will look to discover potential correlations between the performance indicators and the technology and E-learning tools implementation level, as seen in Table 4.3 (Creswell, 2013b). The use of a quantitative data analysis study to provide the basis for further qualitative studies is supported by work by Castro et al. (2010), Huang et al. (2012), McKim et al. (2013) and Feilzer (2010).

These performance indicators have been chosen as they are established measures of course performance, as identified by Thomas (2012a) and HESA (2017). Students' VLE time, for example, is one of the new measures for developing digital pedagogies, as discussed by Beetham and Sharpe (2013). A mix of indicators is important for the reasons previously discussed about the application of this work to the development of TEL in HE teaching and learning. The results from this research could provide new performance indicators or measures to aid the use of E-learning and technology in curriculum. The ILS combined with the student VLE time could be a good indicator of the most effective environment for the learners on the programme, rather than taking the same approach and offering the same support regardless of the cohort, which is often the case in HE at present.

These performance indicators are only one form of programme measurement, and they traditionally give very little indication of the reasons behind the numbers. However, they give an idea of the effect of technology usage and implementation to enhance a course cluster curriculum. The dataset analysed will be for a validation cycle of a programme, which includes academic years of cluster data before and after implementation.

The first study will aim to answer the following question:

1. Have the levels of engagement (virtual learning environment interaction, attendance, achievement) in all year groups of undergraduate students changed due to the implementation of technology-enhanced learning?

The second study will aim to add to the quantitative findings of Study one and, through qualitative methods, develop the newly renegotiated reality. The methods include questionnaires and focus groups with students to give the data analysis of the performance indicators a greater impact and depth of analysis. The second study aims to increase the understanding of the effects of technology enhancement through giving the student body a voice in the research. So, rather than their module results being just shown through quantitative analysis, their views and emotions are added to complement the data and increase the depth of understanding.

The second study will aim to answer the following question:

2. Have the educational changes influenced students' experience of technology-enhanced learning at Middlesex University?

Having established a new reality based on the first two studies, the third aims to investigate whether the use of technology and E-learning tools can provide a personalised learning experience for the students. The final study uses an experimental intervention design using a pre-test/post-test model, which enables the use of a pedagogical intervention, the personalised support materials, to be tested in a controlled manner. Work by McKim et al. (2013) also used a quantitative design as part of a mixed-methods study investigating a student learning environment. The authors found that this was a clear framework and knowledge base from which to add meaning through the qualitative elements of the

research (Hannafin et al., 2004; Huang et al., 2012; McKim et al., 2013). The resources will be personalised using the students' individual learning style in a similar approach to that adopted by Klašnja-Milićević et al. (2011). The learning styles will be found using the ILS, as devised by Felder and Soloman (1997), based on Felder and Silverman's learning style model (FSLSM), developed in 1988. The support both inside and outside of the classroom will then be tailored to this learning style (outlined in Table 4.4). The ILS is suited to assessing the impact of a VLE on the learning of students, as it can be easily aligned to the VLE components and therefore their impact on their learning, as noted by Klašnja-Milićević et al. (2011). The students' view on the personalised learning resources will be captured in weekly learning blogs and the themes followed up with focus groups (as discussed in sections 3.5.1 and 3.5.3) (Ebner et al., 2010; Garcia et al., 2015; Jimoyiannis & Angelaina, 2012; Shih-Hsien Yang, 2009; Wolf, 2010). The qualitative elements of this study will add depth and meaning to the quantitative elements, as suggested by Huang et al. (2012), McKim et al. (2013), Sommer Harrits (2011) and Feilzer (2010).

The third study will aim to answer the following question:

3. Has technology enhancement personalised to undergraduate students' various learning styles significantly altered their progress on a taught module?

The final study will develop the identified themes and outcomes from the first two studies to investigate whether technology and E-learning can be further implemented to enhance individual students' experience through personalising them. The final study will use a mixed-methods design, with quantitative elements establishing the impact of the intervention study and qualitative elements aiming to add depth to these findings through students' learning blogs and follow-up focus groups. Mixed methods is an explanatory, sequential design, and it is noted by Creswell (2013a) to establish the complete findings of the impact of technology-enhanced personalised learning. This all-round picture will help in the creation of a model with guidance on the implementation of technology in teaching and learning to enhance HE programmes.

The TPACK model developed by Mishra and Koehler (2006) identifies facets of knowledge involved in the use of technology in learning. However, the next stage – how to use the

intersections of knowledge most effectively for students' learning – is missing. It is hoped that the development of a conceptual implementation model will build on this identification of knowledge and provide guidance for using technology to assist individual students in module and programme teaching at both practice and strategic level. This model is hoped to indicate how the implementation of such an approach can be carried out in the most effective and holistic manner for all parties concerned in HE programmes.

3.5 Research methodology

The current research operates in the pragmatist paradigm, which allows the use of mixed methods and therefore several research instruments with which to gather the appropriate data. The individual instruments enable a complete picture of the impact of E-learning and technology on the teaching and learning environment and answer the research aims.

3.5.1 Learning blogs

Learning blogs have been used by several authors (Ebner et al., 2010; Garcia et al., 2015; Jimoyiannis & Angelaina, 2012; Shih-Hsien Yang, 2009; Wolf, 2010) to gain views from students on a particular element of teaching and learning. The blogs are self-reflection by students on the teaching and learning that they have experienced, as noted by Wolf (2010). Blogs have also been used as an informal way of monitoring engagement and collating suggestions to improve the subject lessons, as noted by Ebner et al. (2010) and Jimoyiannis and Angelaina (2012). Work by Wang et al. (2014) suggests that blogs could be used to measure the effectiveness of learning systems by gathering evidence on user satisfaction to inform the development of the learning environment. Taking these views into account, the use of blogs is appropriate to obtain students' views on the development of personalised learning materials as part of the third study of this research.

3.5.2 True and quasi-experimental

An experimental method involves observing a phenomenon under controlled conditions and monitoring the effect of an independent variable on a dependent variable. The independent variable is manipulated by the researcher and the effect of changes made by an intervention are seen in the dependent variable (Campbell & Stanley, 2015; Creswell,

2013a; Johnson & Christensen, 2008). In true experimental design, the selection of the control group, which is the group that does not experience the intervention, is by random allocation. If this is not possible due to the nature of the study, as in this instance, subjects are allocated to a group – in this case, students are allocated to a seminar group – and a quasi- experimental design is adopted (Campbell & Stanley, 2015), suited to environments where the researcher cannot control the allocation of subjects to a group or, indeed, has no control group. This approach will be taken in the third study in this current research, due to the existing allocation to the seminar groups. A quasi-experimental study can still exhibit a cause and effect outcome, as it follows a pre-test/post-test design (Creswell, 2013a). McKim et al. (2013) measured the effectiveness of a pedagogical intervention on students' learning with a pre- and post-test, and the data was collected then analysed using statistical methods to establish the effect of the intervention, in this instance experiential learning. An experimental method in isolation will not consider the views of the subjects of the intervention and will therefore only report a part of the phenomenon. To ensure that this is not the case in the current research, the use of an experimental method as part of a mixed-method approach is appropriate (Castro et al., 2010; Creswell, 2013a; Johnson & Christensen, 2008; Feilzer, 2010).

3.5.3 Focus groups

Study two and Study three use focus groups to add depth to the understanding of the observed phenomena. Gilflores and Alonso (1995) state that a focus group can be valuable when aiming to evaluate implementation and is the ideal methodological tool for collecting this type of information. Winlow et al. (2013) agree with this notion and, in their study, focus groups are used to support the development of teaching and learning of their subject. The use of focus groups has to be organised and structured to ensure that the data gathered is meaningful and aid the development of the observations (Creswell, 2013a; Gilflores & Alonso, 1995; Punch, 2011; Winlow et al., 2013). The role of the researcher in the organisation of the focus groups is important and needs to be considered in the design. Cousins (2009) argues that the researcher can make the focus groups' data invalid due to its bias, in certain contexts, thus some researchers employ a third party to conduct the focus groups.

The current research is set in a teaching and learning environment, therefore there is potential for bias, and the measures taken to counteract it are discussed in section 3.7. In keeping with the epistemological and ontological choices, the views from the focus group will help to inform the renegotiation of reality after each study and the development of the implementation model. The focus group data can add to the research as views can be gathered on concrete themes that have emerged through other instruments used in the research, such as the online learning blogs. The focus groups will increase the validity of the data collected in the blogs through triangulation, helping to develop the overall picture of the research, and for this reason will be used in the second and third studies and to add depth to the overall picture. This will help develop a holistic view of the phenomena and the implementation model (Gilflores & Alonso, 1995; Winlow et al., 2013).

3.5.4 Questionnaires

Study two in the current research uses data from questionnaires (NSS and Middlesex module and programme evaluations) to formulate themes for discussion in focus groups. Questionnaires can be an efficient way to gather data from individuals; they can take the form of a qualitative or a quantitative instrument. As noted, the data collected can often be used to inform focus group discussions and help to triangulate the themes. In order for this to be successful the design of the questionnaire is important and needs to be valid, as noted by Creswell (2013b), Johnson and Christensen (2008b), Punch (2011) and Tashakkori and Teddlie (2003). The questionnaire data can give interesting insights into the observed phenomena to gauge the personal impact of the research. In this study, the questionnaires are related to course feedback and have been validated by the university or an independent company such as MORI. The questionnaires are standardised, as each participant receives the same set of questions (Creswell, 2013a). The questionnaires can be designed to be part quantitative and part qualitative, with some questions using a Likert scale to canvass students' views and others to allow text to be entered freely. A Likert scale is useful when looking to measure a latent construct, in this instance the characteristics of the students, such as views, feelings and attitudes towards a research statement, 'Technology has improved your learning environment'. Each Item needs to be written in a certain way so that it is clear to the reader what they are being asked to respond to (Creswell, 2013a; Johnson & Christensen, 2008). By using a pre-validated questionnaire,

these issues are minimised (Boote, 2008; Creswell, 2007; Johnson & Christensen, 2008). In the current research, the views collected from the questionnaires will help to plan the semi-structured focus groups in the second study and aid the triangulation of themes, as discussed by Moran-Ellis et al. (2006) and Stewart and Shamdasani (2017).

3.6 Data analysis

Working in the pragmatist paradigm allows for the use of mixed methods, as discussed previously, which means that the current research includes different types of data. The data in this study is from a variety of sources that have their own appropriate analysis techniques, and these will be discussed in sections 3.6.1 and 3.6.2. They enable the phenomenon to be explained and permit the discovery of which interactions and behaviours are genuine and which occurred by chance. The last subsection (3.6.3) explores how the data will be used to develop the TEL implementation model.

3.6.1 Qualitative data analysis

Data analysis in qualitative research is the analysis to identify and report themes and patterns of behaviour in the phenomenon. A thematic approach helps to organise and add depth to the collected data (Aronson, 1995; Boyatzis, 1998; Jääskelä & Nissilä, 2015; Tashakkori & Teddlie, 2003). This may be used with interviews and focus groups to identify common themes among the groups and, as suggested by Boyatzis (1998) and Tashakkori and Teddlie (2003), to add depth to quantitative data in a mixed-methods approach. The focus groups in this research were analysed using this approach to add impact to the quantitative data collected in the third study. The analysis aided both the description of the phenomenon associated with the research questions and the development of the implementation model.

3.6.2 Quantitative data analysis

Data analysis in a quantitative manner involves the application of a numeric value to a phenomenon and then the analysis of the identified variables through statistical methods. The analysis reviews the distribution of the dataset, as it is an important factor in the identification of the appropriate analysis (Creswell, 2013a). The results from this analysis

can then lead to the results being generalised to larger populations, in this instance students and their teaching and learning. Measuring the effectiveness of teaching in this manner can be effective, as stated by Hutchinson (1999), as it can show the absolute impact of an approach on student learning, regardless of the views of the students. However, to obtain the whole picture of the phenomenon and gain an understanding of the students' views and feelings on changes to their teaching and learning environment, quantitative data analysis should not be used in isolation but with qualitative data (Creswell, 2013a; Johnson & Christensen, 2008; Johnson & Onwuegbuzie, 2004).

3.6.3 Model production

The model in this research is a result of data analysis using a technique called structural equation modelling (SEM). The technique uses advanced regression analysis to model the multiple relationships and potential effects to create an overall impact of the proposed model. The process has set criteria for acceptance of the model (Kenny, 2015; Kline, 2015). The software enables the relationships among the factors to be displayed visually, with their relative impacts (Blunch, 2012; Byrne, 2013). A model produced in this manner aims to display how much variability is controlled by, in the current research, a pedagogical approach to using TEL (Blunch, 2012; Green, 2016; Kenny, 2015; Kline, 2015). The development of this model is the combination of the findings from the studies in this research, as a best fit agreed solution to the problem.

3.7 Ethical issues

All ethical applications were approved, and the permission was granted by the University Registrar to use student data. Individual students were recoded to ensure that their data was anonymised, rather than using the University's student ID system. As part of ethical approval and to conform to the University's policies under the Data Protection Act, each student was informed that their data was being used in educational research. Consent was obtained and the option to opt out of the research was explained in accordance with the ethics application process.

When undertaking pedagogical research, there are several issues to consider, including the impact on the student experience and the researcher's role. One of the issues in this study

is the researcher's role. The researcher is involved in the day-to-day running of the programmes through which the data for the research studies is to be collected and analysed. The role as a worker and insider researcher had to be considered in the context of this study. Due to the researcher's role, there is often guidance available and they can ask for help with the delivery and development of teaching and learning for the provisions involved in this study. The researcher must therefore try to maintain a certain distance during the data collection periods, where appropriate and ethical. If this distance could be achieved without limiting the researcher's ability to carry out their role, then the objectivity could increase the outcomes. This distance is crucial, as colleagues and students will be aware of the research being undertaken and may want it to have a negative or positive effect, on depending their perception of the researcher.

Clarity will be needed in relation to the information given out about the research to try to reduce this element of influence and to attempt to maintain normality. There could be a negative impact on the students' learning environment, which could ultimately manifest itself in a negative NSS score, which would have an adverse impact on the researcher's role and that of colleagues. Any help or direction given to the students is to be well documented to help to understand the resultant scores.

There are a number of moral issues surrounding turning the classroom into a research medium, as discussed by Kincais and Percorino (2004), as students essentially come to university to learn, so any impact on their tuition time or that their grades must be avoided. Due to the researcher's role, achieving positive course performance indicators and an improved student environment would be of benefit not just for this study but the wider University. The researcher is partially assessed by the performance indicators to be used in this research, so a positive change and response would be mutually beneficial. Through the adjustments taken and planning of the studies mentioned above, the impact on the student learning environment will be minimised. With the adjustments in place, it is important not to bias the outcomes positively (Creswell, 2013a; Kincais & Percorino, 2004; Punch, 2011).

An E-learning implementation classification (see Table 4.3) of modules will be undertaken prior to starting teaching, based on how the module is run, with no requirements for change prior to or during the academic year. The students will not perceive any changes

and therefore will not perceive that the delivery is anything other than the norm; the only difference that they will notice is a difference between modules. Therefore, once teaching starts, delivery is unaltered and so is the student experience.

Being an insider researcher has many positive elements, some of which allow the researcher to alter and adapt the course of the research to enable the collection of more complex and complete data set. An example of this is in the focus groups, where themes emerging from the focus groups and questionnaires could be used in groups to advance the discussion further. Sparkes (2009) states that the depth of understanding can be increased as an insider researcher, which aids in the development of a more complete dataset. This viewpoint is important in the context of this research, as the qualitative aspects are designed to add another level of understanding to the data. However, these views could be affected if the correct factors as outlined above are not considered, as the students could start to present the views that they think that the researcher wants to hear, due to their role and their rapport that they have with the student cohorts.

The researcher plans to deal with the above insider researcher issues in a several ways. First, the performance indicators to be used in the quantitative data collection for Study one will be largely collated automatically by the systems at the University. Secondly, the qualitative data for Study two comprises module evaluations and student experience questionnaires, which are online and anonymous, and are administered departmentally. These questionnaires will use Survey Monkey, as is normal practice, which means that the first contact that the researcher will have with the data is at the analysis stage, limiting the potential for influence at the sampling stage. Cousins (2009) states that it is unethical for academics to run their own focus groups, due to bias issues. There are several approaches or views to counteract this, such as to share transcripts with a neutral colleague to check for bias in the analysis. The observer could easily indicate whether there is bias, but it could become resource intensive. Alternatively, the focus groups could be led by a neutral colleague, but this might lead to missing opportunities to develop the discussion further, which could subtract from the impact of the data. The approach chosen in this study is to co-run the focus groups with a neutral academic, who will be present to look explicitly at any bias in the questions posed or responses of the researcher. The outlined measures are

designed to resolve the issues raised by Cousins (2009), Gilflores and Alonso (1995), Johnson and Christensen (2008) and Winlow et al. (2013).

The focus groups are planned to be co-run, as outlined, in a semi-structured group discussion, to allow the themes to be explored in a logical manner. Initial themes will emerge from the analysis of the questionnaires, which will then lead to more in-depth themes being discussed in the groups (Gilflores & Alonso, 1995; Stewart & Shamdasani, 2017, 2014; Winlow et al., 2013). This approach was chosen to produce a dataset with the impact required to add to the embedded design to help to understand the quantitative findings. The focus groups should be the final piece of the picture to complete the holistic view of the impact of both the implementation of technology and E-learning tools and the personalised learning resources. These measures should increase the validity of the research and therefore the potential impact of the findings. Due to the design of the particular modules involved in the research, the sampling could be timed to take place after all assessed work has been submitted. This usefully minimises the impact on the learning environment in that academic year.

The third study will use a quasi-experimental design with two groups, a control and an intervention. The control group will not receive the personalised module support materials but the traditional approach to the content delivery. The intervention group will potentially have an advantage in preparing for the linked assessments, due to the extra resources that its members will receive each week. This approach to an intervention study in education mixed-methods research is supported by work by McKim et al. (2013). The weekly lesson's PowerPoint slides will be made available to both the control and intervention groups, in addition to the weekly blog and formative quizzes. The control group should thus progress, as a normal group would, through the content towards the final assessment. The ethical issues connected with this approach include the situation if the control group students' achievement is significantly lower than the intervention group or has regressed because of the study. To counteract this effect, after the final assessment point is reached all groups will be granted access to the content that was otherwise hidden from them during the weekly delivery, with support. The groups will then be given an opportunity to retake the assessment (McKim et al., 2013).

Since the researcher is to teach on the module (which is made up of 6 seminar groups of 25 students), in which the intervention is taking place, measures are needed to counteract any potential bias in its delivery. The teaching will be shared evenly with another lecturer and the groups will have two taught sessions a week, so each will be taught by both lecturers using the same resources for all sessions, again to maintain consistency and control variables (Cohen et al., 2011; Creswell, 2013a). The module lecturers will meet each week to go through the content to ensure consistency in delivery. The weekly learning blogs that will be uploaded by students could also be influenced by the tutor for those sessions, and the mixed approach to delivery will limit this impact. As with the questionnaires, the uploaded learning blogs will be anonymous and individual, each consisting only of entries from a single student; the only difference between the participants that will be detected by the researcher is whether a blog is by a student in the intervention group or in the control group. The blogs' design means that students will feel comfortable giving their honest views on the personalised resources and how they feel that they are affecting their academic development. The use of learning blogs to gain authentic reflections on teaching and learning is held by many researchers to be an effective, non-intrusive method (Ebner et al., 2010; Garcia et al., 2015; Jimoyiannis & Angelaina, 2012; Shih-Hsien Yang, 2009; Wolf, 2010).

3.8 Outcomes

The final outcome is the production of a TEL implementation model, with guidance on its use in learning and teaching in HE programmes from the data collected from the individual studies. As more programmes embrace the digital world through their teaching and learning strategies, knowledge is essential on how to instigate these changes and the potential impact on students. The model and guidance will potentially add to the body of work as we develop digital pedagogies and technology usage in teaching, as discussed by Mishra and Koehler (2006) in their TPACK model development. Beetham and Sharpe (2013) looked at how technology and E-learning are part of the development of pedagogies to embrace the digital world. These developments need to be conducted for the best reasons, to support learning and the students involved, which cannot be lost in the rush to embrace

all things new or digital (Beetham & Sharpe, 2013; Davies et al., 2017; Davis and Roberts, 2013; Littlejohn et al., 2012; Moore, 2007).

The current research results will hopefully give further evidence and guidance on a transformational approach to E-learning and technology implementation in HE teaching, as noted by Fox and MacKeogh (2003), where traditional teaching is enhanced and supported with technology and E-learning. The comparison of course performance indicators with traditional values and those with modern digital values will be a useful process, as programmes embrace the digital world further in HE. The measurement of technology-enhanced resources used in teaching, which comprise students' VLE logs in terms of both time and usage of electronic media, is an element of the digital world, itself, as the use of technology is supported and encouraged as part of the students' learning, as discussed by Beetham and Sharpe (2013). These are new elements, different from traditional approaches, and are aspects that Davis and Roberts (2013) suggest are important to the future of HE.

Overall, this research aims to provide support and guidance for the continued development of the usage of TEL in programmes - not just in this subject but in the wider community of the HE sector. The gaps identified in the literature review in Chapter 2 concern: how TEL should be implemented, with practical guidance; the efficiency of using TEL in student learning; a coherent programme approach to TEL implementation; the use of TEL to help students to engage with their studies; and, potentially, offering a personalised approach to TEL. The findings from the discussed methodological approaches and the resulting implementation model will help to fill the gaps and add to knowledge to provide practical guidance on the implementation of TEL in a coherent and efficient manner to enhance student engagement and achievement.

3.9 Chapter conclusions

The main themes discussed were the current research ontology and the pragmatist paradigm, as the most appropriate to achieve its aims. The research epistemology was then discussed in relation to the chosen paradigm and the identification of a mixed-methods approach to the research design. The chosen approach means that the best solution can

be found to solve the problems of technology implementation in teaching and learning in HE. The overall research design and the individual studies were then outlined. The research methodologies where discussed, including learning blogs, focus groups and questionnaires. The final topics of discussion in the chapter were the ethical issues and research outcomes.

The next chapter will look at the data collection methods used in each of the studies in the research. The analysis procedures will be discussed, such as the issues involved in working with two data types. The final part of Chapter 4 will look at the methods used to produce the implementation model to be outlined in Chapter 6.

Chapter 4 Data Collection

In this chapter, the data collection procedures will be outlined, as well as the methodologies discussed in Chapter 3, the data analysis, protocols and ethical considerations. The potential limitations to the procedures will be outlined and evaluated. The way in which the collected data is organised to highlight the intended outcomes will be outlined in sections 4.1, 4.2 and 4.3. The analysis procedures and how they link to the production of the model will be covered in section 4.4, leading into Chapter 5.

The research aims are to identify the effects of using technology to enhance learning, progress and achievement in HE. The research further reviews the effect of TEL on student case studies in HE. Finally, it is established whether technology enhancement can be personalised for learners on the basis of their learning style. The results from this research are used to produce a model for the implementation of technology into teaching and learning for HE programmes.

The subjects involved were the current students and alumni of Middlesex University's (MDX) undergraduate Sport and Exercise Science (SES) courses. The alumni offered insights into the development of the SES provision over time and, if they had chosen to continue their studies at postgraduate level, a rationale for progression at the University. The students' views helped to identify the cultural change and the potential reasons behind these.

The age range of both current and alumni students was from 18 to 50, with the highest proportion of students in the 18 to 21 age category. The split between the genders was 70% male and 30% female, representative of many sports programmes across the country (HEFCE, 2018; UCAS, 2018a). Their educational background was predominantly a sport-based and academic BTEC but, over the researcher's time at the University, this has changed to a higher percentage of A-level students with a more traditional science background, reflecting differing levels of academic ability. The UCAS points required for entry have increased from 220 to 300 points, over the course of this research data collection period. Typically, the background of the student body that enrol on an SES course is highly diverse, as sport has very broad appeal (BASES, 2018; UCAS, 2018a).

Ethical approval was granted by the departmental ethics subcommittee for all three studies. The University Registrar granted permission to use student data in the studies. Individual students' data were anonymised for all the data collection points for the studies as part of this research. Each student was informed that their data was being used in educational research as part of the process of securing ethical approval and to conform to the University's policies under the Data Protection Act. At the start of the data collection process for all the studies, informed consent was obtained and the option to opt out of the study was made known to participants in accordance with the ethics application.

The ethical dilemmas involved in being an insider researcher were discussed in Chapter 3, and it was concluded that the researcher needs to be reflexive during the data collection and analysis. The measures (including online questionnaire sampling, focus group facilitation and two staff teaching in the intervention in Study three) mentioned in Chapter 3 were implemented, and the methodology also helped reflection. To address the issue identified in Chapter 3 regarding being an insider researcher and resulting potential for bias in the focus groups, as discussed, an independent person co-facilitated the focus groups to ensure that the participants could discuss elements freely, to allow the output to be checked for authenticity and to make the data collection process transparent. As Creswell (2013a) states, a researcher needs to be aware of potential bias when analysing the results and, later, to reflect on how the results may have been influenced. The notion of reflexivity is bi-directional, with both researcher and participants affecting each other, and the awareness can result in more effective and objective research (Letiche, 2017).

The qualitative elements of the research studies should to be viewed in this light to ensure that the findings are an accurate analysis of the events. The researcher's own views on the use of technology in HE learning and teaching need to be considered. These have shaped the study's methodologies, influencing all involved. When considering their personal views, the researcher needed to be able to step away from the findings and reflect upon them, deliberating on their relationship with them. Reflecting upon the findings in this manner also allowed them to consider how their own views and those of others involved in the research changed (Creswell, 2013b).

The researcher had preconceived ideas about the themes to emerge from this study (see the researcher's personal account in the Appendices for more details), in that technology is viewed as a positive influence on students' learning environment yet that its implementation in HE should be based more on evidence. In addition, the researcher considered that the current use of technology in HE is broad and general, with little consideration of students' learning. Through the focus groups and analysis, the researcher needed to become aware of the issues and not deliberately to find evidence to support their own views. The analysis of the focus groups' data needed to be undertaken in a way that allowed the identification of emerging flexible themes. Through this process a researcher can increase their reflexivity to ensure that the correct themes are identified to answer the research questions (Guillemin & Gillam, 2004; Hellawell, 2006; Letiche, 2017).

The data collected in the studies in this research fell into two main categories, qualitative and quantitative. These are fundamentally different and, as such, it is important to identify and acknowledge the different types and treat them in an appropriate manner. While the data is all student data and can be categorised together, like apples and oranges are both fruit, it is dissimilar in terms of its makeup and requires contrasting approaches to collection and analysis (Creswell, 2013b; Howe, 2012; Johnson & Christensen, 2008). Quantitative data can be defined as that which expresses a quantity, amount or range, and can be referred to as scale data. As a result, as each collection point occurs at an equal increment from the next. Creswell (2013b) notes that scale data has units and empirical methods are usually used for collection, and is amenable to manipulation using two main types of statistics, descriptive and inferential. The analysis therefore uses of numbers to explain phenomena.

Descriptive statistics were used to give a summary of the data collected without any detailed analysis, inference or resultant predictions (Creswell, 2003). Inferential statistics enabled the dataset to be analysed using probability to identify conclusions based on the population and sample data. An example of this would be, in this research, that the difference between student performance, with and without technology implementation, can be analysed, as in Chapter 5. The individual study statistical tests chosen are outlined in 4.1 and 4.3 below and were undertaken using Statistical Package for Social Sciences (SPSS) Mac, versions 23 and 24.

Qualitative data is usually derived from focus groups, open-ended questionnaires and observations, and therefore is non-numerical in nature (Creswell, 2003). The qualitative data in the studies outlined in sections 4.1 to 4.3 came from the open-ended questions in the questionnaires, focus groups and online blogs (Jimoyiannis & Angelaina, 2012; Shih-Hsien Yang, 2009; Winlow et al., 2013). This type of data helps to identify the thoughts and feelings of participants about the phenomena and can be used in the triangulation of the data or to explain quantitative results. The analysis is descriptive in nature and there are several techniques that can be used to identify themes. Word frequency and coding of the qualitative transcripts or blog entries are two methods to enable the development of themes. The analysis used these methods, undertaken with NVivo 11 (Mac Version), by using the word frequency as a starting point to develop the themes to code the transcripts to. This application used because it can categorise several sets of data in a single file, enabling clear analysis to be carried out, and it established the themes and then identified the relationships between them (Aronson, 1995; Fetters et al., 2013; Howe, 2012; Leech & Onwuegbuzie, 2007; Moran-Ellis et al., 2006). The thematic analysis used in Studies two and three is addressed in detail in sections 4.2 and 4.3.

When analysing the data to identify themes and draw conclusions, the different types need to be integrated. There are several ways in which this can be achieved, as noted by Fetters et al. (2013), in mixed-methods research. The integration can occur at the study design level, the methods level and the reporting level, or at only one of these. The studies in this research used all these approaches at all stages. The first two used explanatory sequential design as the quantitative data from the first study informed the qualitative approach taken in the second study. The findings from both informed the design of the final study (Punch, 2011). Thus, the methods are integrated, as the set of themes from one study is built upon at the next data collection point in the following study, as noted by Fetters et al. (2013). The final stage of integration is at the interpretation and reporting level through narrative, which can take a woven, a continuous or a staged approach. A woven approach is when the findings from the qualitative and quantitative analysis are reported in a themed manner within the same study or report. A staged approach is when the themes and findings of the studies are reported separately, with appropriate analysis. A continuous approach is where the findings are reported in one study but with different qualitative and

quantitative sections. The first two studies used a staged approach, as the first used quantitative methods and the second qualitative methods, so it was logical to analyse the themes and then report the findings. The final study used both qualitative and quantitative methods, therefore it was appropriate to use a continuous approach to reporting (Creswell, 2013a; Fetters et al., 2013; Punch, 2011).

The data was organised in Microsoft's spreadsheet application, Excel, and all data used in the studies was anonymised in line with the ethics requirements for the research. Study 3 used an online database using Google Sheets to facilitate data recording during teaching by staff on the module, as the sessions often took place at the same time but in different rooms, so a central recording point was essential. This method also enabled the online formative quiz data to be quickly analysed and support the development of the personalised learning resources for the following week's sessions. The findings from the research studies were each split into three:

1) The impact of the implementation of E-learning on students' module performance

2) The effect of the technology-enhanced personalised learning on students' module performance

3) The impact of the personalised learning approach on individual learning styles.

These allowed the strands of the study to continue through the analysis and to be brought together in the overall discussion (Chapter 6).

This chapter is organised into sections on each individual study (sections 4.1–4.3). A final section on the overall data analysis and the process by which the implementation model was produced, as a product of the research study's findings, comprises section 4.4.

4.1 Study 1 – Effectiveness of technology-enhanced learning on programme engagement of students in higher education

4.1.1 Research question

Have the levels of engagement (including measures of VLE interaction, attendance, achievement/progress, as discussed in Chapter 2) in all year groups of undergraduate students changed because of TEL implementation?

4.1.2 Protocol

The first study focused on the strategic implementation of TEL at a programme level. The study investigated the impact of technology implementation and of the identified HEPS on the student learning environment in the SES undergraduate modules, as outlined in Table 4.1 for academic years 2010/11 to 2015/16.

Table 4.1 Higher Education Performance Scores

Performance Indicator
Students' Module Assessment Results
Student Module Attendance
Student VLE Time
Student Progression or Achievement

The modules in the analysis are all undergraduate SES modules (see Table 4.2), coded as shown in Table 4.3. The identified performance indicators formed four dependent variables, with the independent variable being the E-learning implementation level, as shown. Each module was classified in accordance with Table 4.3. The study data was collected at the end of the academic year in accordance with the University's reporting schedules. To summarise, the data for the six academic years of for the indicators outlined in Table 4.1 was collected from 16 undergraduate modules, across levels 4 to 6.

Table 4.2 SES modules being analysed

New Module	Academic Years Used	Old Module (if required)	Academic Years Used
1240	11/12, 12/13, 13/14, 14/15, 15/16	BMS1515	10/11
1241	11/12, 12/13, 13/14, 14/15, 15/16	SES1234	10/11
1242	11/12, 12/13, 13/14, 14/15, 15/16	SES1200	10/11
1243	11/12, 12/13, 13/14, 14/15, 15/16	SES1520	10/11
2116	11/12, 12/13, 13/14, 14/15, 15/16	SES2202	10/11
2203	11/12, 12/13, 13/14, 14/15, 15/16	SES2115	10/11
2222	11/12, 12/13, 13/14, 14/15, 15/16	SES2323	10/11
2557	11/12, 12/13, 13/14, 14/15, 15/16	SES3113	10/11
3330	11/12, 12/13, 13/14, 14/15, 15/16	SES3188	10/11
3332	11/12, 12/13, 13/14, 14/15, 15/16	SES3336	10/11
3337	11/12, 12/13, 13/14, 14/15, 15/16	SES3550	10/11
3338	11/12, 12/13, 13/14, 14/15, 15/16	SES3557	10/11
3339	11/12, 12/13, 13/14, 14/15, 15/16	HSS3894	10/11
3340	11/12, 12/13, 13/14, 14/15, 15/16		
3360	11/12, 12/13, 13/14, 14/15, 15/16		
3370	11/12, 12/13, 13/14, 14/15, 15/16		

The data analysed included three academic years, from before (2010–2012) and after (2013–2016) the E-learning implementation and the introduction of the departmental

implementation levels (see Table 4.3), which took place at the start of academic year 2013/14. The data includes all levels of study (4–6) in the SES undergraduate programme for all student cohorts for the modules listed in Table 4.2. Where modules did not date back to the earliest years, due to programme revalidation, the module data prior to the revalidation was used, as in Table 4.2. The implementation levels used in this study and outlined in table 4.3, were in line with the university guidance around the use of electronic submission and E-learning.

Table 4.3 E-learning implementation levels

E-Learning Integration Level	Level Requirements
Foundation	To use e-submission and e-feedback in taught modules
Intermediate	As above, but additionally to include the use E-learning tools in the module assessments, and in teaching and learning strategy of the module.
Advanced	As above, with the addition of the use of a video of the lectures.

4.1.3 Study data and sample size

The data used in this study was from 2010 to 2016 and was obtained from the university student record database (as outlined above in 4.1.2). The data used is checked regularly by the academic registry team to ensure that all the data points are stored accurately and the access to the data is very limited and is through permission only to maintain integrity. In total 1698 modules were analysed for each HEPS outlined in table 4.1, with a total data point count of 6792 for the whole study.

The data comprised the final student module grades after the second assessments. The external examiner reports remained consistently positive across the data period, indicating

that the marking was deemed fair and consistent and there was no evidence of grade inflation. The individual students were anonymised prior to the start of data analysis. Each student was informed that their data was being used in educational research, under the terms of the ethics application, and their identification was removed and replaced by a code for each recorded performance indicator relating to them personally, completing the record in the dataset. The data in this study was compiled and processed in line with protocols in the literature (Creswell, 2013a; Field, 2017; Johnson & Christensen, 2008; Punch, 2011).

4.1.4 Quantitative data analysis

SPSS was used to analyse the scale data (as discussed above) from the outlined quantitative sampling methods. The analysis looked at the effect of the E-learning level on the performance indicators and then whether there were any relationships between indicators using correlations. The data was examined using descriptive statistics to identify any patterns and establish normality, before inferential statistics, were used to identify any significance differences or relationships. The relative effect size present was analysed using Cohen's D calculation (Cohen, 1992). Normality checks were undertaken to ensure that parametric statistical tests could be performed. Due to the sample size being more the 50 but less than 2,000, a Shapiro-Wilks test with a supportive Q-Q plot was used in this instance, testing at P=0.05. A non-significant finding meant that multivariate ANOVA and T-Tests followed by Bonferroni correction were used to examine the between and within-subject factors to assess the effect of the E-learning implementation, described above in Table 4.2. Correlations were also performed to investigate which combination of factors had the greatest effect on student performance, and regression was performed to gauge the level of effect. The statistical procedures followed the protocols outlined in Cohen (1992), Creswell (2013b), and Field (2017).

4.2 Study 2 – Effect of the educational changes on the student experience of technology-enhanced learning

4.2.1 Research question

Have educational changes influenced the student experience of technology-enhanced learning at Middlesex University?

4.2.2 Protocol

The second study focused on gained the student's views on the implementation of TEL so their voice could be heard in this research. The study centred on self-completed questionnaires and focus groups to gain a measure of the cultural and personal impact of the E-learning implementation. Qualitative methods were used to capture the views of students to gain an understanding of the course changes that occurred following the E-learning implementation and the increased use of technology in module teaching. The student questionnaire data came from SES modules evaluations, the Middlesex Student Survey (MSS) results and the NSS results across the same period as the data collected in Table 4.2 and outlined in section 4.1.2. The data collection points helped to identify how relevant the E-learning implementation and technology use were to SES students and then investigated the impact on how the students viewed their learning environment. The questionnaires, whilst quantitative in nature, had open-ended text questions that, together with the scored questions, helped to formulate the focus group semi-structured question sheet in section 4.2.3 (Creswell, 2013b; Johnson & Christensen, 2008; Johnson & Onwuegbuzie, 2004; Silverman, 2011).

To gain a more in-depth understanding of the cultural changes associated with the SES courses, focus groups were conducted using the themes that emerged from the questionnaire analysis as a starting point, which allowed additional themes to be discussed. The membership of the focus groups comprised students who had volunteered, to ensure that the groups were not dominated by one gender or age group, and a separate group for each gender was offered to all (Creswell, 2013a). Each focus group was recorded using an MP3 Dictaphone and then transcribed and analysed after the end of the session by NVivo

11 (Mac Version). The focus groups were conducted on the same day as the students were due to be on campus to increase the level of participation.

The focus groups comprised both students from each year group and programme alumni, as discussed in section 3.5.5. Including ex-students from courses before the E-learning implementation served to increase the understanding of the development of the courses. The focus groups were conducted as semi-structured group interviews, enabling themes to be addressed yet allowing the groups to discuss and explore other topics to gain an understanding of the impact of the changes (Creswell, 2013b; Johnson & Christensen, 2008; Johnson & Onwuegbuzie, 2004; Silverman, 2011).

4.2.3 Study participants and sample size

The questionnaire data used in this study was from 2010 to 2016, the same period as sampled in study 1 (as outlined above in 4.1.2) and was obtained from the university quality service department. The total amount of free text comments analysed as outlined in 4.2.3, was 20,590. There was a total of two focus groups in this study, which consisted of 5 students, in each group, with the alumni students recruited from across the years and programmes involved in the sample period.

4.2.4 Qualitative data analysis

The data collected in this study was analysed through an analysis package, NVivo 11. The software allowed the questionnaire data and focus group data to be stored in a single file and to compare themes for more in-depth analysis. Thematic analysis to identify the impact of the changes on the student body took place in a two-part process, as outlined in the previous chapter (section 3.6). The first part took the data from the questionnaires (see section 4.2.2), using the word count frequency tool to establish the key terms. These terms were used to create themes to code the data, and were then discussed in the focus groups. The second part was undertaken on the transcripts of the focus group discussions. Each had its content analysed and coded in relation to the identified themes using the word count tool (Saldana, 2015). This process built up frequency and theme diagrams (see figure 5.4) that identified the dominant themes. The diagrams were developed through the software, which used the frequency count of the coding to identify the most dominant

themes, displayed in a darker colour in the diagram. The analysis of the focus groups needed to ensure that the overall picture was not lost, so a naturalistic approach was appropriate to allow the focus group themes to be identified through analysis, a highly complex process yet one that yielded greater insights into the reasons behind the performance indicator data analysis undertaken as part of Study one (see section 4.1) and an opportunity to co-create knowledge with the students.

4.3 Study 3 – The effectiveness of personalised technology-enhanced learning on the progress of students in higher education

4.3.1 Research question

> Has technology enhancement personalised to undergraduate students' various learning styles significantly altered their progress on a taught module?

4.3.2 Protocol

The third study in this research focused on testing the effectiveness of the identified TEL in a taught module. The intervention was completed in a first-year SES module, SES1242 – Professional skills and work placement, taken by all first-year SES students. The curriculum for the module for the study intervention was 'Introduction to research methods'. This ran for eight weeks and was assessed by online multiple-choice questions. Topics covered in this section are: What is research; The research continuum; Variables and data types; Hypotheses and aims; Descriptive statistics; Displaying data; Correlations; and Introduction to inferential statistics.

4.3.3 Study participants and sample size

The total number of students who participated in the intervention as part of this study was 131 with 66 students in the control group and 65 in the intervention group. In total 1834 data points across all of the measures produced the main variables of; formative assessment grade, summative assessment grade, module attendance and VLE engagement count, as outlined in 4.4. The total number of students involved in the focus groups was 24 with 14 students from the control groups and 10 students from the intervention groups. In total 7 focus groups were held to collate the qualitative data as part of this study.

4.3.4 Control group

The module used in this study had small groups of 20 students for the whole of the 24-week academic year. There were six individual groups, and each group received two hours of timetabled contact time. Three groups did not have access to the personalised support materials, acting as control groups for the third study.

4.3.5 Intervention

To establish the mix of learning styles within the cohort, all the students were asked to take the ILS questionnaire. This tool is suited to assessing the impact of a VLE on students' learning as it can be aligned to the VLE components easily and therefore their impact on learning, as noted by Klašnja-Milićević et al. (2011). The information was then used to produce a weekly range of materials for the students to support them on the taught topics. The personalised support materials were released according to the students' learning style, and only to those in the intervention groups.

4.3.6 Study schedule

Week 1 – All students completed the consent form, the ILS questionnaire (Felder & Soloman, 1997) and answered questions on their preferences for online usage. All groups were then introduced to the online blog, which they needed to upload each week to record how the week had progressed and how they found the support materials.

Week 2 – All groups took research methods MCQ quiz.

Week 3-7 – Taught sessions on topics, with access to the standard lesson materials released each week to all groups. The experimental groups had access to additional material specific to their personal ILS, using Klašnja-Milićević et al. *(*2011) as guidance to adapt the online support materials on the basis of the ILS result, released weekly. Each week, all students were asked to upload a learning blog on how they felt they were progressing with the module topics and on the module's support materials. A weekly formative quiz on topics covered in those sessions was released to all students and groups to support their learning.

Week 8 – All groups took the final research methods MCQ quiz, and the results were released the following week.

Week 9 – All students were given an opportunity to view all the content for each of the week to cover any topics that they felt they needed extra help with. Students were then offered a retake of the MCQ research methods test the following week (Week 10).

Week 10 – Opportunity to retake the MCQ test, for those who requested it.

4.3.7 Personalised learning resources (PLR)

Each week, resources were produced for the students in the intervention, which supported them on the content covered during the timetabled sessions. The support materials followed the guidelines set by Klašnja-Milićević et al. (2011), which indicated the approach to be taken regarding the four identified learning styles, as seen in Table 4.4.

Table 4.4 Personalised learning resources guidance (adapted from Felder et al., 2000; Felder & Brent, 2010)

Learning Style	**Personalised Resource Guidance**
Activist/Reflector	The personalised resources for this type of learning will enable them to complete a practical task which involves them using the theory that was covered in the week's content.
Sensing/Intuitive	The personalised resources for this type of learning enable the student to revise the content covered in the week's seminars using clear factorial boundaries. The resources will be a problem-based approach based on their subject of study sport science.
Visual/Verbal	The personalised resources for this type of learner will be in the form of a video on the content of the weekly seminars which allows the student to revise difficult sections.
Sequential/Global	The personalised resources for this type of learner should enable the student to see the big picture of the theory and then the resultant logical steps which relate to the weekly theory.

4.3.8 Focus groups

Focus groups were used to gain a more in-depth understanding of the impact of the module's personalised support materials, using the approach outlined in section 4.2.2. The

themes that emerged from the online learning blogs acted as a starting point to allow for additional themes to be discussed. The approach taken led to knowledge being co-constructed with the students and a more in-depth understanding of how their learning style and the personalised support impacted on their learning environment. There was one focus group for each module teaching group, so six in total.

4.3.9 Quantitative data analysis

The scale data from the quantitative sampling methods was analysed through SPSS to investigate, through correlation analysis (Field, 2017), the effect of the intervention on the achievement of the student groups and to establish if there were any relationships. The data was collected over one semester, as outlined above in the protocol (see section 4.3.2). The data was examined through descriptive statistics before using inferential statistics to identify any significance or degree of freedom and, finally, the relative effect size was analysed using Cohen's D calculation (Cohen, 1992). As stated in section 4.2.3, normality checks were undertaken and due to the sample size, a Shapiro-Wilks test with a supportive Q-Q plot was carried out, testing at P=0.05. The normality testing procedures were not significant, therefore multivariate ANOVA was used to examine the between- and within-subject factors to assess the effect of the intervention. Correlations were performed to investigate if there were any relationships between the HEPS and the use of the personalised learning resources and a regression analysis was performed to gauge the level of effect. The statistical protocols used in this study followed the procedures outlined in Cohen (1992), Field (2017) and McKim et al. (2013).

4.3.10 Qualitative data analysis

The data in this section was from the student's online blog, and were analysed using NVivo 11 (Mac version) software. The themes and categories were examined in a similar manner, as in section 4.2.3. The first part of the analysis used the students' weekly blog entries. The blog data was analysed using a word frequency tool to identify the key themes in relation to the impact of the intervention on the student body and their achievement. The entries were coded in relation to the themes to highlight the dominant categories and topics to be discussed in the focus groups (Saldana, 2015). The second part was on the data from the

focus groups, which had students from each teaching group in the intervention module. The results of the focus groups were analysed as in section 4.2.3, in relation to the established themes, to ensure that the overall impact of the intervention was identified.

4.4 Data analysis and model production

Upon completion of the data analysis, the findings and quantitative data were used to create an implementation model using SEM. This technique is used where there are multiple variables potentially impacting on several outcomes, which can be linked in a system. SEM is a statistical technique that can be used to analyse structural relationships. The technique employs a combination of regression and factor analysis to explore the structural relationship between latent constructs and variables. A latent construct is a theoretical inferred relationship that cannot be measured, and variables can be used to establish the construct in which they sit. The variables in this study are the VLE engagement count, the student assessment results, both formative and summative, and the student module attendance percentage. The inference and therefore the latent construct are that, through the personalisation of learning resources, these variables can be increased and student performance as a whole improved. The data used to construct the model came from the third study and built on the initial inferential analysis undertaken as part of the study, in line with section 4.3.8. The size of the dataset meant that the model's relationship will be robust and valid in its application (Blunch, 2012; Byrne, 2013; Green, 2016; Kenny, 2015; Kline, 2015). The dataset was assessed using Cohen's D for the validity and impact of the sample size of the variables (Cohen, 1992).

Through the use of ANOVAs, regressions and correlations, initial relationships were identified and eliminated. The regression relationships identified as part of this analysis formed the main part of the model equations, and the impact of several of the relationships on multiple outcomes were then modelled. The constants identified from the regression analysis were critical when using SEM in constructing the model. SEM takes the variance-covariance matrix of observed variables as inputs and produces a model of the relationships of the variables with the identified construct and interplay.

The SEM enabled the exploration of links by suggesting an increase in one area; that is, more personalised resources, and viewing the outcomes on student performance. The level of resource required to make a significant improvement in students' performance was identified, therefore a direction for the implementation of personalisation learning was proposed. The model used software known as AMOS (IBM, version 24), which helps to visualise proposed relationships. This quickly identified the effect of changes in the input levels of the identified measures. The level of resource to increase or decrease the measure was calculated so, from an institutional point of view, the level of investment could be identified and assessed accordingly. The model proposed solutions to the research, as a whole, to develop implementation of technology in student learning in a more personalised, efficient and effective manner.

4.5 Chapter conclusions

The main themes from this chapter centre on the aims of the current research and the individual studies, which is broadly to investigate the effect of TEL in HE. The participants in the research are sport students, largely in the 18 to 22 age bracket and with a 70% male, 30% female, from mixed academic backgrounds, either thorough vocational studies or the traditional A-level route. The ethical issues of the research discussed the potential impact on students' learning and how this can be countered whilst still involving them in the research to produce an understanding of the current research phenomena.

The reflectivity of the researcher identified the need to be transparent about their views on the research topic and the approaches to be taken to reduce bias in data collection. The types of data and how they were to be reported were identified so that the qualitative and quantitative datasets could be used appropriately. The detailed individual study designs, which build on the different data types, determined how the data was analysed and the emerging themes used to answer the research questions. The final section discussed the techniques to produce an implementation model.

The data analysis in the next chapter aims to identify themes and data trends to enable the construction of the model presented in Chapter 6. The SEM techniques will produce a

model that, it is hoped, will inform the sector on implementing technology in students' learning in HE.

Chapter 5 Results

In this chapter, the findings from the studies in this research will be presented in a chronological and study order and interpreted, with the impact on the study questions and aims. An interpretation of the findings as a whole will be undertaken at the end of each subsection and then from an overall research perspective at the end of the chapter. The final and fourth main section will be the development of the themes and statistical relationships to develop the implementation model constructed from the findings of the research, as outlined in Chapter 6.

The first study investigated the effect of technology on the engagement of students in the modules which make up the programme in the research. Obtaining the datasets to begin the first study proved more problematic than expected, due to system changes at the University that meant that the data was stored in various locations and formats. When the datasets were analysed there were some interesting results, and this offered a guide to the second study, investigating the students' perspective of the technology changes on their programmes and how they felt this impacted on their studies and whether there were any areas for future development. The final study assessed the intervention designed as a result of the first two studies, using technology to personalise the students' learning experience. The individual study results then led to the production of a model using SEM. These results and the final model will be discussed further in the next chapter.

5.1 Study 1 – The effectiveness of technology-enhanced learning on students' engagement in their programme

5.1.1 Study question

> Have the levels of engagement (VLE interaction, attendance, achievement, as defined in key terms section of this thesis) in all year groups of undergraduate students changed as a result of technology-enhanced learning implementation?

5.1.2 Key findings

Once the data had been collected it was organised and coded appropriately, as outlined in Chapter 4. All the datasets used in the first study had normality checks to ensure that parametric statistical tests could be performed. A Shapiro-Wilks test with a supportive Q-Q plot, testing at P=0.05, indicated that the datasets were normally distributed. An ANOVA was performed to examine the effect of the E-learning and technology implementation on the performance indicators outlined in Table 4.1 for the outlined modules. A Pearson correlation was performed with resultant regression analysis to investigate the extent of the relationship between E-learning level and the dependent variable. Cohen's D was calculated to identify the effect size of the identified relationships (Cohen, 1992).

5.1.3 Student assessment

The results showed that that there were significant differences (p=0.001) between the final module grades when comparing pre-and post-Moodle results and between the different level of technology integration, namely the foundation and advanced levels. The level of E-learning and technology integration had a significant effect on module grades, with the advanced and foundation levels having a significant effect (p=0.001) on the final module grades. The intermediate level of implementation was not shown to be significantly different from the pre-Moodle final grade mean. Cohen's D calculations supported this finding by indicating that the effect size for the foundation level was D = 0.17 and for the intermediate level was D = 0.15, which are both considered a small effect size. The advanced E-learning level had a medium effect size where D = 0.47. A Pearson's correlation found that the final module grade was not correlated to E-learning level, r=0.124, p<.01. A linear regression was calculated to predict a student's grade based on the module E-learning level. A significant regression equation was found ($F(1, 3513) = 54.766$, $p < 0.000$), with an r^2 of 0.015. Students' final grade is equal to 7.808 + (0.760 x (E-learning level)), where E-learning level is coded as 1 = Foundation, 2 = Intermediate and 3 = Advanced. Students' grade increased by 0.706 per E-learning level.

E-learning was a significant predictor of students' module grade. The change in grade is rounded up to one grade on the Middlesex grading scale, which represents 2% to 4%. Figure

5.1 shows the effect of the E-learning level on the final grade average, which indicates that although there are significant differences the real effect on a student's module grade is limited. The average grade is 10 for the advanced modules and 8.5 for the intermediate E-learning level modules, indicating a range of 1.5. The variability in the module grade (indicated by the error bars on Figure 5.1.1) was reduced for the intermediate and advance level modules, 10 and 9.5 respectively, when compared to 13 for the foundation level modules. So, although the impact on the overall module grade was low, the range of marks was reduced, which could indicate that a more structured approach to supporting the students' learning through technology use reduces the variability in their achievement. The type of resources offered online through the intermediate approach is an element that was further investigated in Study 3 to further reduce variability and enhance students' module grade.

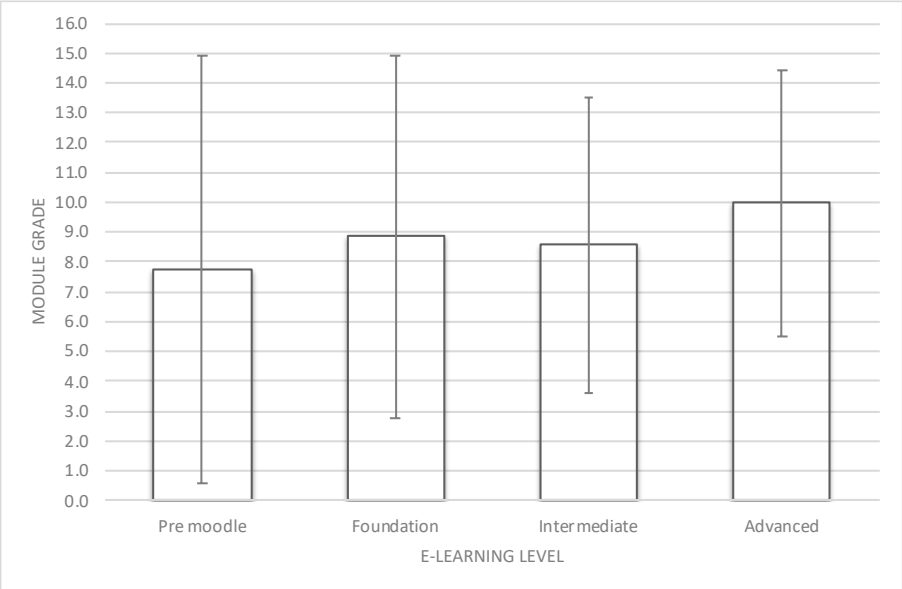

Figure 5.1 Effect of E-learning level on module final grade average on MDX grading scale

5.1.4 Student attendance

The effect of E-learning integration level on the students' module attendance follows a similar trend to the grade analysis (see Figure 5.2). The advanced and intermediate levels of integration had, on average, significantly higher student attendance (p=0.00), with the intermediate level of integration having significantly higher attendance than advanced modules (p=0.05). The reason for this was explored in Study 2 with the students and could

be because the support offered online by the advanced modules meant that some of the students did not feel a need to attend. The difference in the attendance rates was 61% vs 77% so, although significant, this was one session in four missed more in the advanced modules vs the intermediate modules. Cohen's D calculations supported these findings by indicating that the effect size for the intermediate and advanced E-learning level, when compared to the foundation level, were D = 0.74 and D = 1.0 respectively, which are both considered a large effect size. The advanced and intermediate comparison had a medium effect size, where D = 0.56, supporting the smaller difference between the levels, as noted above. A Pearson's correlation found that student attendance is strongly positively correlated to E-learning level, r= 0.710, p<0.01. A linear regression was calculated to predict students' module attendance based on the module E-learning level. A significant regression was found (F (1, 3513) = 3563.702, p < 0.000), with an r^2 of 0.504. Students' module attendance is equal to 1.631 + (23.150 x (E-learning level)), where E-learning level is coded as 1 = Foundation, 2 = Intermediate and 3 = Advanced. Students' module attendance increased by 23.150 % per E-learning level. E-learning level was a significant predictor of a student's module attendance.

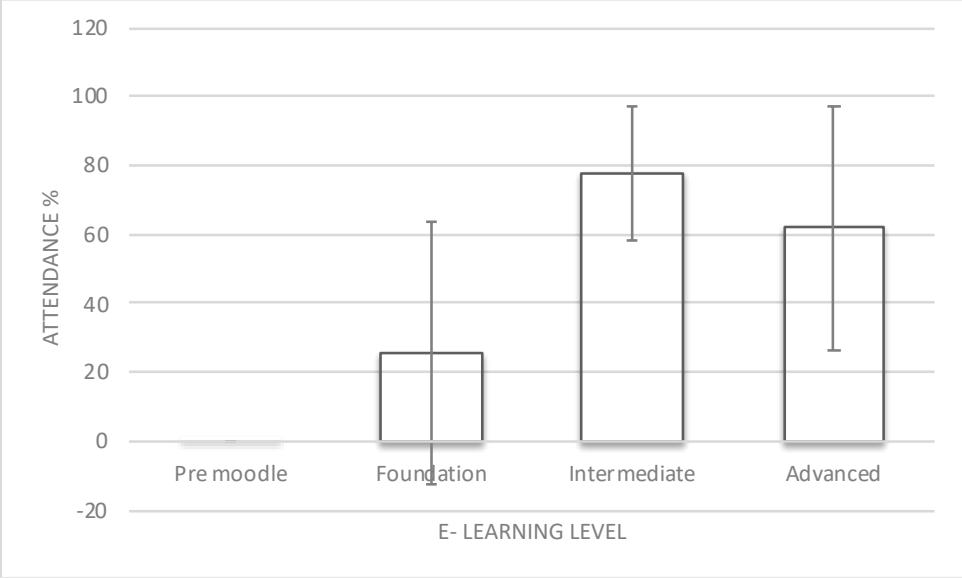

Figure 5.2 Effect of E-learning level on module average attendance

5.1.5 Student VLE engagement

The students significantly engaged more with the VLE post-Moodle implementation (p=0.00), <=10 VLE touchpoint per module vs <=70 VLE touchpoints per module. The level

of E-learning integration (see Table 4.3 for explanation) had a significant effect (p=0.00) on the number of VLE touchpoints that the students made per module, with the intermediate and advanced modules having higher touchpoints per student than the foundation-level modules. The significant difference in VLE touchpoints (as defined in section 1.2.1) supports the notion that if the support materials are made available to the students and they know how to access them, then they will use them. Cohen's D calculations supported these findings by indicating that the effect size for the intermediate and advanced E-learning level, when compared to the foundation level, were D = 1.33 and D = 1.04 respectively, which are both considered a large effect size. The advanced and intermediate comparison had a small effect size where D = 0.29, supporting the smaller difference between the level as noted above. A Pearson correlation establishes that student engagement is strongly correlated to E-learning level r=0.800, and significant, tested at p<.01. A linear regression was calculated to predict a student's module VLE engagement based on the module E-learning level. A significant regression equation was found (F (1, 3513) = 6233.037, p < 0.000), with an r^2 of 0.640. Students' module VLE engagement is equal to 4.278 + (23.150 x (E-learning level)), where the E-learning level is coded as 1 = Foundation, 2 = Intermediate and 3 = Advanced. Students' module VLE engagement increased by 25.252 % per E-learning level. E-learning level was a significant predictor of a student's module VLE engagement. Figure 5.3 indicates a similar shape, as in section 5.1.2, where the intermediate level of E-learning integration has a higher level of effect.

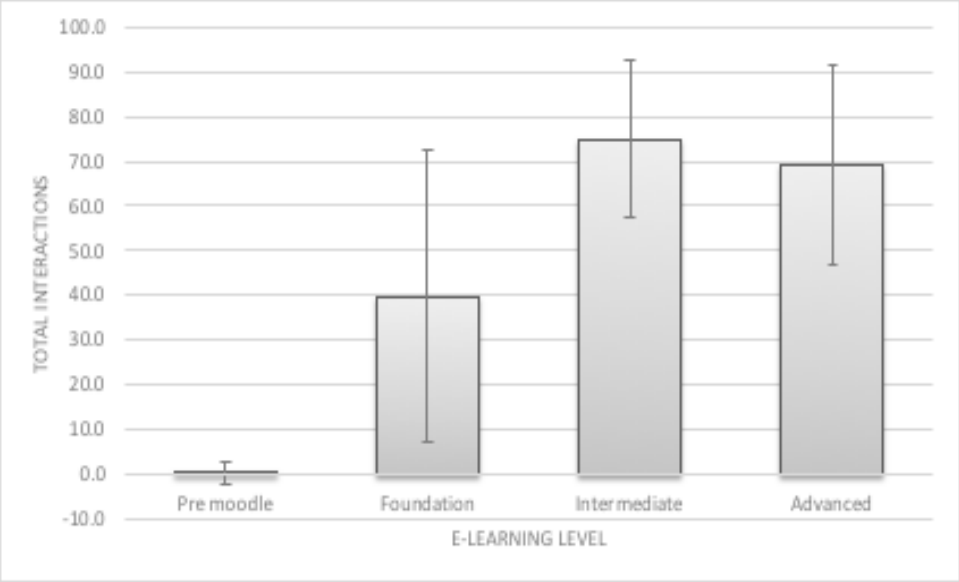

Figure 5.3 Effect of E-learning level on module average VLE interactions count

5.1.6 Variable intersectionality

The findings in section 5.1.3 to 5.1.5 indicate the effect of E-learning level on the three main variables of student assessment (final sit grade), module attendance and engagement (VLE engagement). E-learning level is shown to have a significant effect on the module attendance and engagement of students, but only a non-significant effect on their assessment. There were some intra relationships between the variables identified through a Pearson's correlation. As established, the student assessment grade was not considered correlated (r=<0.50 +/-) to any of the other variables. Module attendance and E-learning level were found to have a large, significant, positive correlation with engagement, 0.710 and 0.800 respectively. As a result of the significant correlation result, a multiple regression was performed to identify to what extent attendance and E-learning level could predict VLE engagement. Both variables were found to be significant predictors of engagement, $F(2,3512) = 6538.72$, $p<0.005$, $r^2 = 0.79$, which produced the following prediction equation:

VLE engagement = 3.413 + (0.530 x "Attendance") + (12.986 x "E-learning level")

If we assumed that an example student had an attendance of 80% and the module was at intermediate E-learning level, then there VLE engagement would be predicted to be

VLE engagement = 3.413 + (0.530 x 80) + (12.986 x 2) = 71.785 touchpoints

The regression analysis gives an indication of the relationship between student attendance and the E-learning tools used in the modules, showing that both have to be at a good level for the engagement touchpoints to increase. Students still needed to attend to increase their engagement, suggesting that the E-learning tools supported contact teaching sessions, not replaced them. The effect on student module attendance of the relationship between E-learning level and engagement was investigated using multiple regression analysis. The E-learning level of the module and the student VLE engagement were found to be significant predictors of module attendance, $F(2,3512) = 4266.89$, $P<0.005$, $r^2 = 0.71$, which produced the following prediction equation:

Attendance = -1.701 +(0.779 x "VLE engagement") + (3.482 x "E-learning level")

If we assumed that an example student had an engagement score of 60 touchpoints and the module was at intermediate E-learning level, then their module attendance would be predicted to be:

Attendance = -1.701 + (0.779 x 60) + (3.482 x 2) = 52.003%

The two prediction equations indicate that the E-learning level does have an impact on a student's module attendance and VLE engagement. However, the use of E-learning tools in the modules is not to the detriment of module teaching attendance, as they have a positive effect on each other rather than the online presence replacing the classroom attendance in a negative inverse relationship.

5.1.7 Study conclusions

The results from this study indicate that the E-learning level (see Table 4.3 for explanation) of the students' module does have an effect on their attendance, VLE engagement and overall grade. The degree depends on the level of E-learning used in the module, with the intermediate level having the greatest overall impact. The advanced level had an enhanced effect only on the students' final module grade. The linear regression model indicated that the overall grade of the module work increases by one grade point on the MDX scale (2-4%) per level of E-learning use. The attendance level of the students increased to a point

by 23% per level of E-learning use, as indicated by the linear regression. The relationship between the VLE engagement and E-learning level showed a 25% increase per level, which is unsurprising as the students would have largely had to access online the new resources available for the E-learning level on the VLE. The potential relationships between all three measures the students' attendance, engagement and achievement indicate that there is a significant positive relationship between VLE engagement and attendance, which is affected by E-learning level. The students' achievement through assessment grades was not shown to have a significant intra-variable relationship. The intra-variable relationship is an element explored further in Study three in a more experimental approach to technology implementation in modules.

5.1.8 Relationship of study findings to study question

The results answer the study aim by showing that the level of E-learning on a student's module has an effect on their grade, attendance and VLE use, and therefore their engagement. These findings support the notion that, if used appropriately, students employ the E-learning made available to them on their programme modules, which in turn increases their engagement with the module. It is interesting to note from the findings that the advanced level of E-learning use had a lower impact on attendance and VLE use, which is potentially because the high level of resources that the students could access obviated their need to attend sessions. The impact on the final grade was highest in the advanced level of use, which supports the notion of the level of resources for students to use in their studies. These themes will be explored further in the second study and potentially identify a way to enhance the advanced level of E-learning to increase its impact across all the factors.

5.2 Study 2 – The effect of the educational changes on the student experience towards technology-enhanced learning

5.2.1 Study question

> Have the educational changes had an effect on the student experience of technology-enhanced learning at Middlesex University?

5.2.2 Key findings

Feedback from the students via questionnaires such as the NSS, MSS and module evaluations was used to identify students' views on the use of technology, from which overall themes emerged. The data period was the same as that for the changes to the use of technology and E-learning on the programme and the implementation of Moodle, as analysed in Study one (see section 5.1). The themes from the questionnaire data and the data analysis in Study one helped to form the questions for the semi-structured focus groups in this study. The final questions used for the focus groups can be seen in the appendices. The themes taken forward into the focus groups are shown in Figure 5.4, emerging from the analysis of word frequency in the free text comments in the questionnaire data, as seen in Table 5.1.

Table 5.1 Words used to develop themes

Resultant theme	Phrases or terms	Frequent words
Understanding technology	Online paces, electronic submission, electronic resources, computer access	e-books, confidence, equipment, online, interactive, materials, technical, presentations, videos, excel, Facebook, submission
Technology use	Subject specific technology, PowerPoint, Social media, Web tools, Moodle	Module, like, lectures, feedback, resources, communication, availability, slides, Turnitin, software, techniques, submission, tools, upload
Changes in technology experienced	Impact of change, Technology issues due to change, Positive experiences due to change	Assignments, taught, organised, access, knowledge, coursework, improved, information, Equipment, computers, feedback, camera, voice, machines, preferred, multimedia, internet,
Technology development ideas	Mobile Technology, Module consistency, Personalisation, Module resources, Discussion forums	Revision videos, iPads, Apps, intuitive, personalised, consistent, online, accessibility, quizzes

The understanding of technology, in relation to the technologies that the students could access and use in the course, was the first theme, as indicated in Figure 5.4. The second was the change in technology use through their studies. The impact of the technology changes was the third, and the final theme was areas of development in relation to technology use as part of the students' learning. The theme charts were constructed as outlined in section 4.2.3. The highest frequency of coding against a theme is indicated by a darker segment colour, as in Figure 5.4. The themes of technology use and changes in technology experienced had a greater amount of transcription coded against them, so have a darker segment in the figure.

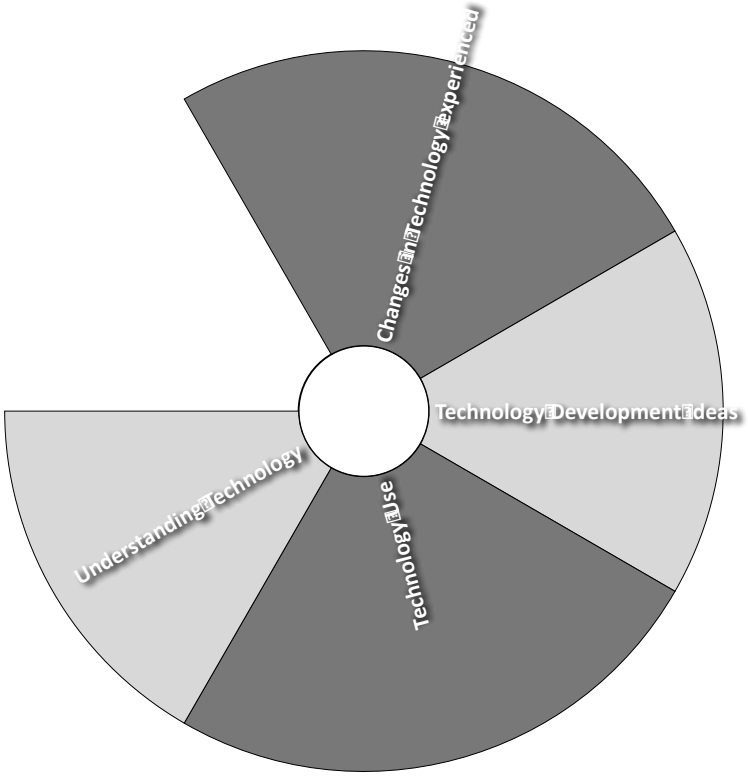

Figure 5.4 Main themes identified through analysis of student feedback; the darker grey, the higher the number of responses

The students indicated in their text comments that use of technology was varied across the programme but had increased throughout their study time at the University. The students' understanding and use of technology changed across the comments, from using it just a data source to access their grades to being part of their learning, as noted in the two quotes below:

"Just grades" (MSS, free text comments, 2013)

"Utilised to develop my learning" (MSS, free text comments, 2016)

The impact on assignment feedback in relation to usefulness and speed of delivery changed through the years of questionnaire data, as seen in the quote below, indicating that feedback was initially limited to very useful feedback, in the second quote.

"limited feedback' (NSS, free text comments, 2011)

"Very helpful feedback" (MSS, free text comments, 2016)

Each of the themes derived from the thematic analysis of the questionnaires, as shown in Table 5.1, were used to plan the focus group guide. The results from the focus groups are examined the next section.

5.2.3 Theme 1 – Understanding technology

The first theme to be explored was the students' understanding of what technology was, in their view, and what they had used on their course. The students noted that they had all used some form of technology during their course, even if it was to just to submit assignments. The students' understanding of how technology could help their learning had the least responses in the analysis of the focus groups. Responses ranged from module-specific pieces of technology to e-books. The notion that technology could help them learn directly, or the phrase E-learning, was not strongly found in the analysis. Both focus groups had the same trend, that they could identify technology that was available for them to use but not how it helped them in their course in any great detail, as noted in the following quotes, which were typical responses.

"PowerPoint. And then working through the fitness test and stuff, so all that kind of technology, machines"

"say, in the library or uses of, like, e-books and journals."

The students referred to the technology that they identified with throughout their time on the course, but in a very general way and with no indication of the impact that it had had, if any, on their learning. The students, in the majority, did use technology in their teaching sessions and could identify what technology was, but did not see the value that it added to their learning experience directly.

5.2.4 Theme 2 – Technology use

The second theme analysed during the focus groups built on the identification of technology to explore how technology in their modules had helped them to study the content in the modules that they were taking. Figure 5.5 indicates the technology that the students discussed in relation to how it had helped them learn the content.

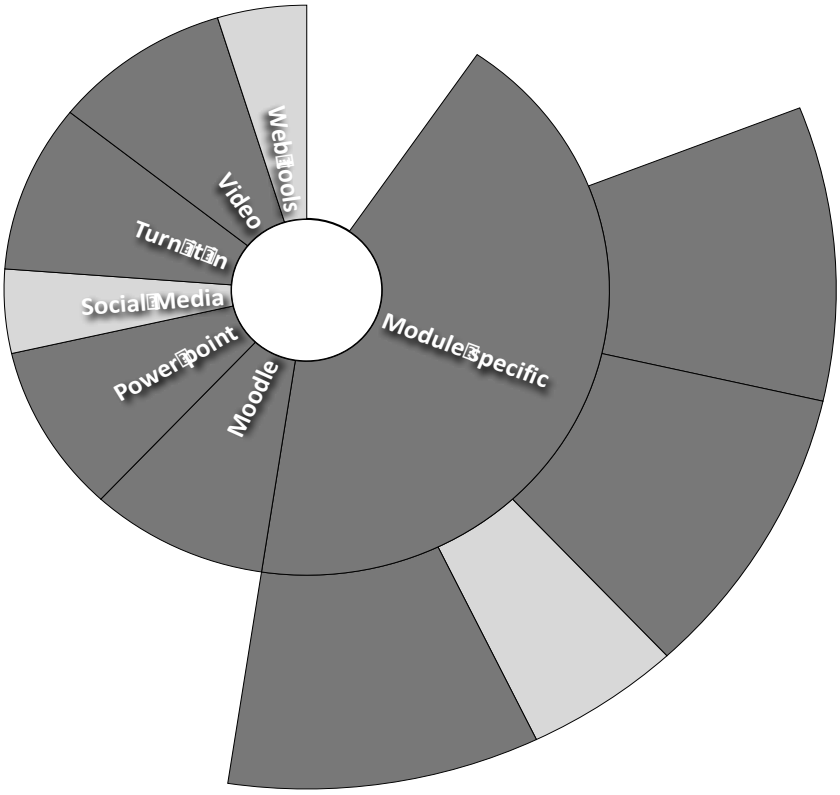

Figure 5.5 Technology identified by students as used throughout their studies; the darker the grey, the more responses

Aside from module-specific technology, the main elements of this theme were identified to be the use of video, PowerPoint, Turnitin and Moodle. The use of PowerPoint had a large number of responses and was the dominant technology mentioned by students outside of module-specific technologies. This indicates the level of integration of technology and understanding in the student learning to be basic and generic. Most lectures or seminars used PowerPoint to convey information to students.

The use of Turnitin was the second highest in this group, as this became the main route for students to submit their assignments and receive their feedback, so they had to interact and use it. The students attached value to the use of Turnitin as it gave them a way of recording their work and receiving feedback.

> "I used Turnitin for the three years that I was here. I think that it was a good system and it allowed you to have proof of when you submitted your assignment, stuff like that."

> "I think it made feedback a bit clearer"

> "Yeah. So they had, after you'd submit your work, you could go back onto that piece of work, you could see your grade"

The above quotes indicate that students engaged with the application 'Turnitin' and understood its use in their programme. The use of video and Moodle had similar depth of agreement in the student views, which gave an indication of the emerging use of these technologies as a means to help them in their learning, as the below quotes indicate. This shows how the technologies were implemented and were appreciated by the students and how they liked the approach as it was new, and the accessibility of the media meant that they could review the module content at any time.

> "Like YouTube, if you're not sure about an exercise, you can just type it in and they give you different variations of the same exercise."

> "Some of our lectures were also videoed and the lecturers put it online so you could watch the videos just to refresh your memory."

> "little videos or little clips. They're just really handy revision tools"

The students noted that the use of video helped them to revise and refresh their memory of key topic information from previous lectures; so, rather than the technology being just a resource, it had started to become part of their learning experience. Some of the issues discussed by the students in the second theme of technology use involved inconsistencies in materials, differences between lectures and the speed of the media as indicated below:

> "there was some inconsistencies with the stuff being uploaded online"

> "I think it depended, kind of, on the teachers of the modules at times"

> "It's been times where it was, kind of, freshly just come about, there was times where it could move slower or it might crash"

The use of Moodle was a topic that was discussed by the majority of students in the focus groups, as noted in Figure 5.5. The viewpoints were discourteous towards the platform in its earliest form, indicating that it was unfriendly and not the easiest to navigate. The way in which the technology is used and setup by the teaching staff is important, obviously within the limits imposed by the institution. However, the consistency issues mentioned by the students can help with the navigation of a system, if all the modules have the same layout.

5.2.5 Theme 3 – Changes in technology experienced

The next theme analysed was the change in technology use throughout the students' time on their programme. The impact of a change in the use and implementation of technology was noted in the majority of responses, indicating that the implementation of technology in their programme of study changed over their time on their course. The positive elements of change are displayed in Figure 5.6. Course information, revision resources and feedback

are shown as the elements of positive change with the highest response, with revision resources being a particularly dominant voice in the focus group responses.

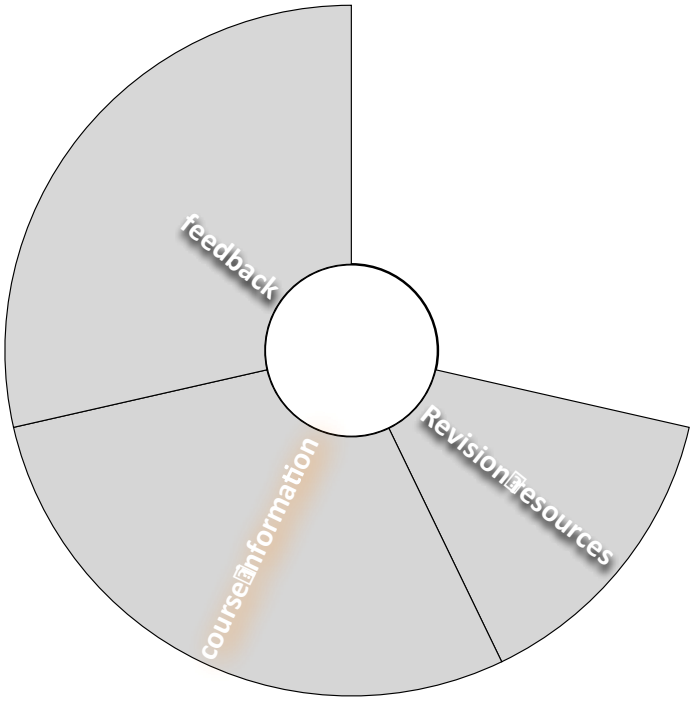

Figure 5.6 Elements of positive change identified by students

The effect of Turnitin is reflected in this figure, because the students reported that they received their feedback quicker through this technology, as well as it being more accessible and gave the students guidance for their next assignments, as indicated below:

> "'Turnitin' made a massive difference."
>
> "good feedback notes next to your assignment."
>
> "I mean, it made the feedback that anyone did get easily, or more easily, available"

The module information gave students a greater understanding of the content that they were studying, what the assignments entailed and what information they needed to cover. The use of Moodle, again, is reflected in this positive element as this module's information was available to the students on the Moodle pages whenever they wanted to access it.

> "With the online stuff, a lot of the lectures and things were put online. And so they were easily accessible and that helped during revision time, going over notes and stuff."

> "I just think the lecturers try their best and obviously they try to give you as much information and detail as you need and the students on…. on the University hub just so that we can be able to access it whenever we needed it."

The positive elements of change outweighed the negative issues identified by the students, with only a few responses to this theme. Although the use of Moodle and Turnitin were seen positively in this theme, students also encountered some issues during implementation. An analysis of the issues showed that these two technologies received the most responses and indicated that the negative comments were system related, as the students noted in the quotes below:

> "if you wanted to upload something and too many people at the same time were trying to upload their assignments, then it wouldn't get uploaded properly."

> "The only thing that we really found, not really the fault of the technology, is where you're having to upload videos for any kind of movement screens."

The final issue identified by the students was the lack of consistency across their programme modules, which meant that some modules had a high level of support online to help them revise whilst others would just have the lecture slides. This inconsistency issue reflects how the implementation of technology was evolving over time, and that some of the students in the focus groups felt that the use of technology increased through their time on the course, with the final year being the best. Whilst for some students this change in available content was an overnight change, others felt it was a gradual increase as Moodle use increased and more technology was implemented as staff became more familiar with what could be achieved.

"It definitely got better but having it… there are certain areas, certain degrees or pathways that might benefit from it being added to, I think."

"Yeah, definitely, especially the amount of, on my course particularly, the amount of contrast between the anatomy and theory-based stuff and then applying those concepts into your practical knowledge."

"I think they did improve over the years. I think I enjoyed Moodle more the longer I used it, because I got to learn a lot more."

"I think it depended, kind of, on the teachers of the modules at times."

5.2.6 Theme 4 – Technology development ideas

The final theme to be explored was the students' thoughts on the future development of technology use on the programmes. All students agreed that the use of technology to enhance their programme modules had improved positively but wanted it increased further, to be more intuitive and easier to use. Figure 5.7 indicates the suggestions made by the students, with some familiar elements from previous themes being mentioned.

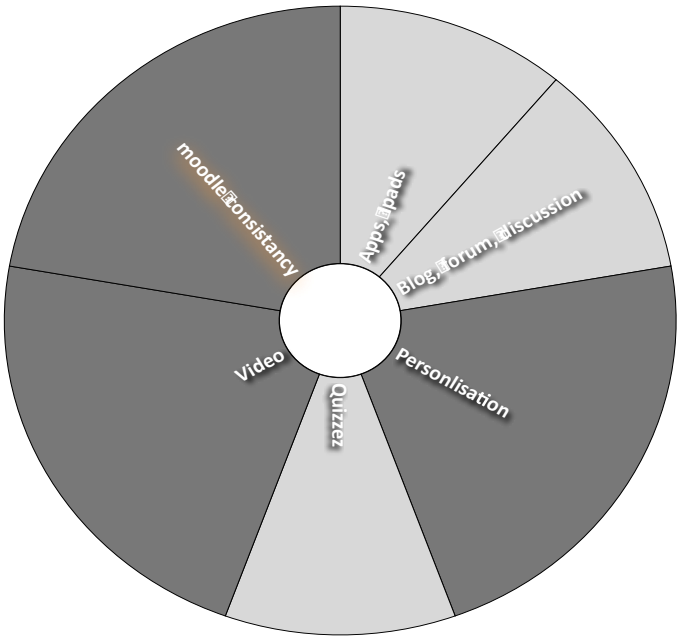

Figure 5.7 Technological improvements noted by students; the darker the grey, the higher the number of responses

The increased use of video was mentioned by several members of focus groups in very positive language, citing how this could help them to revise content delivered in class and receive information in another way, apart from the lecture. The issues around the difference in the module setups on Moodle were the most dominant suggestion, with students emphasising the need to have a consistent level of resources across the programme modules.

> "allows the students to then tailor their studies, as opposed to maybe having just one medium."
>
> "make the learning experience for the individual much better."
>
> "offering a bit of a personalisation, a little bit,"
>
> "would probably just suggest that if they can… are able to make it a bit more personal to the actual students themselves".
>
> "It'll take a lot of time."

A large number of students discussing the development of resources or technology that was more personalised or tailored in some way to the individual learner, in relation to the systems being more intuitive. Students felt that this was the next stage in the development of the online environment to support learning but acknowledged that it would require time, as noted in the above quotes. The use of several media, not just the PowerPoint slides, was suggested as building on the comments made about revision videos and quizzes. Students felt that it would be easier for them to use and match their studies if the technology was personalised to individual preferences.

5.2.7 Study conclusions

The themes from the first part of this study from the analysis of the student feedback showed firstly that the students, on the whole, felt that the use of technology across their programmes was very varied. Over the period of the feedback analysed, 2011 to 2016, the use of technology increased and developed from being merely an information source to

something that had started to be used in the students' learning. The students noted the use of technology on their programmes, particularly at modular level, had increased through their time on the programme and had an impact on their view of the module, as they were able to revise topics in preparation for assessments. This impact was particularly evident in terms of the feedback given on students' work. It was noted that both the speed of delivery and the usefulness of feedback had increased through the development of the use of technology. Although this centred on the use of Turnitin, with increased use by the institution as a whole as it moved to online assessment submission, the students felt that it helped them with assignments and to achieve their degree programme.

The final theme identified in the student questionnaires was the impact of technology implementation and change on their personal learning. Students, as mentioned, cited the change in the type of technology involved in their course learning, with various new elements being introduced into their learning experience. These three major themes of identifying and understanding what technology was used in this course, and what technology in relation to their learning and the change was experienced in relation to the technology in their learning experience, were then taken forward to the second part of the study and discussed in the focus groups.

The theme of technology use was introduced in the focus groups by exploring what the students felt was technology and how it was used throughout their studies. Both focus groups could identify the technology available to them but not how it was used to help them in their studies. There were some negative voices in the focus groups from the older alumni, who had only experienced technology in their final year and still felt that it was not in line with that of other universities. They did not value the tools that were made available to them, aside from Turnitin. The second theme explored students' use of technology on their courses, from access to PowerPoint slides and the introduction of Turnitin and e-books. This demonstrated that in the past the understanding of technology in the courses was limited but did develop, over time, and started to have an impact on their studies.

The use of video on the Moodle pages was noted as a great learning resource and one that both focus groups identified strongly with, although PowerPoint still drew the highest response. The students noted that the increased use and implementation of technology

had started to impact on their studies and helped them revise and learn outside of contact time. The development of the use of technology linked well with the next theme, which was the change of technology, and the students noted that the increase in feedback, course information and revision resources were positive aspects. With the increased implementation, the students did identify issues associated with this, and Moodle use and Turnitin accounted for a large proportion of negative responses, along with issues concerning the system being slow or unresponsive at times.

The final negative issue of technology use was Moodle inconsistency across the students' module and programmes, which the students found frustrating. The final theme identified in the focus groups was a suggested development of the use of technology in their learning. Both focus groups agreed that they would like to see the technology become more intuitive to use and offer a more personalised supportive learning environment. Within the improved online space, the use of video could be increased, as it was seen as the best way to help students to revise topics, along with a more consistent approach to module pages on Moodle. These suggestions and overall themes identified in Study 2 helped to form the approach taken to produce the learning resources used in Study 3.

5.2.8 Relationship of study findings to study aims

The results of this study provide some answers to the study question. The focus groups indicated that the development of students' modules in relation to the type of E-learning tools and technology implementation had an influence on the student experience and they did notice a change. The students on the whole noted a positive effect of TEL on their module experience. Four themes emerged from the data in relation to their learning, understanding of technology, technology use, the changes in technology and technology development ideas. The students' understanding of technology and how it could help their module learning ranged from basic use of PowerPoint to the use of videos to help revision. The students' use of technology in their modules changed as a result of TEL to include not just the use of PowerPoint but Turnitin videos, social media and Moodle. The third theme demonstrated how this change had affected their studies in a positive way through improved feedback, revision resources and access to course information. The final theme showed where students wanted the use of TEL to be developed: Moodle consistency

between modules, increased use of videos for support materials, blogs or forums for discussion and students' suggestion that modules could be more intuitive and personalised to them. The positive impact of the use of technology enhances learning, and the suggestions made by the student for future development will be used in the approach taken in the third study, to help maximise the effect of TEL on the students' module learning.

5.3 Study 3 – The effectiveness of personalised technology-enhanced learning on the progress of students in higher education

5.3.1 Study question

> Has technology enhancement personalised to undergraduate students' various learning styles significantly altered their progress on a taught module?

5.3.2 Key findings

The results for Study 3 will be divided into three parts. First, the findings from the blogs that students posted throughout the study will be presented with reference to the learning support materials, how the materials were presented and overall module online presence. Secondly, there is analysis of the students' weekly quizzes to help with revision, with the blog and focus group findings. Finally, the impact of the personalised learning materials is analysed in both qualitative and quantitative terms. The final questions for the focus groups are in the appendices. The analysis was completed as in sections 4.3.8 and 4.3.9.

Table 5.2 Phrases used to develop the themes from the blog posts

Theme	Subtheme	Phrases or terms
Weekly progress	Positive progress, Negative progress, Neutral progress	Progressing, well, interesting topics, current week, understand data, progress knowledge, great information, steadily learning, weekly quizzes, believing in self, Excel assessments, gradually confident, extended understanding, overwhelmed with topic,
Learning resources	Positive learning resources, Negative learning resources, Neutral Learning resources.	Learning materials, learning support, found useful, beneficial, provide information, extremely helpful, essential, benefit, detailed, interesting questions, support in revising
Module assessments	Positive towards assessments, Negative towards assessment, Neutral towards assessment.	Assessment performance, sections, revision of equations, individual quiz average, correct, scores, hopefully pass, remember equations, to advance is aim, appropriate assignment, challenge but complex assessment, confused on topics, need to improve, know requirements, need to revise, struggling with topics, should be successful

The students were asked to post an online learning blog throughout the data analysis section of the module. They were encouraged to write down their thoughts on themes including the weekly topics covered, the module learning support resources, their own progress on the module and how they thought they will perform in the module assessment. The views the students wrote in their blogs were viewed only by the student and the researcher. The blog posts were analysed for themes, using the same method as in Study two: word frequency. The results led to themes emerging, as seen in Table 5.2. Overall, the experimental groups engaged with the learning blogs more than the control groups, although the posts from the control group were more in depth, on the whole. The experimental groups were generally more positive in their comments about the identified themes, using a short sentence rather than a comment, using more positive language than in the control groups. Regarding negative responses, the experimental groups wrote fewer negative comments than their control group colleagues, although the language was at a

similar level. Each theme derived from analysis of the student blogs, as shown in Table 5.2, is examined in the next sections individually.

5.3.3 Blog posts theme – weekly progress

The first theme analysed from the blog posts was the weekly topics responses, where the students noted how they felt they had progressed with the topic that they had covered that week, in relation to their understanding of the content. As seen in Figure 5.8, both groups gave positive responses.

Figure 5.8 Weekly views of weekly topics noted by students; the darker the grey, the higher the number of responses

The control group made a higher proportion of positive than negative comments, mirrored in the experimental groups' comments, which had an even higher proportion of positive than negative comments. The content and materials used on a weekly basis were deemed by both groups to be appropriate and helped them with their understanding of the topic.

5.3.4 Blog posts theme – learning resources

The second theme analysed in the blog posts was on the students' views on the module learning resources and how they supported their learning on the module. Both groups found the learning resources a positive element of the module, as noted in Figure 5.9.

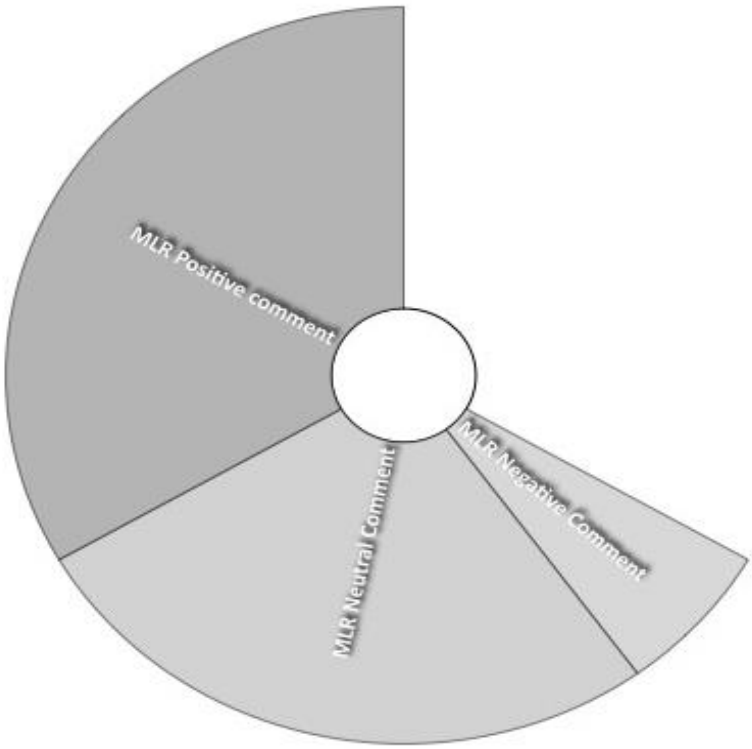

Figure 5.9 Weekly views of module learning resources noted by students; the darker the grey, the higher the number of responses

The experimental group, which had both the standard resources and the personalised resources available to them, mainly responded in a positive manner, similar to the control group focus group where, however, there were some negative responses mainly centred on the accessibility of the module on Moodle, so this was more a technical issue. The negative posts were at the beginning of the modules, and this can happen at the start of the year due to enrolment issues.

The increase in positive posts by the experimental groups about resources could be linked to the extra content made available to them, as there were no other differences in the learning resources made available to the groups. Additionally, both sets of students commented on the clarity of the layout of the module and the ease of accessing the

materials, which added to the positive nature of the responses from both groups, as can be seen in the quotes below. The module layout was the same for both the control and experimental groups, so the effect was controlled:

> "Everything is so easy for me to find on Moodle. I have all the learning materials I need at hand when needed."

> "I have found the materials very useful because the structure"

The personalised learning resources may have accounted for the increase in positive comments found in the experimental groups and the lack of negative comments. It could have been because the experimental group members were encouraged to interact with the online pages more, due to the extra content available, which meant they had more opportunity to post.

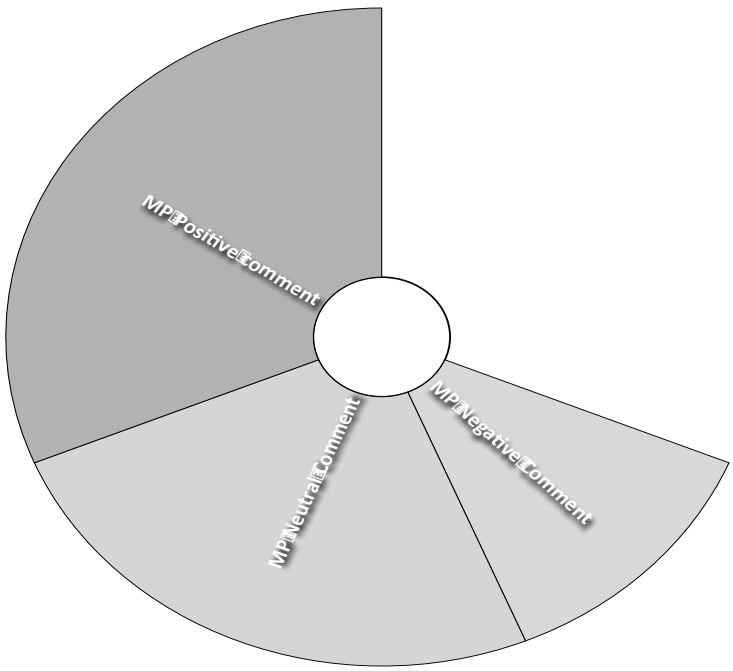

Figure 5.10 Weekly views of module progress and how they were developing (MP) as noted by the students; the darker the grey, the higher the number of responses

The biggest difference between the two groups was found when analysing students' thoughts on their personal progress through the module as a whole. The theme of the students' own progress received the greatest number of responses from all groups, which followed a similar trend to the other themes, as seen in Figure 5.10, with positive

comments being posted. The experimental groups' comments were almost all positive, compared to just over half the comments in the control groups, indicating that the students in the experimental groups thought they were making good personal progress.

The students' understanding of progress could be different: the type of language used to describe progress in the experimental group involved 'knowledge' 'understanding' and links to their grades. On the whole, the control group students still felt that they were making positive progress but the language used was just 'making progress' or 'progressing well', which did not given any context. In the control group, a substantial number of voices were neither positive or negative, and just said 'it's not going bad' and 'I need to interact more' which, with the positive comments, made up the majority of the responses from the control focus groups. Overall, the groups felt that the content and materials were helping them to progress through the module, with the experimental groups indicating strong positive progress, as the below quotes show:

> "I feel I'm progressing well in this topic and the learning support materials have been very helpful."

> "I am fairly satisfied with the learning support materials for this section of the module because it is easy to understand and find on Moodle."

> "I am progressing well, making the most of the online resources the University has to offer as well as applying that to online knowledge and pre-gained knowledge."

5.3.5 Blog posts theme – module assessments

The final theme to be analysed from the blog data was the students' views on how they felt they would perform on the module assessments related to the data analysis topics covered. As shown in Figure 5.11, on the whole the students responded with positive comments to how they felt they would achieve in the module assessments, and neutral comments were the second most common response.

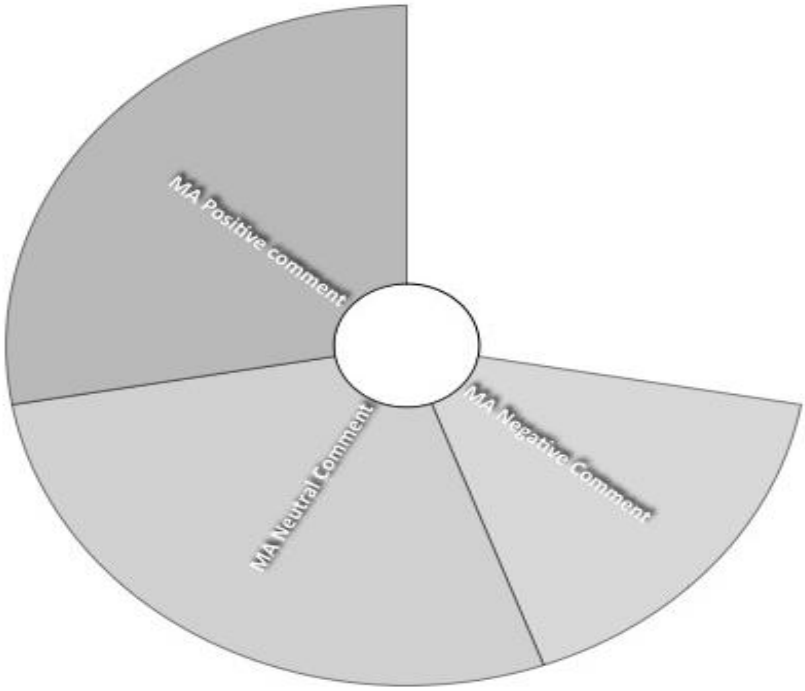

Figure 5.11 Weekly views of how students felt they would perform on the module assessment (MA), as noted by students; the darker the grey, the higher the number of responses

The experimental group and control groups both had a majority of voices giving positive comments in relation to module assessments. The control group had a slightly higher proportion of neutral comments than the experimental group. The positive response to the module support and teaching was still evident when the responses were split, as indicated in the quotes below. The language used in the quotes is similar, with both saying that they will 'perform well' and state 'I will', taking ownership of their performance in the assessment. From the control groups:

> "I think I will perform well on the assessment for this section because I have good understanding of the requirements needed".

> "I think I will perform quite well in this section as long as I remember the key terms and correct information".

From the experimental groups:

> "I am confident about the assessment".

"will perform well on the assessment with some individual revision".

The negative responses were in the minority for both groups, but the language use was very different. The experimental group stated, 'quite a challenge' while the control groups said 'not confident' or 'struggle'.

Throughout the data analysis of the identified themes, the students' blogs were overwhelmingly positive about how the module had supported them. The experimental group had a higher proportion of positive responses to the themes, which could be attributed to the extra personalised content made available to them through this section of the module. This is due solely to the use of the personalised resources, as the rest of the module and the teaching staff were the same. As outlined in section 3.6, each seminar group had two sessions a week, one taught by the researcher and the other by the second member of staff on the module. The use of two tutors meant that the students in either control or experimental groups could not be unduly influenced. Each of the themes derived from the thematic analysis of the student blog posts, as shown in Table 5.2, were used to plan the focus group guide for this study. The same process for developing the themes to code the focus group responses was conducted in the blog posts and the word frequencies, which made up the themes can be seen in Table 5.3. From this analysis, the themes to interpret the focus groups were established, and will be examined in the next sections.

Table 5.3 Phrases used to develop the themes from the focus groups

Theme	Sub theme	Phrases or terms
Module E-learning resources	Module learning, Module assessment, Personal development, Learning resources issues	Helped a lot, resources, understanding, boosted skills, online practice, modules, using analysis, Excel examples, formula techniques, MyUniHub approach, interpretation exercise
Personalised learning resources	Positive experience with personalised learning resources experience, Developments for personalised learning resources, Personalised learning resources issues.	Quizzes, terms provided, analysis examples, lesson revision, interactive, dataset, graphs, learner structure, advanced, encouraged subject, personalised, subject, weaknesses,
Module learning experience	Improved experience, Reduced experience, Unchanged experience.	Data understanding, questions, data skills, analysis work, learn, revision resources, understanding, YouTube resources, confident with skills, research skills, resources explained

5.3.6 Focus group theme – Module learning resources

In this study, both groups had access to formative online weekly quizzes designed to help them revise the topics covered that week and help reinforce their learning through engagement with the resources made available on the module pages. The students noted these as very beneficial to their development of the data analysis knowledge and as a revision aid for the final assessment. These comments were found in both the learning blogs and focus groups, as noted in the below quotes:

> "I think I'm going to perform quite good, as I got 10 points from the last quiz."

> "I feel I am progressing well. This shows in my weekly quiz."

> "Did well on the weekly quiz, so hope to do well."

"They're for practice and pushing us."

"The quiz about what sort of learning we want, so I feel like doing that, especially, that helped me out massively"

The quizzes were multiple-choice questions and available to all groups in the same format, and students were able to retake them as many times as they liked. As stated above, all groups reported that they helped to provide support for the students, away from the weekly taught sessions. The quizzes were used in tandem with the resources made available online, which also received a positive response, as noted above, and added to the positive learning environment created on the module.

5.3.7 Focus group theme – Personalised learning resources

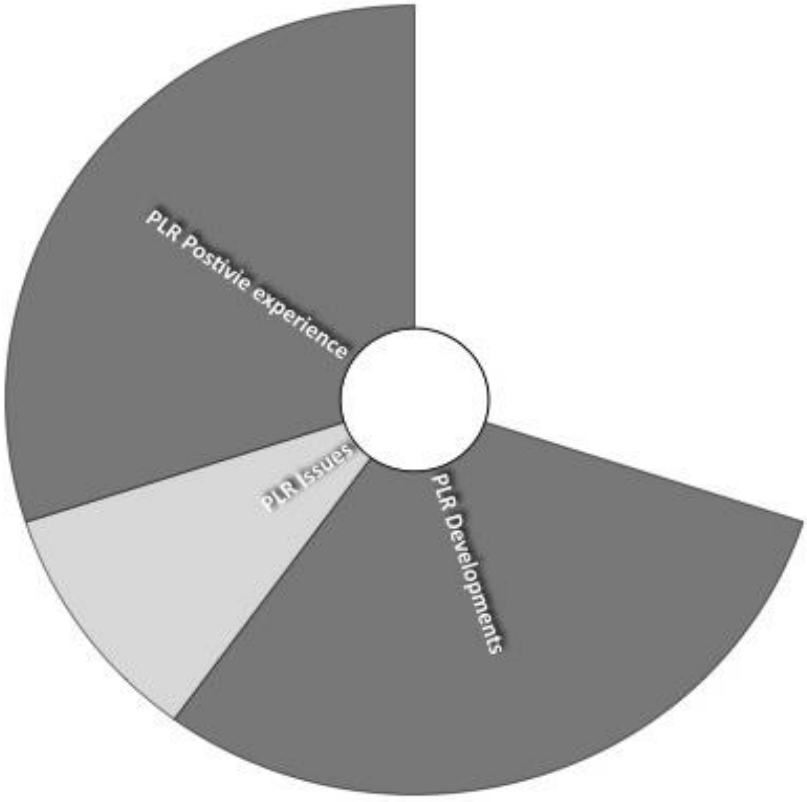

Figure 5.12 Focus group responses of students on their experience of using the personalised learning resources; the darker the grey, the higher the number of responses

The final part of the learning environment of this module was the use of the personalised learning resources made available to the experimental group every week after the taught

session. The resources were drawn up in line with the guidance outlined in Table 4.4 and each student's personal learning style. The resources were designed to help to support the students' learning of the weekly topics and guide them through the content towards the module assessment. The students' views of the resources were collected mainly through the focus groups and supplemented by some responses from the learning blogs. Figure 5.12 indicates that the students who had access to the personalised learning resources felt that they helped to create a positive learning experience, accounting for the majority of the responses in the focus groups. The quotes indicate this positive effect on the students, and the language used mentions their 'understanding', feeling 'understood' and how they 'helped us'. The students used positive language in relation to the theory of data skewness and kurtosis, which is unusual, and could indicate their engagement in the topics.

> "I didn't struggle as much, because the way it was done is you built it up to, like, kurt and skew. So, we, kind of, like, understood it."

> "Yeah. It's good to have them always on. You can always get them when you want to, when you are struggling. Yeah, I think it's good. "

> "going through some of the data, like, you know, the skew and kurts and that, it helped us to be able to have more understanding of how to do data and analysing them."

5.3.7 Focus group theme – module learning experience

The effect of the personalised learning resources on the groups' perception of the module learning experience was noted to be more positive, in the majority of voices in the experimental groups, than the control group responses. The control group had some responses that indicated that the resources did not change their module experience, compared to no mentions of zero change in experience in the experimental groups, which again shows the impact of the personalised learning resources on the learning experience. Both the control and experimental groups reported that the resources used in the module helped them with their personal development and learning of the module and course

subject. As noted in the below quote, students reported that the skills learnt in this module helped them to develop their general research and data analysis knowledge.

> "What we did from this module, you're able to look at, like, data and information in a different light, in the way where you're able to analyse it better."

The experimental focus groups made more suggestions for their personal development due to the module resources and the personalised learning resources. The increase in this development could be linked to the extra personalised learning resources that the experimental students had access to. The layout and organisation of the resources were generally seen as a positive element of the module, which could have also affected their personal development. The students suggested developments to the resources to make them more intuitive to individual students, as they felt that this would enhance the positive experience further. As the quotes below indicate, a student would like the personalised learning resources to have the level of interactivity increased and to introduce this approach across the other modules on their programme. Making the resources more intuitive to the individual student could be achieved by allowing each student to see the whole range available so that they could make a choice, and they felt that they had ownership of this element.

> "if there is an opportunity or something where you could make it even more interactive"

> "Resource levels should be brought up on the other modules"

The students' responses suggested that the resources helped them with the module assessments, but there was no real difference between the experimental and control group students in terms of the proportion of positive responses. The major difference noted from the focus groups was in personal knowledge and generic skills development, which had a higher response rate in the experimental student focus groups. The impact of the personalised learning resources approach, from the student perspective, was positive for the overall module experience and their own personal development. However, in terms of

the impact on assessment, there was little difference in terms of the level of response, as discussed.

The assessment results for this module were compared to gauge the numerical effect of the use of personalised learning resources. A Shapiro-Wilks with a supportive Q-Q plot, testing at P=0.05, indicated that the datasets were normally distributed. A multivariate ANOVA was run with supporting Cohen's D calculations to gauge the effect of the personalised learning resources on the students' data analysis module assessment, VLE engagement and module attendance. A non-significant Levene's test indicated that the groups had equal variance, and the similar size of sample groups 65 (experimental) vs 66 (control) meant that a Tukey post hoc test could be used with the ANOVA.

5.3.8 Student assessment

The use of personalised learning resources had an effect on both types of assessment, the formative weekly quizzes and the summative data analysis quiz. The effect on the weekly quizzes showed a significant (p=0.036) increase in grade, by 9%, and a Cohen's d figure of 3.01, which is a large effect. A linear regression was calculated to predict students' data analysis grade based on their weekly quiz average using the personalised learning resources. A significant regression equation was found ($F(1, 63) = 14.557$, $p < 0.000$), with an r^2 of 0.188. The predicted data analysis grade of students using personalised learning resources is 48.1 + (0.414 x (weekly quiz average)), where the weekly quiz grades are shown in percentages. Using the equation above with an example student with a 75% weekly quiz score, we can see that using personalised learning resources they would be predicted to gain an overall data analysis grade of 79.15%. The score in the formative weekly quiz was a significant predictor of students' data analysis summative grade. The personalised learning resources available to the experimental group had an impact on a weekly basis, with a higher average grade. The use of the weekly quizzes, as noted above, was seen as a positive element by the students, also reflected in their performance.

The findings of the effect of the personalised learning resources on the summative module assessment, when comparing the control and experimental groups, indicated that the personalised materials had a significant effect (p=0.01) on the final data assessment grade,

as seen in Figure 5.3.6. The grade increase between the control and experimental groups' final marks is on average 10%. The Cohen's D figure was 3.70, which is a large effect. The students who used the personalised resources on average performed a whole grade boundary higher than those who did not. There was no significant difference between the type of personalised resources available to the students, which indicates that the approach was consistent in supporting the students and that no single category of learner in the experimental groups received significantly more support than another. There were no reported large effects from the Cohen's D calculations for the different types of personalised resources, again supporting the notion that the approach was consistent.

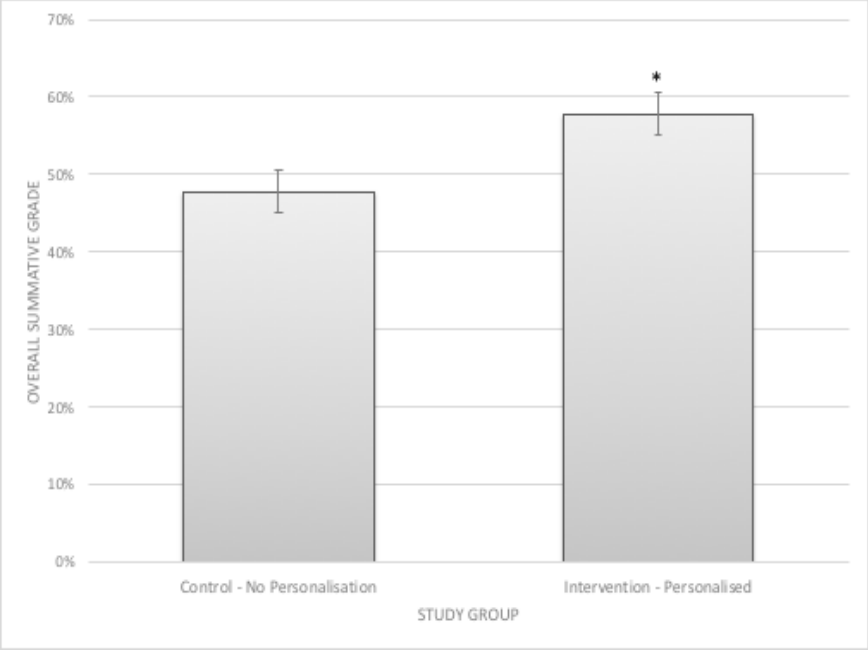

Figure 5.13 Overall mean comparison of final summative grade between personalised and non-personalised study groups. Summative grade is shown as a percentage, with the error bar showing one standard deviation; * indicates a significant difference

5.3.9 Student attendance

The students in the personalised learning resource study groups, on average, had 10% higher attendance then their control counterparts. The difference in attendance was not significant (p=0.056), yet the effect of personalised resources on module attendance was considered large in accordance with a Cohen's D figure of 2.7. These results indicate that although the personalised resources groups received more content online to help with their studies, students still valued face-to-face contact rather than seeing the resources as

a replacement. A linear regression was calculated to predict students' data analysis grade based on module attendance average using the personalised resources. A significant regression equation was found (F (1, 63) = 20.396, p < 0.000), with an r^2 of 0.245. Students using personalised resources had a predicted data analysis grade equal to 21.6 + (0.448 x (Module Attendance)), where students' module attendance is measured as a percentage. Applying the equation above to an example student with an 80% module attendance, we can see that by using personalised resources they would be predicted to gain an overall data analysis grade of 57.4%. Module attendance was a significant predictor of students' summative grade for data analysis.

5.3.10 Students' online engagement

The online engagement of the students on the module was significantly (p=0.00) affected by the use of personalised resources. Cohen's D indicated that there was a large effect with a D value of 4.61. The students in the experimental study group on average had 38 more touchpoints with the online materials than the control group students. A touchpoint in this instance is when the student logs into the module page on the University VLE for a period of time (minimum 5 minutes) or accesses the library resources for the module. For the 10 weeks of the data collection section, eight being content sessions, the personalised study group students were making on average four extra interactions per week. As seen in Figure 5.14, the students in the personalised study groups (using their learning style and guidance outlined in Table 4.4), made 10 touchpoints per week compared with five for the non-personalised study groups. The significant difference is not unexpected, as the students in the personalised study groups had more content to view on the module pages (due to the personalised resources available) and therefore a higher touchpoint count could indicate that the students did engage with the extra resources made available to them.

A linear regression was calculated to predict students' data analysis summative grade based on VLE engagement using the personalised resources. A significant regression equation was found (F (1, 63) = 13.346, p < 0.001), with an r^2 of 0.473. Students using personalised resources predicted data analysis summative grade is equal to 47.3 + (0.001 x (VLE engagement)), where VLE engagement is measured in touchpoints. Using the equation above with an example student with 50 touchpoints, we can see that by using personalised

resources they would be predicted to gain an overall data analysis grade of 47.35%. VLE engagement was a significant predictor of students' summative grade for data analysis.

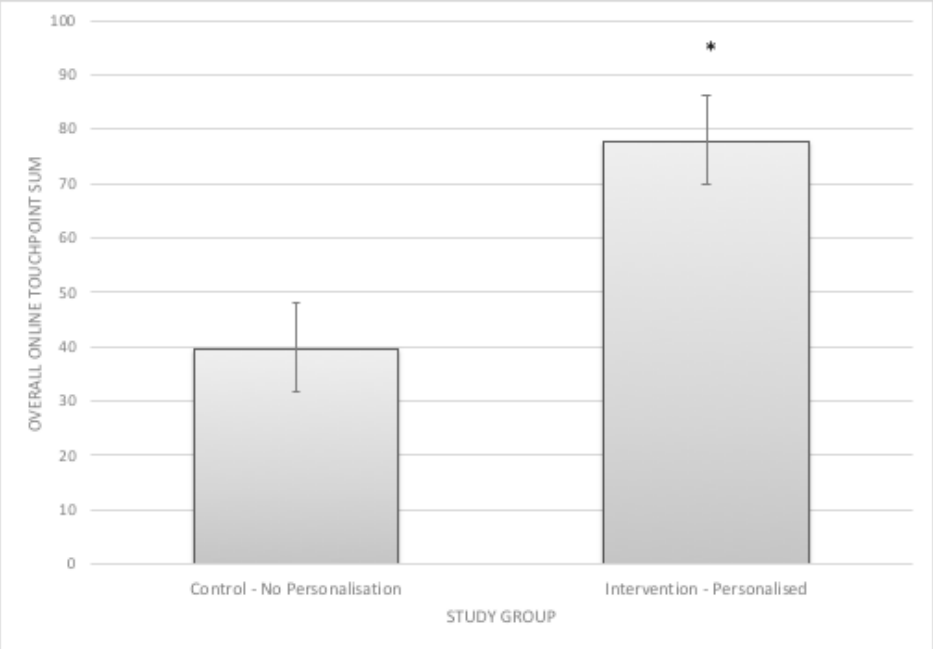

Figure 5.14 Effect of personalised learning resources on students' average online touchpoint counts; * represents a significant difference (p=0.00) between the two groups, with the personalised resources group having a significantly higher count

5.3.11 Personalised resources overall effect

To compare the effect of personalised resources on all of the independent variables and therefore as a predictor for a student's final summative data analysis grade, a regression analysis was undertaken. The resultant experimental and control prediction equations could then be used to calculate the effect of using personalised resources on the student's final summative data analysis grade. A multiple linear regression was calculated to predict students' summative data analysis grade based on VLE engagement, weekly quiz average score and module attendance using the personalised resources. A significant regression equation was found ($F (3, 61) = 10.778$, $p < 0.000$), with an r^2 of 0.346. Students using personalised resources had a predicted data analysis grade equal to 19.9 + (0.001 x VLE engagement)) + (0.336 x (weekly quiz average)) + (0.287 x (module attendance)), where VLE engagement is the number of weekly touchpoints made by the student online, and attendance and weekly quiz grade are measured in percentages. Using the equation above with an example student with 50 touchpoints, 80% attendance and a 75% weekly quiz

score, we can see that using personalised resources they would be predicted to achieve an overall data analysis grade of 68.11%. The module attendance, weekly quiz score and VLE engagement were significant predictors of students' data analysis grade.

A multiple linear regression was calculated to predict students' summative data analysis grade based on VLE engagement, weekly quiz average and module attendance when not using personalised resources. A significant regression equation was found ($F (3, 62) = 9.028$, $p < 0.000$), with an r^2 of 0.304. Students not using personalised resources had a predicted data analysis summative grade equal to 36.2 + (0.001 x VLE engagement)) + (0.181 x (weekly quiz average)) + (0.052 x (module attendance)), where VLE engagement is the number of weekly touchpoints the student makes online, and attendance and weekly quiz grade are measured in percentages. Using the equation above with an example student with 50 touchpoints, 80% attendance and a 75% weekly quiz score, we can see that using personalised learning resources they would be predicted to gain an overall data analysis grade of 54.43%. Only VLE engagement was a significant predictor of students' data analysis summative grade in the multiple regression for the non-personalised resources group.

Using the regression equations with this example student, the effect of personalised resources can be seen in the difference in the two predicted summative grades, where the student using personalised resources could have their grade increased by 13.63%. This demonstrates that the use of increased has a significant impact on VLE engagement, weekly quiz scores and module attendance, as a result of which there are increases in the students' overall summative assessment grade. The students noted in the focus groups that they felt the personalised resources had a positive effect on their learning, as can be seen in Figure 5.12, supported with the above stated regression analysis results.

5.3.12 Personalised learning resources intersectionality

The use of personalised learning resources is effective, as shown above in the results, however the implementation model needed to be developed incorporating staff resources (their time) as a factor. The intervention used in Study three used four different resources for each taught session to match the learning styles (see Table 4.4). The preparation time

required to produce the extra resources for each session could been seen as too high, even given the clear potential benefits of using personalised learning resources. A subsequent model needed a reduction in the quantity of personalised learning resources to ease acceptance and adoption in practice. In order to choose which resources would be used in the final model, the various combination needed to be modelled through regression techniques and considering the views of the students from Study two on the final choice.

The significance level for the regressions modelling was the same as in the other regression analysis in this study, where $p>0.005$. The r^2 value was also considered in the decision, where the higher the value the greater the control of variability offered by the regression model. The significance level and r^2 value were used as selection criteria, in line with literature in the area (Blunch, 2012; Field, 2017). The initial personalised learning resources regression equation used a set of test values, and this was used in this analysis, where "online engagement" was set at 50 for test value 1, "module attendance" was set at 80 for test value 2 and "weekly quiz average" was set at 75 for test value 3. It is important to note that the original personalised learning resources regression equation cited in section 5.3.11 gave a predicted summative grade with the same example figures of 68%, so any adjustments to the number of resources needed to be comparable. The regression results in Table 5.4 all used the standard regression equation of:

Summative grade predication = B constant + [("online engagement" x Test Value 1) + ("module attendance" x Test Value 2) + ("weekly quiz average" x Test Value 3)]

Table 5.4 Personalised learning resource combination regression analysis results

PLR resources	*B* constant	Online Engagement	Module Attendance	Weekly quiz average	Predicted Summative grade %	Significance	r^2
1&2	26.400	0.000	0.191	0.528			
Calculation		0.000	15.280	39.600	81.280	0.000	0.499
1&3	10.400	0.000	0.438	0.297			
Calculation		0.000	35.040	22.275	67.715	0.001	0.358
1&4	14.700	0.000	0.333	0.638			
Calculation		0.000	26.640	47.850	89.190	0.001	0.494
2&3	6.700	0.000	0.539	0.210			
Calculation		0.000	43.120	15.750	65.570	0.000	0.428
2&4	7.200	0.000	0.494	0.404			
Calculation		0.000	39.520	30.300	77.020	0.001	0.557
3&4	-2.000	-0.001	0.725	0.291			
Calculation		-0.050	58.000	21.825	77.775	0.013	0.503
1&2&4	16.600	0.000	0.327	0.516			
Calculation		0.000	26.160	38.700	81.460	0.000	0.503
1&3&4	5.400	0.000	0.510	0.351			
Calculation		0.001	40.800	26.325	72.526	0.000	0.400
1&2&3	22.400	0.001	0.287	0.235			
Calculation		0.050	22.960	17.625	63.035	0.000	0.349
2&3&4	2.900	0.000	0.578	0.277			
Calculation		-0.002	46.240	20.775	69.913	0.000	0.458

Using the established criteria, the top resource combinations were identified, as in Table 5.4. Resources 1 and 2 are very similar, both being a worksheet or activity that builds on the content covered in the taught session. The difference between the two was the subject specificity requirement for Resource 2. As a result of the overlap, the need to have both in the final combination is reduced. The students said that they liked to have a revision video available to them after the taught session to summarise the key themes and repeat any key techniques from the taught session. Resource 4 was a global thematic image of how the taught session fitted into the whole module topic, which appears in all the top combinations, as in Table 5.5.

Table 5.5 Best combinations of personalised learning resources using criteria

Choice	PLR combination	% Predicted summative grade	% Difference from original PLR	Significance	r^2
A	1&4	89.190	20.835	0.001	0.494
B	2&4	77.020	8.665	0.001	0.557
C	3&4	77.775	9.420	0.013	0.503
D	1&2&4	81.460	13.105	0.000	0.503
E	1&3&4	72.526	4.171	0.000	0.400

Taking all of these considerations into account, the combination that reduces the amount of preparation time for the staff and meets the established criteria is Combination E, as in Table 5.5. The full significant linear regression for this combination of resources used in the production of the model was found to be ($F (3, 46) = 10.215$, $p < 0.000$), with an r^2 of 0.400. A predicted summative grade equation for this combination (1&3&4) is equal to 5.4 + (0.118E-5 x VLE engagement)) + (0.351 x (Weekly Quiz average)) + (0.510 x (Module Attendance)), which, using the test figures, gives a grade of 72.55%, thus higher than the original personalised learning resources equation. The r^2 value is also improved from the original equation, which means that it shows more control of the variability and is a greater fit to the data. The chosen combination indicated that the impact of personalised learning resources can be maintained whilst reducing the amount of preparation required for staff to implement personalised learning resources.

5.3.13 Study conclusions

The first part of this study explored students' views on a more consistent approach to the online presence of the taught module in this study, in addition to the impact of personalised learning resources on their learning and assessments. The students responded positively to the module format and felt that it positively affected their learning, as they understood their weekly progress and knew where to find materials to help them

to revise and prepare for the following week's topics. They felt that the online environment supported their learning in the classroom sessions. These positive views were from both the control and experimental groups of students. This feedback was rewarding, as the research has maintained that TEL should support, not replace, module taught sessions.

The main part of the final study looked at the impact of personalised learning resources on the students' assessment, module attendance and online engagement. The students were split into control and experimental groups. To ensure that there was no significant difference between the student groups' data analysis knowledge, an independent samples t-test was completed on a baseline data assessment to compare the two: control group (39.94 ± 28.11) and experimental group (38.28 ± 24.511), t (129) = 36.1, p= 0.719. The t-test indicated that there was no significant difference between them as both were starting at a similar level of knowledge.

After the intervention was completed and students had undertaken their final data assessment, the difference between their baseline and final score was calculated. An independent samples t-test was conducted on the change in data assessment result, to compare the two types of groups: control (8.76 ± 50.311) and experimental (27.72 ± 47.018), t (129) = -2.228, p= 0.028. The t-test indicated that there was a significant difference between the groups, which meant that the experimental groups had increased their assessment score from their baseline score on average 27.72%, which is 18.96% higher than that of their control group counterparts, which increased by 8.76%.

The impact of personalised learning resources can be noted as significantly positive, as seen in the significant difference in the change from baseline to final summative score. Breaking down this impact to look at the direct impact of personalised learning resources on assessment, this study found that, for formative assessment, students who had access to the personalised learning resources had a significantly higher grade (p=0.036), on average 9% higher. The formative assessments were available to the students in the form of weekly quizzes. The summative results of those of the experimental group who had access to personalised learning resources, too, were significantly different (p=0.01), achieving on average 10% higher for the data analysis summative assessment. The impact in terms of

the students' assessment overall was significant, with an average 10% difference between the experimental and control groups.

The next component to be explored in detail is the effect of personalised learning resources on students' module attendance. Although there was a 10% average increase in attendance in the experimental group compared with the control group, this was not found to be significant (p=0.056).

The final component was students' online engagement, which was found to be significantly (p=0.001) higher in the experimental group. These students on average engaged with the online environment for a total of 38 touchpoints. These findings indicate that, as could be expected, the students in the experimental group engagement more online than the control group but that this did not affect their module attendance, as was the case in previous studies.

The time taken to produce the personalised resources and weekly quizzes to support the topics for the module sessions that week had been underestimated. Preparation time will be considered when developing the final implementation module for personalised learning at the end of this research. It could be reduced by scaling down the number of types of personalised learning resources offered to the students, as identified in section 5.3.12. The individual personalised learning resources type analysis gave no indication of a significant difference, which is good in terms of a consistent level of quality. However, when looking at Cohen's D effect size, some types had a large effect where others only had a small effect. These differences, in conjunction with the regression model noted above, will form the basis of the model production using SEM techniques.

5.3.14 Relationship of study findings to study question

The results from this study answer the study question by indicating that personalised learning resources that use technology significantly affect students' achievement in the summative assessment. The students on the whole noted a positive effect of personalised learning through technology in their module experience. They noted that the format of the module on a weekly basis helped their learning and made their progress through the topics easier. The overall module resources available to all students on the course gained the

positive approval of the majority, suggesting that they helped in their learning. Students on the whole noted that the resources and the way the module was set up online helped them in their assessment and personal development. The use of formative assessments each week, in the form of quizzes, was seen as a positive element of the module as they helped in revision and preparation for the following week's sessions.

The personalised learning resources helped the students in their achievement, as noted by the comments in the focus groups and the significant difference in the final grade, moreover the students noted further positive effects. The students with access to the personalised learning resources noted that it helped them to develop personal skills that would be useful for their future in education as a whole. The use of personalised learning resources had a significantly positive effect on the students' final summative grade and on their online engagement, and a large effect on student attendance according to Cohen's D calculation, but this was not considered a significant difference. It had an effect on students' attendance, formative grades and summative grades, so regression analysis was conducted and an equation produced. As noted above, the regression model equation indicates that the effect of personalised learning resources on those variables leads to a 13% summative grade increase. The difference that such resources have on a summative grade increases to 18% with the best combination identified (see section 5.3.12). The positive impact of the use of TEL in the form of personalised learning resources, students' suggestions for future development and the regression analysis will be used in the production of an implementation model in Chapter 6.

5.4 Chapter conclusions

In this chapter, the results of three studies were reported in relation to the overall research aims. The first study's findings indicated that the level of E-learning and technology implementation in the students' modules did have an effect on their attendance, VLE engagement and overall module grade. The results answered the first study's research question and the level of implementation in the modules identified themes to be explored in the second study. The second study explored the technology enhancement that the students had experienced and how they felt it impacted on their learning and development, identifying some future directions of technology use which could be

explored. The students generally noted a positive experience of the increased implementation of technology in their modules and programmes. They noted that their use changed from just a file store to become more interactive, which they felt was the direction that further development should take. Students also suggested that the technology helped them in their revision and obtaining feedback on their work, which aided their progress through the course. Overall, the study research questions were answered and students felt that the technology implementation should be continued and that ways to make it more personal or intuitive to the individual learning should be explored, as well as a general improvement in consistency of approach to the online environment.

The final study answered the question by concluding that the use of personalised learning resources in a taught module had a significant effect on students' achievement in assessments, both formative and summative, their online engagement and, although not significant, their module attendance. The students' view in relation to the use of personalised learning resources was that they felt it was a positive element of the module and it helped with not only module knowledge but also personal development. The students noted that they found different types of learning resources useful at different stages of their module learning, (see 5.1.7, 5.2.6 and 5.3.7). To take into account of the student voice the production of the implementation model will utilise a range of PLR, from which the students will choose from to self-personalise their learning experience.

The themes from the final study, in conjunction with the regression model produced, will be discussed and then developed further in Chapter 6 to produce an implementation model. The model will build on the results from the three studies discussed above to form a final implementation model with guidance on the use of personalised learning resources in a taught model in HE.

Chapter 6 Model Creation

The use of technology in HE teaching and learning is not a new phenomenon but, as discussed throughout this research, a consistent approach to this has had limited investigation completed. One way to achieve positive implementation is through the production of a model. The literature on models for implementing technology in teaching and learning, as discussed in Chapter 2, is largely theoretically based. The models discussed include the TPACK model by Mishra and Koehler (2006), the PCK model by Shulman (1986) and the UDL model by Hitchcock et al. (2002), and have both positive elements and faults, which have been discussed at length by several authors: Angeli and Valanides (2013, 2009); Graham (2011); Whetten (1989); and Yeh et al. (2014). The criticism centres on the definition and integration of the categories used in the models, in particular the TPACK model, which has been criticised and its validity questioned. The fundamental aim of the models is to provide guidance on the implementation of technology in teaching; even with the identified faults, they represent a starting point in this process.

The models all agree that the use of technology in teaching and learning should not be without a pedagogical foundation. Graham (2011) notes that a learning environment that could be created, using particularly the TPACK model for guidance, could allow for personalisation for the students to support to them in achieving their goals. In addition to the research on the models, frameworks have been proposed to offer guidance on the use of technology in HE, but again these are too theoretical or tied to a particular subject area (Doering et al., 2009b; Graham, 2011; Hammond & Manfra, 2009; Haomin, 2011; Hinrichsen & Coombs, 2013; Mishra & Koehler, 2006; Niess, 2013). The area that published research, current models and frameworks omit to cover is practical guidance on how technology can be implemented to create an effective technology-enhanced and perhaps personalised learning environment in taught HE modules.

In this chapter, the data analysis from all the studies (see Chapter 5 for details) are developed into a model to demonstrate the effect of introducing personalised learning materials, showing the potential benefit of the extra resources for students. The procedures to develop the models are outlined, including the methodologies previously discussed and the models' validity in terms of appropriateness and 'fit' in relation to the

data. The limitations of the model are also discussed in this chapter. The chapter reviews each stage of model development, including the rationale for rejection at each stage, leading to the construction of the final model.

From the ANOVA and regression analysis results (see sections 5.3.10 and 5.3.11), the personalised learning resources as a whole had a significantly positive effect on the overall summative grade of students. However, breaking down the effect of the four types of resources and their combinations has an effect on the overall impact on the final summative assessment grade. The process of identifying which combinations have the biggest effect was important, as already noted. The staff time required to produce the four different resources on a weekly basis is unsustainable on a mass scale, even given the potential 18% grade increase that was noted. The analysis in section 5.3.12 concluded that a similar and still significant impact could be achieved if the category of resources were limited to a weekly extended task activity, which could be a worksheet and support revision video together with a global module thematic picture to show where each contact session fits. This resource is an indication, in diagrammatic form, of how the individual sessions' content and themes relate to the overall concepts covered in the module (for further details on the different resource categories, see outline in Chapter 4). The more efficient approach proposed to support resources production, for instance a reduction from four to two resources, would cut the time taken in the model.

6.1 Model specification

It is important to ensure that the construction of a model follows a set procedure to ensure that it is valid, so the conclusions drawn from its use are accurate and reliable. Kenny (2015) states that to use SEM involves the following four steps, usually through an appropriate modelling software package. For this research, IBM AMOS was used in conjunction with SPSS v24. For more details on the justification for the specification process of the construction of the model, see Chapter 4, section 4.4.

The model developmental stages (1-4) outline below are adapted from Blunch (2012), Byrne (2013), Green (2016) and Kenny (2015).

STEP 1: Specification

The model needs to be drawn and proposed in equation form or as a path diagram to identify each variable and its potential impact.

STEP 2: Identification

The proposed model variables need to be matched to observed data from the research, considering the following:

- A latent variable is a non-observed measure
- An exogenous variable is not caused by another variable but rather causes one or more variables in the model
- An endogenous variable is caused by another variable.

STEP 3: Estimation

The relationships proposed in the model are estimated from regression analysis and developed using SEM software.

STEP 4: Model Fit

The model is reviewed against the agreed parameters to evaluate its proposed effect and the fit of the model to the data. If the model is rejected by any of the parameters, then the process returns to step 1.

Table 6.1 Summary of model acceptance levels

Development Stage	Acceptance Level
1 Specification	Completed path diagram of model
2 Identification	All relevant latent, exogenous and endogenous variables identified and appropriately linked on diagram
3 Estimation	A significant regression and or ANOVA analysis of identified variables
4 Model fit	A model r value of above 40% in the context of education a pass grade AIC and BIC level lower than the saturated model level RSMEA lower than 1.00.

Considering the steps in model development, as in Table 6.1, the first stage of developing the model, specification, states that the current research proposes that the use of personalised learning resource has an effect on several module elements. These are the weekly quizzes as part of formative assessment, module attendance, online interaction, are the module elements, which in turn have an effect on students' summative grade.

The second stage of the production displays the identification of the model variables, which indicates that the current research does not have any latent variables. The formative average grade, weekly quiz grade, attendance, online interaction and personalised learning resource are all exogenous variables, as they are observed and have an impact on other variables. The summative assessment grade is an endogenous variable, as it does not have any impact on any other variable, but was measured and observed. Both types of variable in the model developed in this research have error values associated with them, indicated by an 'E' in a circle in the figures below. The error values are included to account for any measurement error associated with the variable, due to the fact that they are observed variables and not inferred variables. The error values are important in the context of the current research, as the groups involved in the data collection are students from various backgrounds, as noted in Chapter 4.

The third stage of model development is the establishment of relationships between the proposed variables from Stage 2. The regression and ANOVA analysis conducted in the

previous chapter (Chapter 5) indicate that the effect of the variables on the summative grade is 18%, and is significant. The results from this analysis means that the model can be estimated and therefore the third stage in model development can be undertaken in line with the criteria in Table 6.1.

Stage 4 of the model development is the assessment of the fit indices; the first measure for consideration at this stage is the overall r value in relation to a subject context acceptance level. The r value is the measure of how much variability the model can account for on a scale of 0 to 100%, so in the context of the current research an r value of 0.30 accounts for 30% of students' summative grade. The second measure, which reflects whether the model can be accepted, is the level of best fit indices. The sample size in the current research means that the model fit indices to be used for assessment are: Bayesian Information Criterion (BIC); Akaike Information Criterion (AIC) and Root Mean Square Error of Approximation (RSMEA).

The level for acceptance for AIC and BIC is a figure lower than the saturated model. For the model to have an acceptance using RSME, the figure should be lower than 0.1 to be considered a good indicator of fit. It is important in research with smaller sample sizes and therefore a lower degree of freedom not to 'cherry pick' the model fit indices, which is why in this research three model fit indices have been used (Blunch, 2012; Byrne, 2013; Kenny, 2015; Kline, 2015).

In the model diagram, a straight arrow indicates the effect of a causal variable, therefore an exogenous variable affecting an endogenous variable. A curved arrow with a head at each end represents covariance between exogenous variables or disturbances, with curved lines representing unanalysed associations, as noted by Kenny, (2015). An observed variable needs to have an error value associated with it in the model, indicated by a small circle with an 'E'. The error value considers any potential measurement error associated with the observations to collect the data for the exogenous or endogenous variable. These error values can be associated with each other in the context of this research due to the online platform used the same for the measured variables, therefore an error on one section of the system would affect another variable's error.

These steps have been followed to produce several models, as detailed below, and each is considered against the established criteria of the r value and model fit indices. The process allows for the models to be fine-tuned to increase the r value and the model best fit indices (see above for explanations). The development process was repeated until the r value was satisfactory for the field and subject of study and the model fit indices allowed for acceptance.

6.2 Model development

In this section, the proposed models will be outlined, towards constructing the final model, seen in section 6.3. At each stage, the steps in section 6.1 are used to judge and approve the model for acceptance in line with Table 6.1 before moving onto the next stage of development.

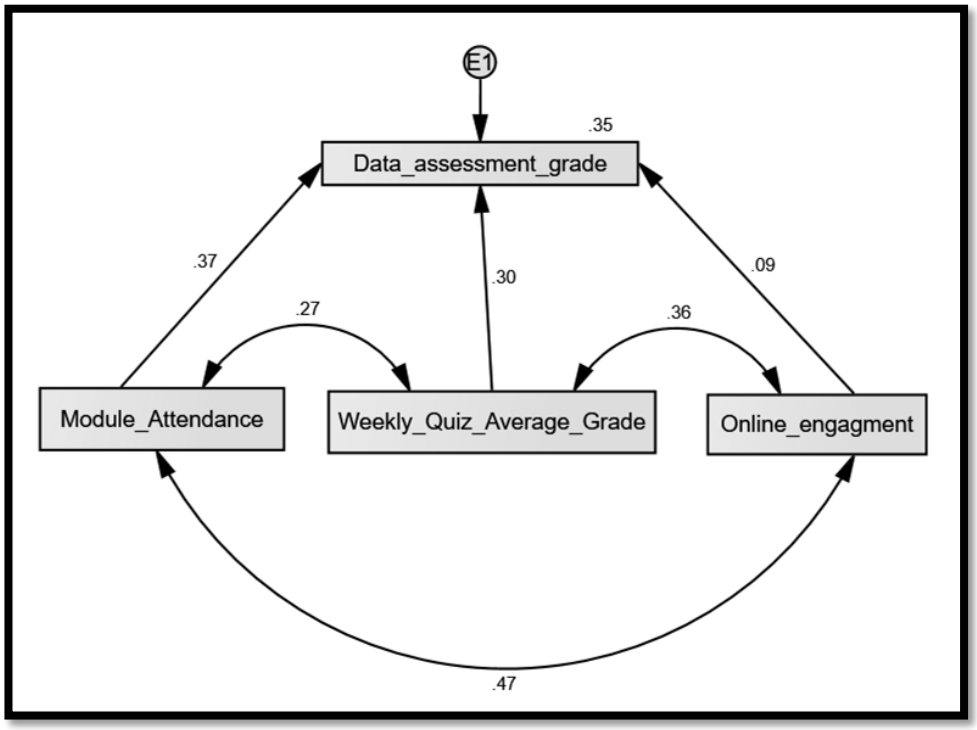

Figure 6.1 First implementation model

The first model was simplistic and contained just the major exogenous variables of attendance, weekly quiz average and online engagement. The proposal was that each exogenous variable had a causal effect on the data assessment summative grade, as depicted by the singled-headed arrow in Figure 6.1. Each was proposed to have a

covariance, which was supported by the correlation and regression findings in Chapter 5. The R values shown in Figure 6.1 indicate that, overall, the model can account for 35% of the variability in the final summative grade, which is not considered to be strong. The covariance figures indicate that online engagement had the greatest effect on module attendance, at 0.47, in a similar trend to that throughout the research.

The next stage of acceptance for this model is to review the model fit indices. Table 6.2 indicates that the AIC fails the test of acceptance, as the unconstrained and saturated model figures are the same. The BIC figures could not be calculated and therefore the model cannot pass this acceptance test. The RMSEA figure is 0.09 over the acceptance level, so the first model fails all of the acceptance tests outlined in Table 6.1 and was reviewed.

Table 6.2 Model fit indices for Figure 6.1

Model	AIC	BIC	RMSEA
Unconstrained	112.000		
Saturated model	112.000		
Independence model	339.541		.190

The first revision made to the model in Figure 6.1 can be seen below in Figure 6.2, which shows that another exogenous variable, the formative mock quiz grade average, has been added to the model. This variable was added due to the correlation and regression results found in Chapter 5, which indicated that this had a positive effect on the summative student grades.

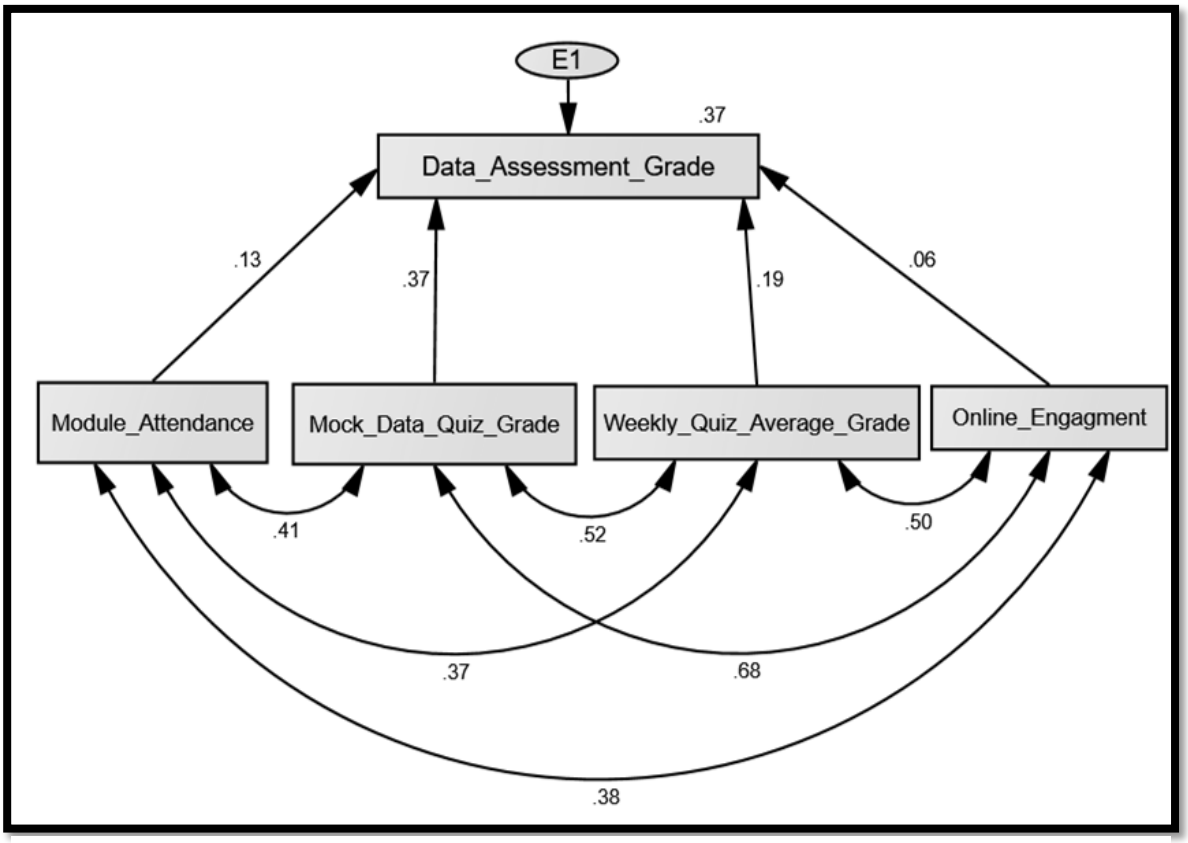

Figure 6.2 First revised model

The R values shown in Figure 6.2 indicate that, overall, the model can account for 37% of variability of the final summative grade, which is not considered to be strong yet is higher than the model in Figure 6.1 by 2%. The covariance figures indicate that online engagement again had the greatest effect on the other exogenous variables, with values of 0.68 and 0.50 for mock quiz and weekly quiz average, respectively. The added variable of the mock quiz also had a good relationship with the weekly quiz, with an r value of 0.52, which is to be expected as they are both formative assessments. The next stage of acceptance for this model is to review the model fit indices. Table 6.3 indicates that the AIC failed the test of acceptance as the unconstrained and saturated model figures are the same (120.000). The BIC figures could not be calculated and therefore the model fails this acceptance test. The RMSEA figure is 0.236, which is 0.136 over the acceptance level. In conclusion, the overall r value for model in Figure 6.2 was improved but the fit indices were worse than the previous model and, as the model fails all of the acceptance tests, it must be reviewed in line with Table 6.1.

Table 6.3 Model fit indices for Figure 6.2

Model	AIC	BIC	RMSEA
Unconstrained	120.000		
Saturated model	120.000		
Independence model	521.920		.236

Upon the rejection of the model in Figure 6.2, the second revision was made, as seen below in Figure 6.3. This displays another exogenous variable, the measured learning style of the student, and therefore the precise use of the personalised learning resources. Adding in these resources as a separate variable allows for the individual relationships to be analysed and considered in more detail. The exogenous variables' online interaction and attendance have been moved back, as their r values were the lowest in terms of effect on the summative assessment grade, and the p values, although significant (>0.05), were not highly significant (0.0001).

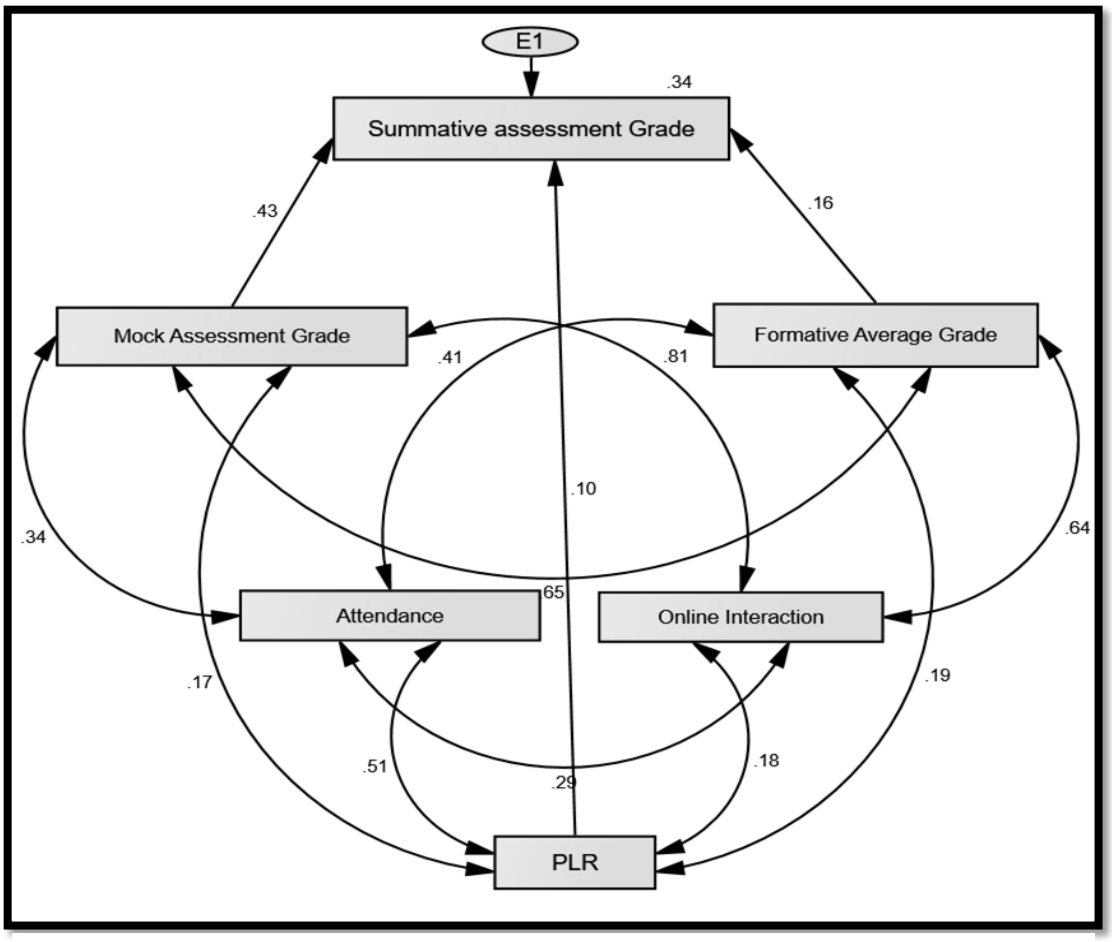

Figure 6.3 Second revised model

The R values shown in Figure 6.3 that, overall, the model can account for 34% of variability of the final summative grade, which is not considered to be strong and is lower than the model in Figure 6.2 by 3%. The covariance figures indicate that the mock quiz and weekly quiz average have a high covariance, at 0.65, which, as previously discussed, is not unexpected. Using personalised learning resources has on average the same impact on all the variables, 0.10 to 0.18, aside from attendance, where the r value was 0.51. Online interaction in this model has an increased impact on the formative assessment of weekly quizzes and the mock quiz, 0.64 and 0.81 respectively. The next stage of acceptance for this model is to review the model fit indices. Table 6.4 indicates that the AIC meets the test of acceptance as the unconstrained figure is less than the other model figures. The BIC figures could not be calculated and therefore the model fails this acceptance test, as outlined in Table 6.1. The RMSEA figure is 0.000, which is below the acceptance level. In conclusion,

the overall r value for the model in Figure 6.3 was not improved and, even though fit indices were improved from the previous model, further revisions were required.

Table 6.4 Model fit indices for Figure 6.3

Model	AIC	BIC	RMSEA
Unconstrained	311.683		.000
Saturated model	324.000		
Independence model	840.920		.137

Upon rejection of model in Figure 6.3, a third revision was made, as seen in Figure 6.4, which displays a new exogenous variable, formative average grade, which includes both the mock and weekly formative assessments.

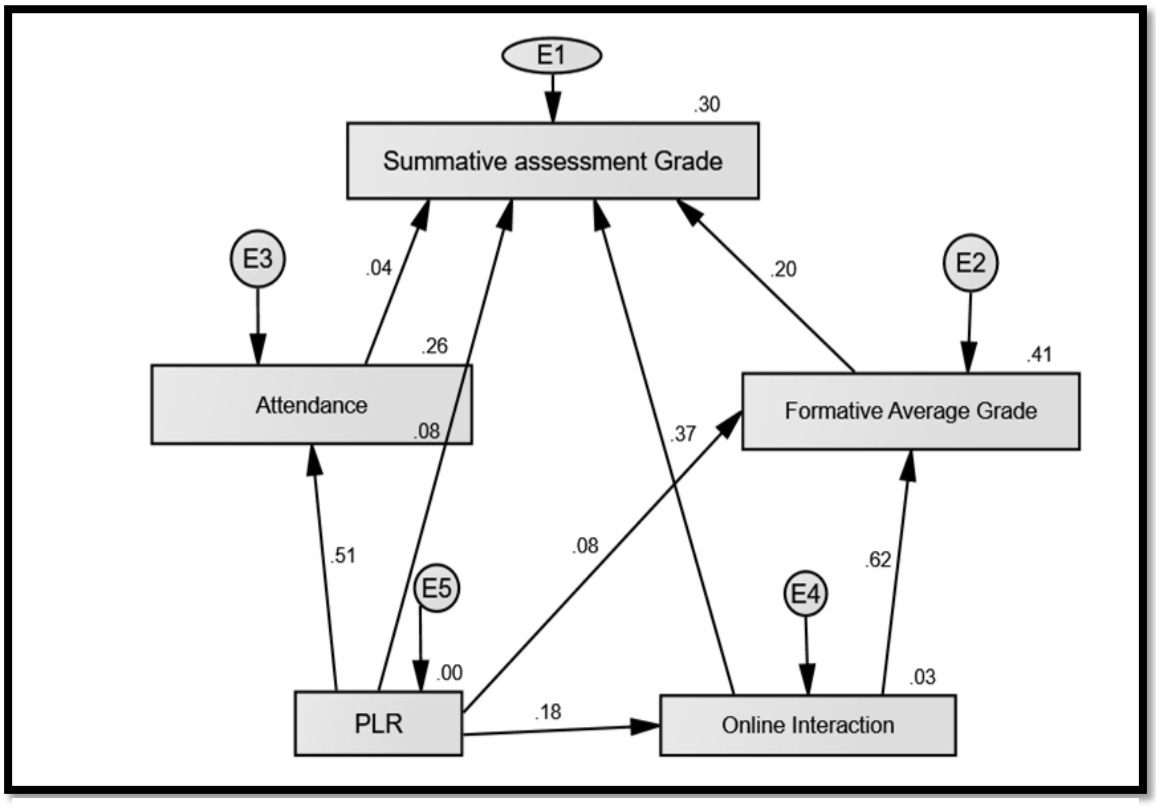

Figure 6.4 Third revised model

A combined weekly quiz average score and the mock quiz score variable was calculated as both assessments were of the same type; that is, formative, and it also clarified the strength of the relationship with the other variables to identify the direct impact of personalised learning resources on each stage of the assessment. The high covariance, as previously discussed in Figure 6.3, was also a factor in combining these into one variable. The arrows used in this model show direct relationships, not inferred, based on the regression analysis and displayed in the single-headed arrows in Figure 6.4. The overall R value for the model decreased to 0.30, which is one of the lowest in the model development process, accounting for just 30% variability which, at 4%, is lower than in Figure 6.3. The individual impact of the variables on the student summative grade was, overall, positive, with a range of 0.04 to 0.37. The next stage of acceptance for this model is to review the model fit indices in relation to those outlined in Table 6.1.

Table 6.5 Model fit indices for Figure 6.4

Model	AIC	BIC	RMSEA
Unconstrained	303.532	338.161	.132
Saturated model	240.000	278.477	
Independence model	535.286	554.524	.128

Table 6.5 shows that the AIC meets the test of acceptance, as the unconstrained figure is less than the other model figures. The BIC figures follow a similar trend and therefore the model passes this acceptance test. The RMSEA figure is 0.132, which is above the acceptance level. In conclusion, the overall r value for the model in Figure 6.4 was not an improvement on previous models and was not considered to be strong, so even though two of the three fit indices passed, further revisions were required to improve the r value.

6.3 Final implementation model

The following section will outline the final implementation model developed from the current research. The same process of evaluation will be used as in previous versions and

the reasons for its acceptance will be explained before moving onto section 6.4 to discuss the links with the overall study. The final implementation model in terms of structure is similar to earlier versions of the model, in Figures 6.1 and 6.2, however the direction of the paths between the variables is similar to that in Figure 6.3.

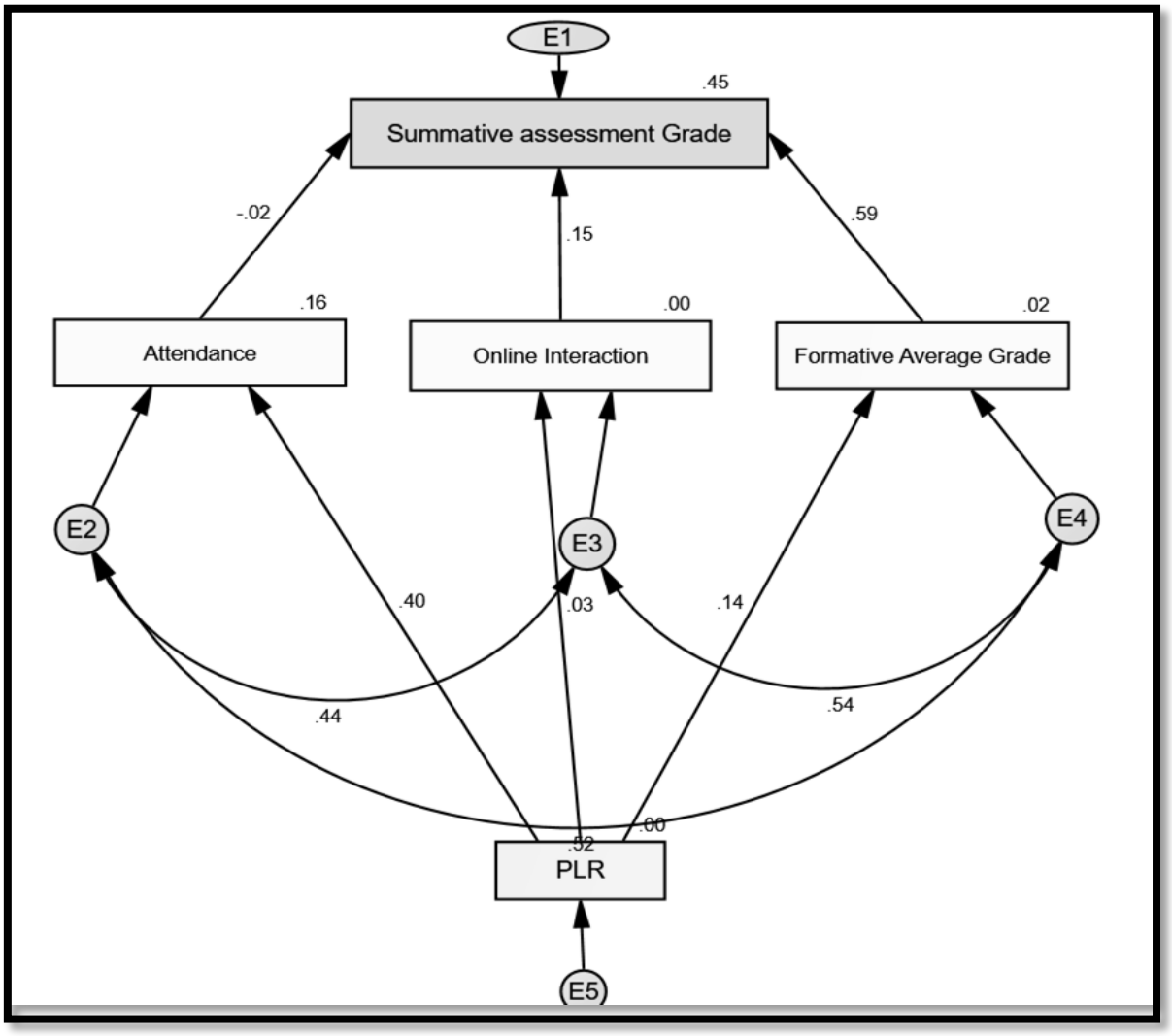

Figure 6.5 Final version of the model

In the final model, the direct link between the personalised learning resources and the summative assessment grade was removed as, in the regression modelling process, significant results were found when the relationship was established using the variables of attendance, online interaction and formative average grade. The use of personalised learning resources was established by the regression and ANOVA analysis in Chapter 5 to have an effect on these variables, as indicated by the single-line arrows in Figure 6.5. Another development in the final model is the linkage of the error values (shown by the 'E'

in Figure 6.5). The causes of error associated with the exogenous variables (E 2, 3 and 4) are similar, as they are all gathered through the same computer platform. So, although they can be identified as individual errors on the variables, they also have an effect on the other error values. This relationship is shown by double-ended arrows between the E2, 3 and 4.

To assess the acceptance of this model, the same process is used as in earlier versions: first, the overall R value for the model is improved from 0.30 to 0.45, indicating that this model accounts for 45% of summative grade variability which, in the context of this research, is over the pass mark for most academic modules, 40%. Therefore, in the context of this research, this level of r value can be accepted. The next stage of the acceptance of the model is to look at the model fit indices, as shown in Table 6.6. AIC and BIC are both lower for the unconstrained model than the other models, which means that they meet the acceptance criteria. The RMSEA figure is 0.000, which is below the acceptance criteria. Taking these three indices results into account, it can be concluded that this model is a good fit for the data and can be accepted.

Table 6.6 Model fit indices for Figure 6.5

Model	AIC	BIC	RMSEA
Unconstrained	116.983	133.869	.000
Saturated model	120.000	137.775	
Independence model	243.597	252.485	.178

Having accepted the model in line with Table 6.1, the individual links and effects can be explored in more detail. The use of personalised learning resources has a direct positive impact on the three main variables of attendance, online interaction and formative average grade. Their use, although not directly linked in Figure 6.5, has a total effect on the overall summative grade of 0.078. Online engagement had a total effect size of 0.15, which indicates the online nature of the module resources. The module attendance had a slight negative effect on the summative assessment grade, -0.02, so 2%, but the use of personalised learning resources had a 0.40 or 40% positive effect on the attendance. This

relationship is similar to the results in Study one, where the highest category of online resources modules had lower attendance for the module than the intermediate category. A variable with a positive total effect was the formative assessment grade, which had a 0.59 overall effect, indicating the identified importance of weekly formative tasks for students to complete in relation to the summative task. The link between the formative tasks and the overall summative grade was also identified to be 0.59 in the model on the direct arrow which a highly significant p value of >.0001. The overall effect of the use of personalised learning resources on the three exogenous variables was 0.52. So, although the individual direct links ranged from 0.03 to 0.40, the overall effect was considered large. The links established all form the overall effect on the student summative grade, which can be seen as positive through the model, where 45% of variability is accounted for by using them in the approach proposed in Figure 6.5.

6.4 Study links

The development of the model from the results gathered as part of the research demonstrates its impact through answering the objectives. Through the proposed model the usage of technology to personalise learning can affect students' achievement in summative assessment by controlling 45% of variability. The level of variability proposed through the model and in conjunction with the regression analysis should mean that students pass the programme module, were the approach implemented, with an 18% grade increase over non-implementation (see Chapter 5 for details). The personalisation resources used in the final model are a first a supportive problem-based worksheet, for students to develop and practice the ideas and concepts covered in contact.

Secondly, there is a revision video of the session with guidance or talk through of key concepts or techniques. Further guidance on the use of the model in Figure 6.5 can be seen in the appendices. As suggested in the first study, there is an optimum level of online resource that can be provided, and Figure 6.5 indicates that attendance does have an effect on the other exogenous variables but, in terms of a direct effect on the summative grade, it has a -0.02 effect. The use of personalised learning resources has a 0.40 impact on attendance, so therefore needs to complement the session content rather than replace it, as described above and indicated in the student feedback in Chapter 5, where it was noted

that revision videos, not lectures, were preferred. The regular use of formative assessments, as noted in the proposed model, has a great impact on the summative grade, 0.59, which is supported by the students' views noted in Chapter 5, whereby they help in developing their understanding of the weekly topics and they could see the direct link to the summative assessment.

The use of personalised learning resources, it is proposed, should use two types of category or resource, as noted at the start of this chapter, to improve the time efficiency of implementation for the staff member, in conjunction with regular weekly formative tasks or quizzes. The proposed model helps to answer the research aim and supports the notion that if technology is implemented in a structured manner through the approach depicted in the model, it can have a positive effect on the students' learning and subsequent progress.

6.5 Chapter conclusions

In this chapter, the results from the data analysis, Chapter 5, were developed into an implementation model to achieve one of the overall research objectives. The development of the model used a process outlined by Kenny (2015), which has four stages, as in section 4.4. Stage 1 is specification, where the variables are drawn in either path diagram or equation form to identify the relationships and impact of each of the variables. A double-ended arrow between two variables on a path diagram indicates a relationship, and a single-headed arrow indicates an impact. The second stage is where the variables are matched to data from the research, and is termed identification. Where a variable is matched to observed data, it is either exogenous or endogenous. A variable matched to non-observed data is called a latent variable. Exogenous variables are not caused by others but impact one or more variables, which are likely to be endogenous as these are only caused by other variables. Once the identification phase has been completed, the model is calculated and the proposed relationships are estimated using the regression analysis in Chapter 5, which allows for the impact of the model to be established. The final stage is the assessment of the model fit, and the impact of the model is considered, operating on percentage scale, where the higher the percentage the more variability of the outcomes is controlled by the model. The model is also assessed to establish if it fits the data, and the

AIC, BIC and RSMEA were used in this chapter to test the model against set parameters. If the model meets the parameters, then it is accepted; if it fails a test, then the process starts again.

The development of the models is outlined in this chapter in Figures 6.1 to 6.4, showing how the identification of the relationships of the variables was revised at each stage in response to the acceptance parameters. The use of personalised learning resources was not originally in the model as a variable but rather as a whole but, through the development, it was inserted so the individual relationships could be estimated and revised accordingly. The error values, represented in the models as a circle with an 'E', were considered through the process to identify potential links due to the nature of the subjects and environment used in this research. The complexity of the model was reduced by this process, and only the key relationships were included to focus on the model impact calculations, leading to the final model being accepted, as shown in Figure 6.5.

The final model, accepted as the implementation model for this research, displays module attendance, module online interaction and formative average grade as the variables impacting on the students' summative grade. The use of personalised learning resources is shown to have an impact on those three identified variables. The impact was greatest on module attendance and least on online interaction. The relationships were all positive and reflected trends identified in Study one in Chapter 5. The students were interacting online through the module as the norm, therefore it did not increase this, however the impact, following the formative tasks, potentially changed their type of interaction to enhance their learning on the module. The formative assessment grade had the greatest impact on the students' summative grade and module attendance the lowest, slightly negative impact. These trends were also in line with those established in Study one and Study two in Chapter 5. The overall impact of the model was shown to account for 45% of the variability of the students' summative grade, which in the context of the current research is good, as that level is above the module pass threshold of 40%.

The model was accepted because it met all three of the model fit measures, AIC, BIC and RSMEA, indicating that it fitted the data at an acceptable level. The final model gives a clear indication of which technology tools can be used to support students online in their studies.

Existing models, as discussed in Chapter 2, have given only a theoretical indication of what was needed to make an informed pedagogic decision about technology implementation. The final model in this research develops this requirement of knowledge to give a clear indication of which technology element combinations have an impact and therefore what knowledge is required by the staff member to implement a successful online support environment (for guidance on how to use the model, see appendices).

The current research aimed to produce a practical implementation model to allow lecturers to enhance students' learning environment by using technology in a personalised manner. The proposed model (Figure 6.5) meets this aim to provide a practical basis to develop the online environment for a teaching module in HE that supports rather than replaces the staff contact session in a personalised approach (Beetham & Sharpe, 2013; MacKeogh & Fox, 2009). The model proposes a method for the implementation of technology into module teaching in HE. The model identifies three main areas that need to be monitored: attendance; online engagement; and formative assessments. The use of personalised learning resources has an established impact on students' learning, as noted in Chapter 5, and the model takes this impact and indicates the effect on the three identified variables. The proposed model indicates that the student summative grade variability can be controlled by 45% through the process identified in the model, which in the context of this research is above the pass threshold for undergraduate modules in UK HE.

The model has met the criteria for acceptance, due to the variability being controlled as indicated by the r value of 0.45 (45%) and the model fit indices of Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC) and Root Mean Square Error of Approximation (RSME). The model shown in Figure 6.5 therefore provides a solution to the outlined problem in the form a practical framework that can help staff to use technology effectively in their teaching in HE. The guidance for using the model can be found in the appendices.

The final model and topics identified in this and the previous chapter will be discussed in Chapter 8. The themes from this section, in conjunction with the individual study findings established in Chapter 5 and the points in relation to identified literature, will be discussed

in the next chapter. Through this process, the research questions and aims for the current research will be fully answered and lead to the research conclusions.

Chapter 7 Discussion

In this chapter, the findings from the studies in the research will be critically examined in relation to the existing literature in the subject area, as identified in Chapter 2, the literature review. The process will enable conclusions and judgements to be drawn, allowing the new knowledge to be established and its potential impact to be shown. The findings will be discussed and evaluated in relation to existing research and how it could develop the subject area. The limitations to the research will then be discussed to identify any potential future developmental work to further this current research. This chapter's findings, as detailed above, will then be taken forward to allow conclusions to be drawn in Chapter 8, where the research will be concluded in line with the overall aims, identifying the limitations and future research.

7.1 Study 1 – The effectiveness of technology-enhanced learning on students' engagement in their programme

Research question:

> Have the levels of engagement (including VLE interaction, attendance and achievement/progress) in all year groups of undergraduate students changed because of technology-enhanced learning implementation?

The findings of this research are that if technology is used in a structured, coherent approach across all students' module teaching, then it positively impacts on the levels of student engagement with the content and increases their achievement on the module. A coherent approach in this context means that all the modules are designed online using the same set guidelines, so the support is provided, regardless of the level of technology use, and can be accessed in same way by the students.

The findings first showed that a consistent approach to module design on the VLE helped student engagement if undertaken across all the modules that a student is studying. A consistent approach in this study is one where the layout and content provided on the online module pages for all of the modules on the VLE are the same. Study one used the same outline across all the module types and compared the results to before the

implementation of this layout, which indicates that the consistent approach had a significantly positive effect on student performance.

Second, the research found that there is an optimum level of technology use associated with the module content provided on the VLE, at an intermediate level of enhancement, which had an overall greater impact on student performance than the other levels of enhancement. The difference between the intermediate and advanced levels of enhancement is the inclusion of a video of the module lectures for the advanced level modules. This was in addition to the online resources and formative quizzes, which are part of the intermediate-level modules. Rather than support the student further, the advanced level of technology achievement was at the same level as the foundation level, which just provided lesson slides and online assessment submission. The achievement and engagement levels were inversely reflected in module attendance, which suggested that in the advanced modules the students were less likely to attend as they knew that they would receive the lecture online, however this led to less engagement in the topics covered and no depth of understanding was developed, as seen in the final module grades.

The findings from Study one are similar to those noted by Beetham and Sharpe (2013), Fox and MacKeogh (2003), Hannan (2005), Juniu (2011), Karamanos and Gibbs (2012) and MacKeogh and Fox (2009), who found that technology implementation and enhancement needed to be undertaken in a coherent approach across the students' learning to ensure that access to information did not cause frustration and disengagement. The use of technology should also develop the pedagogical approach taken by the teacher, and not replace or change their approach to the module sessions. The use of TEL resources by the student is diminished without the impact of the tutor in class. Therefore, attendance in class is imperative for successful engagement with the online environment to experience the identified positive impact on module progress. If technology is implemented in the suggested manner, this can lead to an improved experience for the staff and students involved. The intermediate approach to technology implementation in Study one best followed the reported findings by allowing the technology to be implemented into the teaching approach taken by the lecturer.

The technology did not obviate the need for the student to interact with the lecturer, as in the advanced approach, as no video of the lecture was included in the module's online approach. The resources and formative tasks provided online on the module page supported the face-to-face content provided by staff to enhance the learning environment. As a result, in the modules where the intermediate approach to technology enhancement was adopted, module attendance (77%), online engagement (75 touchpoints) and module grade (MDX 8 = 60%) were all higher than in the foundation and advanced approaches. The valuing of contact with the tutor, which is suggested by the attendance data found in this research, and where the contact with the staff is highest, yielded the best performance across the established values, supporting the work of Catcheside (2012), Nehme (2010), Shaw (2012) and Strijbos (2011). The students require this contact to establish a bond with the lecturer and an understanding of the module as a whole, which leads to motivation and engagement being maintained through the duration of the module (Lin et al., 2017; Mah-Ngee, 2012; Nehme, 2010).

Once the bond is established, it helps to increase students' engagement in their module learning and, importantly, they take ownership of their individual learning and achievement. Using technology in this process allows the student to access additional content away from the classroom or lecture theatre, which will help them to develop further their understanding of the themes covered in the module sessions. Through the classroom contact with the tutor, the student is more motivated to engage online to access this content and take ownership of the learning, leading to greater achievement as noted in established research (Geçer & Dağ, 2012; Karamizadeh et al., 2012; Wong et al., 2014; Wu & Hwang, 2010). Increased engagement and emotional attachment with their studies helps the students' learning and their personal identity within their HE modules. The online environment can encourage this development by providing the right content online through the VLE, as noted in the current and established research (Hanson, 2009; Mertens et al., 2014; Saadé & Kira, 2009). The findings in Study one of this research support this notion through the use of the intermediate approach to students' modules.

In studies by established researchers (Bell & Bell, 2005; Browne et al., 2006; Groves & O'Donoghue, 2009), the approach taken in HE to providing content online to support programmes and modules is often an individual staff approach, resulting in an

uncoordinated process. Academic staff see it as a labour-intensive and unrewarding process and are inconsistent in using the VLE and how they see its value in general. The current approach and usage are partly because there is limited resounding research to provide evidence for an alternative coordinated approach and focus from HEIs to ensure that this is being carried out. The limited research can also mean that when new staff undertake a teaching qualification in HE (PgCert HE), new approaches are not covered, thus the knowledge is not gained in the first instance. As it is unlikely that staff will read outside of their own discipline, once established, research is required on VLE use to show HEIs the evidence and focus their staff development through academic enhancement centres.

An inconsistent approach to providing resources or materials online through the VLE can cause confusion among students and a perception that, due to the online layout, one module is better than another. This can cause disengagement from the provided resources and module. The impact of a consistent approach to the online resources and the items included in the individual module pages is positive, as found in the current research in Study two (section 5.2). The results from the first study provide evidence to address the problem of an inconsistent approach to VLE development. The first study's findings also show which items on the module page benefit the module outcomes and the level of technology integration that can be used. This evidence can help staff to make an informed decision on the outline of their VLE modules pages and, with more research into the area, could even provide clearer guidance.

The findings also demonstrate the effect of the type of module content on students' performance when made available online through the VLE. The measures used in Study one, as mentioned above, included module attendance, online engagement and assessment grades. The intermediate level of content was found to have an overall significantly positive impact on these. The evidence for the content proposed as a solution to the outline problem is provided through the findings of Study one. In addition to a consistent approach to VLE design across the modules as noted, the content should be uniform and include, as a minimum, lecture notes, formative support tasks, online submission, online feedback and support materials.

The findings from Study one add to the body of work on the implementation of technology in HE teaching and learning. The study found that a consistent approach to the layout on a VLE of the content to support learners had a positive impact on students' performance. The individual modules on a programme should be consistently displayed so that the student sees clearly how to navigate to the materials for the module in question. If students do not know where the materials are, there is a tendency to assume that support materials are not present rather than actively to seek them out. These assumptions then negatively affect performance on the module. The other part of Study one was to look at the most effective content to be included on the VLE module pages in terms of module attendance, modules achievement and online engagement.

The study used three classification of technology use for the support content for a module. The first level of content for modules, the foundation stage, included weekly lecture slides, online assessment submission and online assessment feedback. The second level, the intermediate stage, included everything from the foundation level plus support material, online formative quizzes and discussion forums. The third and final level, the advanced stage, included everything from the previous two stages, plus a video of the week's lectures. Making the video of the lectures available online decreased module attendance and contact time with the staff member, which decreased achievement. The findings from Study one indicated that the intermediate-level modules had significantly positive effects on the outlined module measures of attendance, achievement and online activity.

The finding of the effectiveness of the intermediate level of resources adds to the evidence for the approach proposed by current research, where technology should not replace taught delivery but support teaching and learning in HE modules (Beetham & Sharpe, 2013; Fox & MacKeogh, 2003; Hannan, 2005; Juniu, 2011; Karamanos & Gibbs, 2012; MacKeogh & Fox, 2009). The findings from Study one differ from the established research and add to the area of knowledge by establishing that the specific support offered by the technology positively affects taught modules. Study one can help to guide staff on the development of the VLE content and the use of technology to support taught modules, in particular non video use of whole lectures. The type of resources found to have a positive impact in the intermediate approach were taken forward to be used in Study three and influenced the development of the resultant model.

7.2 Study 2 – The effect of the educational changes on students' experience of technology-enhanced learning

Research question:

> Have educational changes influenced the student experience of technology-enhanced learning at Middlesex University?

The use of technology to enhance the learning experience of students at HE should not be driven just by module assessments and overall grades but seek to increase the quality and usability of the VLE to aid the development of independent and mobile learning. Achievement on a module is not the only aspect that is important in the learning journey. As stated in Chapter 2, Krämer and Bente (2010) and Marton and Säljö (1976) suggest that students need to develop a deep understanding of their subject and develop their own learning to study efficiently in HE. A lecturer in HE needs to have an understanding of this to be able to facilitate it, especially at level 4, as stated by Entwistle (2001) and Felder et al. (2000), to ensure that the learning environment created enables this for each learner. The use of technology in this process can help with students' engagement, providing that the systems used are accessible to all levels of learning and previous technology experience (Bryson & Hand, 2007; Case & Marshall, 2008; Kuh et al., 2008; Nehme, 2010).

The findings from the second study support existing research on access, as the students stated that a consistent approach to the module online would help in finding support materials. When the modules were inconsistent it caused frustration and disengagement from the materials, which links into the findings from Study one. Students' engagement with the module topics and online content is important for all involved. The time required by the lecturer to provide content both in contact sessions and online through the VLE is a finite resource. Whether the student engages with the resources or not is critical to staff's motivation to create them and make them available. As shown in Study one, the support materials online can have a positive impact on student performance, so student engagement is vital. The findings from Study two indicate that students do appreciate and value the online support resources, providing that they are in a format that they can easily access and follow. These findings support those from Study one and are in keeping with established research, adding to the evidence base for providing a coherent approach to

online support module resources using technology (Hu & McCormick, 2012; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Kuh et al., 2008; Pemberton et al., 2006; Rodriguez & Armellini, 2013; Thomas, 2012; Trowler, 2010).

Study two found that when a programme had a holistic approach to TEL, the modules' easy navigational approach to providing resources were commented on by students as helpful to them to learn and progress in their studies. The students liked the inclusion of regular formative activities online, as they could revise the week's topics in preparation for the following week's work. The use of regular formative work helps in knowledge retention, which gives the student a sense of achievement and motivation to progress with the module. The increased engagement in the modules created a positive attitude towards learning, in keeping with research discussed previously by Paulsen (1995), Thomas (2012) and Trowler (2010). The engagement with the module and increased positive attitude towards learning achieved through the VLE helps to create a positive environment in the classroom. The wider knowledge base acquired through engagement with the formative tasks means that the work covered in contact sessions can be more progressive and stretch the students more, helping them to achieve a higher level of knowledge.

Through the identified approaches to technology implementation in a module's online support, the students saw value in the resources and interacted accordingly. Catcheside (2012) states that this the most important stage in technology implementation: if the students do not value the use of the technology then its quality is irrelevant, as they will not engage with it. The findings from Study two indicate that the students had preferences in terms of types of support resources, and if they were not present then the module's online support was not valued. In particular, students preferred support videos for revision, not lecture videos, as they value the staff contact. These views again support the notion that technology should enhance current pedagogical approaches and not replace them, as stated by Fox and MacKeogh (2003) and MacKeogh and Fox (2009). The findings of Study two support the data analysis of Study one, where the intermediate approach to TEL was concluded to be the most favourable progress route due to enhancing practice, not replacing it.

The research conducted as part of Study two aimed to answer a similar problem to that in Study one, but from the students' perspective rather than with a purely data and performance focus. How the modern HE student views the online environment and how it can support their studies are invaluable insights to develop a technology implementation model. The students' views on how technology has potentially improved the learning experience can help to provide clarity to guide further implementations. The students' views on the developing use of technology in their learning indicate that it improved throughout the course of their programme (see Figure 5.4). It was noted that in some cases this change was a major contrast, coinciding with a major system change at the University (blackboard to moodle). Students noted that the use of technology improved the speed and accessibility of feedback on their work, which was helpful in improving it (see Figure 5.6).

Consistency in approach to module online support through the VLE was an issue that was raised and a point for improvement. Students commented on how some modules on the VLE were designed in a way that helped them to identify relevant content for each topic, and the inclusion of information that was consistently present to help them to develop their understanding on the module topics and concepts. One of the improvement points raised by students was the inclusion of formative tasks or quizzes, helping to reinforce the concepts from the week's contact sessions and the support resources that were made available online in some modules but not others. They felt that this would increase understanding in all modules, if it were present, which is in partial agreement with published research in this area (Browne et al., 2006; Groves & O'Donoghue, 2009; Lingard, 2007).

The use of video on a regular basis was seen as a potential revision tool, but the videos should be not recorded lectures but revision videos, and should be focused on a particular element of a topic. A recording of a lecture was felt by students to be often not as good as attending the actual lecture, due to the lack of interaction. This contrasts with the published research (EL-Deghaidy & Nouby, 2008; González, 2010; Karamanos & Gibbs, 2012; Wong et al., 2014; Wu et al., 2010). Feedback from the students also noted the potential to personalise the module pages to the needs of individual students. This could help to target the needs of the students on an individual basis and help them to feel at

familiar with the online resources. The findings from Study two provided evidence to answer the problem and helped to identify the online approach that should be taken in Study three to research personalised learning resources.

The findings from Study two of the research add to the body of work on the implementation of technology in HE teaching and learning by providing students' views on how changes have affected their learning environment. Students agreed that having the module resources online did help their studies. The study established themes from across the focus groups, which had alumni from several years, some of whom had access to formal VLE only in the latter years of their programme, so the change from having no real VLE to a structured one was indicated to be highly positive. The use of online assessment was seen by students as a positive use of technology, as in logistical terms they did not have to queue up to submit their work, and through the use of anti-plagiarism software they also learnt about referencing.

The other element of online submission seen as a positive by the students was the improved speed and depth of feedback. The students felt that they could access the feedback more readily and it helped them to develop their studies, as it was always accessible and linked to their work through the grade mark system. The improvement of feedback in this manner is an important point, as feedback is often used as an HEPS and, as the students noted, it is a learning mechanism. If the feedback is accessible and timely it can help them to become more autonomous to improve their work and knowledge. These themes are in line and add to the body of knowledge in current research on technology use and the impact on the engagement of the students and subsequent achievement on the module (Bryson & Hand, 2007; Case & Marshall, 2008; Fox & MacKeogh, 2003; Kuh et al., 2008; Nehme, 2010; Thomas, 2012; Trowler, 2010).

Where the findings from Study two differed from the established research was in the identification of one of the negative themes to emerge from the study: the lack of consistency in the layout and delivery of the support materials online and how this varied between modules. The students felt that this needed to be improved as, when there was consistency, it facilitated quick navigation and ease of use in the online environment and subsequent support materials. It was also noted in the findings that the students preferred

videos to be supportive and to help in revision of themes covered in the contact sessions, not to replace the session itself. The final theme that added to the body of knowledge and is different from the research was that students noted that they wanted the systems to 'do more' and be personalised in some way to give students an individual experience.

7.3 Study 3 – The effectiveness of personalised technology-enhanced learning on progress of students in higher education

Research question:

> Has technology enhancement personalised to undergraduate students' various learning styles significantly altered their progress on a taught module?

The use of technology to enhance a student's learning environment was found by Pemberton et al. (2006) to increase students' engagement but, due to the inconsistency of technology use, the impact on the grades was limited. Later research by Ginns and Fraser (2010) and Jennings and Kachel (2010) developed the concept of a TEL environment and found a positive effect on student achievement in modules, in conjunction with increased engagement. The approach taken by Ginns and Fraser (2010) was to personalise the support materials provided on the VLE in order to match the resource to the learner's individual needs. Personalising the support materials boosts the students' enjoyment and motivation, which is vital to students' achieving on the module, as noted by Doyle and Jacobs (2013), Graf et al. (2010) and Krämer and Bente (2010). How the support materials are personalised and made available online has been researched by several authors, using different approaches and with varying impact on the students' achievement (Doyle & Jacobs, 2013; Geçer & Dağ, 2012; Graf et al. 2010; Klašnja-Milićević et al., 2011; Zajac, 2009).

Producing material that is personalised to the learners' needs in a uniform manner involves identification of students' learning style. Bishop and Foster (2011), Klašnja-Milićević et al. (2011) and Zajac (2009) used the ILS questionnaire to establish students' learning style to enable the staff to customise the support materials. The current research developed the idea of using ILS to provide personalised learning resources to the students in a consistent manner using technology. It was found to have a positive impact on students' module

achievement, in agreement with published research (Ginns & Fraser, 2010; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009; McKim et al., 2013). There is currently little published research on the assessment of education interventions, and the approach to Study three adds to this body of work. The findings from Study three were as a result of an intervention, enabling the impact of the use of personalised learning resources on established performance metric to be measured, in line with work by McKim et al. (2013).

The results from the current research also noted increased student engagement and enjoyment of the content in the modules, which supports research undertaken by Pemberton et al. (2006). Students are more likely to engage with the content online if they see its value and feel that it will help in their studies. The content, in the form of personalised learning resources, was valued and therefore increased online engagement in this research, and these findings add to the established evidence in published research (Bailey & Tuohy, 2009; Coole & Watts, 2009; Hu & McCormick, 2012; Jennings & Kachel, 2010; Kuh et al., 2008; Lo et al., 2012; Rodriguez & Armellini, 2013). It was found that the students who engaged and used the personalised learning resources on the module used in Study three increased their average summative grade by 18%, or nearly two degree classification boundaries. Four different types of personalised learning resource were created to support each contact session on the module in the current research, in line with published research (Klašnja-Milićević et al., 2011; Zajac, 2009). The findings from the current research support the established research and answer the research aim, suggesting that personalised learning in the form of personalised learning resources, in the current research, does significantly improve the achievement of students on a taught undergraduate module.

The use of technology in learning and teaching in HE, as discussed in the first two studies in this research, generally takes varied approaches and does not quite meet students' expectations. The students in Study three suggested that technology could be used to provide a more personalised approach to supporting their studies. Personalised learning using technology has seen limited research to establish a method of delivery and assess its effectiveness. Study three aims to provide solutions to these problems and provide evidence to use in the development of an implementation model. Study three used the ILS

questionnaire in conjunction with work by Klašnja-Milićević et al. (2011) to personalise the setup of the module pages for students. The approach allowed for personalised resources to be tailored to students, based on their ILS, and made available to give them a unique feel for the support for their studies. The students received one resource type per week, on the basis of their ILS, and four types of extra resources were prepared, in total, per week. These extra resources were in addition to the formative quiz and lecture notes from the week's contact session.

The approach each week was consistent and uniform, so the students knew where to go each week and what to expect, in line with what they were noted to want in Study two. The resources did not replace the content received in the contact sessions, but helped to enhance and provide support outside the contact sessions with the same themes. Again this approach was in line with student feedback and research by Fox and MacKeogh (2003), Ginns and Fraser (2010 and MacKeogh and Fox (2009). The approach taken in Study 3 was positively received by the students, as seen in Chapter 5 (see section 5.3.5), which indicates a solution to the first part of the problem of a method of providing personalised learning support. The second part of the problem was a measure of the effectiveness of personalised learning in taught undergraduate provision. The impact and effectiveness of the approach taken in Study three were measured using the three main metrics of module attendance, assessment grade (summative and formative) and online interaction.

Study three found that the approach adopted had an effect on all three metrics, and a significant effect on both summative assessment and online interaction. A regression analysis was performed, and indicated that through the use of personalised learning resources in Study three approach an 18% grade increase would be seen. The results from the analysis of Study three formed the basis for the development of the implementation model in Chapter 7. The second part to the proposed problem was that there was no analysis of the impact of the personalised approach, thus the work in Study three answers this problem and provides its solution through a detailed impact analysis. The approach researched in Study three provides a clear outline that has a significant impact regarding the use of technology to support students outside of contact sessions.

The findings from Study three of the research add to the body of work on the implementation of technology and the personalisation of support provided to student to help in their achievement on a taught module in HE. The personalisation of resources was conducted using the students' learning styles as a guide, in conjunction with existing research to create four types of resource for the students. The results indicate that if a consistent approach is taken to the delivery of content online, and with personalised resources then students' summative achievement improves, in line with current research, and adds to the body of work due to the level of impact shown by the current research (Doyle & Jacobs, 2013; Geçer & Dağ, 2012; Ginns & Fraser, 2010; Graf et al., 2010; Klašnja-Milićević et al., 2011). The use of weekly formative quizzes was also shown to help learners to understand the concepts in the contact sessions and to improve summative grades.

Some of the strategies used in Study three had been researched prior to this study, however Study three brought several strategies together in a uniform approach to support student learning outside of the classroom through the VLE. The uniform approach to the study was measured from a metric standpoint and through student feedback to gauge its effectiveness. The results from both sides of this evaluation were positive and add substantial knowledge to the subject area, giving a clear, evidence-based indication of an effective approach to supporting students using technology that can be adopted on a multi-module scale. The findings from Study three found that all the types of personalised learning resource had a positive impact on students' achievement and/or engagement in the module. Through analysing the various combinations of resources in the personalised activity (which could be a worksheet), a thematic image of how the taught session fitted into the overall module picture was found to have had the greatest impact.

The students noted that they liked the use of video as a revision tool for the taught sessions' content or to cover a key technique. Therefore, video resources were included in the final choice taken forward into the development of the model and guidance (see appendices). The student voice in this research had an important impact on the model production, not only with inclusion of a video resource, but also the self-selection of the PLR. The model includes the identified range of PLR as a whole with no imposed selection of which resource is available to which student. The result means that the student has a choice to how they personalised their learning environment which can change through the course of their

module learning. This identification of the effectiveness of the various types of personalised learning resources in Study three adds to the body of work on the use of ILS to personalise support for students (Zapalska & Brozik, 2006; Chen et al., 2014; Felder et al., 2000; Ginns & Fraser, 2010; Gurpinar et al., 2010; Halbert et al., 2011; Liu, 2007; Lo et al., 2012; Zajac, 2009; McKim et al., 2013). The use of personalised learning resources, in conjunction with regular formative assessment on the module, was found beneficial to students, who enjoyed the activities, as they helped them to revise the current week's topics and then prepare them for the following topics (see Chapter 5 for results). The development of these concepts was taken forward into the production of an implementation model (outlined in Chapter 6), which indicates the potential impact of this proposed approach and guidance, without being resource intensive for teaching staff.

7.4 Implementation model for TEL in HE

The development of models which can guide the use of TEL in HE teaching and learning has been research by many (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Mishra and Koehler, 2006; Zajac, 2009; Mikropoulos, 2006). However existing models, as discussed in Chapter 2, are theoretical in nature and offer guidance on what is required by academics who are making pedagogical decision about their module teaching. Considering the TPACK model, devised by Mishra and Koehler, (2006), as an example, the need for knowledge of technology content and pedagogy is apparent but the next stage to TEL use and its implementation is not. To this end TPACK is not an implementation model but rather a guidance piece of what is required as a starting point to utilise a TEL implementation model, as without the knowledge identified by Mishra and Koehler (2006), the ability to follow an implementation model would be restricted.

The proposed model from this research suggests a solution to this knowledge gap and gives a clear indication of which elements of TEL can be utilised to have a positive impact on module teaching. The proposed model outlines how support for the students can be created so the learning environment outside of the classroom is maximised and encourages engagement in the module (for guidance on how to use the model, see appendices). The current research has developed the model and guidance to give a framework for taught

modules which academics with the relevant knowledge can work within to enhance the student learning environment. The framework outlines key elements which effect the summative module grade such as formative tasks, module attendance and online engagement, and gives an indication of how the online environment can use resources to impact these. Impacting the outlined elements in a positive manner as identified through the development of the model (see chapter 6) will positivity impact the student summative grade. The development of the model aims to add to published research and progress the area (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009; Mikropoulos, 2006).

The proposed implementation model from this current research gives evidence based and practical guidance which can be used by lecturers and universities to enhance students' learning environment using TEL. The proposed model (Figure 6.5) meets the research aim above to provide an outline for the online environment for a teaching module in HE that supports rather than replaces contact sessions (Beetham & Sharpe, 2013; MacKeogh & Fox, 2009). The resources outlined in the guidance and model, allow the student to self-personalise their own learning environment by utilising the resources they feel is the most appropriate at that stage of the model for their preferred way of learning. The change in personalisation choice from auto to self-selection, as outlined earlier in 7.3, is to take into account the student voice in this research, which noted that the students liked to use different types of resources at different stages of their progress through the module. The final model (see figure 6.5) identifies three main areas of module teaching: attendance; online engagement; and formative assessments which need to be observed. The use of PLR has an impact on students' learning, as established in Chapter 5, and the model is developed to utilise the impact to give a clear indication of the effect on the identified main areas.

Through the statistical analysis of the model completed to validate the approach and outcome, 45% of the summative grade can be accounted or controlled by following the model. When looking at the use of the model in universities as part of an institutional approach, this figure, which is above the pass threshold for undergraduate modules in UK

HE, would give substantial evidence for using the model. However as noted the proposed model is specific to this case study and population of students involved in this research. Further work needs to be completed to test the model in different populations of students and subject areas for the level of variability control to be fully accepted. The limitations of the model and future work will be discussed further in the next chapter.

7.5 Chapter conclusions

In summary, the three studies in the current research all provided a solution to the stated problem, which led to the development of the proposed implementation model (see Figure 6.5). Study one found that the use of technology to an intermediate level was the most effective in terms of the data measures of module attendance, online engagement and achievement. These findings were in line with established research but also differed in the identification of an approach to taught modules, so added knowledge to published research in the subject area (Beetham & Sharpe, 2013; Fox & MacKeogh, 2003; Hannan, 2005; Juniu, 2011; Karamanos & Gibbs, 2012; MacKeogh & Fox, 2009).

The second study found that students preferred a consistent approach to the online implementation of technology in their modules. The use of formative tasks, online submission and feedback were also seen as positive changes to their online environment, due to technology. The students noted that they preferred video to be used for revision rather than to replicate lectures, and that they felt technology could be used to customise students' online experience more. These findings agreed with the findings of the first study, in part, and partly with research published in this area (Bryson & Hand, 2007; Case & Marshall, 2008; Fox & MacKeogh, 2003; Kuh et al., 2008; Nehme, 2010; Thomas, 2012; Trowler, 2010), adding new detail to the knowledge area on this particular use of video and personalised learning.

The final study in the current research established the impact of the use of ILS to create personalised learning resources on a taught undergraduate module. The findings indicated that the personalised learning resources impacted positively on students' grade by 18%, which added a new performance element and direction to the limited body of published research on personalisation using technology (Zapalska & Brozik, 2006; Chen et al., 2014; Felder et al., 2000; Ginns & Fraser, 2010; Gurpinar et al., 2010; Halbert et al., 2011; Liu,

2007; Lo et al., 2012; Zajac, 2009; McKim et al., 2013). The final element of the current research was the production of an implementation model for the use of personalised learning resources. The proposed model gives a framework for taught modules, which includes formative tasks, module attendance and online engagement as factors that can affect the module summative grade. The model aims to develop and build on published research in the area (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009; Mikropoulos, 2006).

The limitations of the current research, which will be discussed in more depth in the conclusions chapter, are the subject area of students, their age range, the level of module and the module assessment type used in the study. The potential future areas of development from the current research are to test the implementation model in different subject areas, at different levels of learning, including postgraduate level, and on modules to include non-examination-based summative assessments. The suggested future developments will help to answer the limitations and add to the validity of the model and its potential impact on sector practice and will be discussed in Chapter 8.

Chapter 8 Conclusions

The findings from the current research add to the body of work on the implementation of technology and the personalisation of support for the student using technology in their HE studies. The research has produced an implementation model that aims to offer guidance to staff in the development of their teaching module online space and gives an indication of the impact of personalisation of resources. The model has been developed with staff resources (time) as a consideration, as the number of resources types proposed for each topic was reduced from four (as prepared in the current research) to two to reflect the preparation time involved. The reduction was made to ensure that the model has a realistic practical application whilst still being effective in terms of providing a solution to the problem. The personalised learning resources model produced by this research (see Figure 6.5) adds knowledge to the area of both technology use and implementation in HE teaching and learning and the personalisation of students' learning using technology.

The model gives evidence for the positive impact that technology can have on teaching and learning if it is used in a consistent and supportive manner. The impact of technology on key elements of teaching and learning in HE modules, such as attendance, formative work and online engagement, is established in the current research. Using these key elements in a uniform manner, with measurement, in this current research added new knowledge to the field of assessing the impact of technology in HE teaching. The use of technology in this manner is in keeping with established research and, further, provides evidence for this approach and develops the area (Beetham & Sharpe, 2013; Graf et al., 2010; Hannan, 2005; Karger et al., 2008; MacKeogh & Fox, 2009; Pemberton et al., 2006). The model developed from the research is different, as it gives direction on the use of personalised learning in HE, and the impact that this can have on key factors, as discussed previously, and including students' views on its use.

The use of personalised learning resources has been shown to be effective and, included in the proposed model, its implementation can impact students' achievement and online support environment, which helps to develop this research area yet further and build on established work (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010;

Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009).

In this chapter, the findings from the current research will be outlined in relation to the overall aims and objectives of each study and the addition of new knowledge to the subject area. The potential benefits for the implementation of technology in teaching and learning practice in HE will be discussed. The future areas for research will be examined in more depth, highlighting both potential impact and practice enhancement. Finally, this chapter will evaluate the research with respect to its initial aims and objectives.

8.1 What was learnt and the relationship to published research

The research set out to answer one main aim and three main questions to provide a solution and guidance to implementing technology in teaching and learning practice in HE. The main aim of the current research was:

> To produce a model for the implementation of technology for its use in module teaching in higher education programmes to improve the student experience.

Achieving this aim identified the result of using technology in module teaching on students' engagement with their modules and their experience of personalised learning. The implementation model produced (Figure 6.5) realises the aim of the research and builds on the established literature, including the TPACK model by Mishra and Koehler (2006), the PCK model by Shulman (1986) and the UDL model by Hitchcock et al. (2002). In particular, the model adds to Graham's (2011) works, where it is suggested that personalised learning by a technology implementation could be achieved by using the TPACK model.

The model produced in this research differs from the established literature as it offers pedagogic principles which can offer guidance (see appendices) on the implementation of technology in taught modules. The proposed approach is statistically significant and can personalise the support to students. The current literature including TPACK (Mishra and Koehler, 2006), identified the need to have technology, pedagogical and content knowledge to be able to have effective practice using TEL. However, the literature gives no guidance on how you should use TEL in practice if you have the required knowledge. The

pedagogical implementation model for TEL produced as a result from this research gives the lecturer and universities guidance on an effective approach for TEL (see Appendices). To fully utilise the model from this research the practitioner will need to have content, pedagogical and technology knowledge. The current model provides the missing part of the TPACK literature, which is the suggested guidance on how to utilise this knowledge to enhance learning environments using technology. The current research provides an evidence-based approach and suggested guidance on how to effectively use TEL, building on the lecturers own TPACK knowledge.

The following is a summary of the results answering each of the main research questions.

1) Have the levels of engagement (virtual learning environment interaction, attendance, achievement) in all year groups of undergraduate students changed because of the technology-enhanced learning implementation?

The impact of the use of technology on the three main key measures identified in Question 1 was established through Study one. The findings indicate (please see 5.1 for more details) that technology had a positive effect on the three measures, if used in a consistent and coherent manner. The level of technology use was also evaluated, and it was found that intermediate-level use was the most effective in relation to the three performance indicators of module attendance, online engagement and module achievement. The module attendance (77%), online engagement (75 touchpoints) and module grade (MDX 8 = 60%) were all higher at the intermediate level of technology use than at the foundation and advanced levels (see Figures 5.1.1–5.1.3).

The intermediate level of technology use in a module included weekly lecture slides, online assessment submission and online assessment feedback, support material, online formative quizzes and discussion forums. The approach did not involve a video lecture, which was part of the advanced level, as it was found to be less effective. The findings from Study 1 were in line with current research by Beetham and Sharpe (2013), Fox and MacKeogh (2003), Hannan (2005), Juniu (2011); Karamanos and Gibbs (2012) and MacKeogh and Fox (2009), where the use of technology, taking a coherent approach,

ensures that there is easy access for all and that the technology enhances the pedagogical approach adopted by staff.

The findings for this question, which were different from the published literature, outlined how technologies can used at the intermediate level of implementation for a positive impact on taught modules. The approach did not use videos of complete lectures but a range of support resources online. These findings are different and build on current research in this area (Catcheside, 2012; Nehme, 2010; Shaw, 2012; Strijbos, 2011), and support the approach that technology should support teaching and learning and not replace taught delivery in HE. The findings answer the research question positively if an appropriate approach, is used as identified in the first study.

2) Have the educational changes influenced the student experience of technology-enhanced learning at Middlesex University?

The impact of the use of technology on student learning and on the students' experience was investigated through Study two. The findings indicate that students preferred a clear, coherent navigational approach for their online module support and the inclusion of regular formative activities aimed at enhancing the topics covered in the weekly taught sessions (see section 5.2). Students felt that the weekly formative tasks increased their level of understanding of the module topics and prepared them for the following week's sessions better than on their modules where these resources were not present. The students started to see value in the online support resources through this process, and this increased their engagement with both the online environment and the module as a whole. The process of a weekly schedule involved the students attending the taught session, receiving the resources for that session, undertaking the formative tasks and completing them prior to the next taught session.

These findings added to the body of published work in the field (Hu & McCormick, 2012; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Kuh, 2012; Pemberton et al., 2006; Rodriguez & Armellini, 2013; Thomas, 2012; Trowler, 2010). Students noted both that the use of technology to submit work and receive feedback helped them in their studies, and that they received guidance on how to improve their work quicker and in more detail.

Although this is now common practice in HE, the consistency of structure and detail in feedback was not so, at the time of the research, and this approach should be taken forward. The students noted the use of the online module pages to provide support materials, which they viewed as a positive change and use of technology.

The use of video was discussed, and students identified that its role was beneficial in providing guidance on certain elements of a topic for revision, rather than as a replacement for a lecture. The findings from Study two supported the findings in Study one in that technology should be used in the students' learning environment to enhance teaching and learning by providing support for the taught elements and not instead of this element. The combination of these findings answered Question 2 and added to the body of knowledge on this subject (Bryson & Hand, 2007; Case & Marshall, 2008; Fox & MacKeogh, 2003; Kuh et al., 2008; Nehme, 2010; Rodriguez & Armellini, 2013; Thomas, 2012; Trowler, 2010). The findings differed from the established research in identifying that students wanted a more consistent approach to the delivery of online support on their taught modules, and preferred video to be used for revision of themes, not replication of lectures.

3) Has technology enhancement personalised to undergraduate students' various learning styles significantly altered their progress on a taught module?

The use of technology in a personalised approach to enhance the students' learning environment was investigated through Study three. The personalisation of the learning resources and module pages was carried out using the students' learning style. The individual learning styles were established through the ILS questionnaire, and the implementation of its results was in line with research by Bishop and Foster (2011), Klašnja-Milićević et al. (2011) and Zajac (2009). The approach to measure the impact of the personalised resources was based on research by McKim et al. (2013), who also used an intervention to discover the impact of an element on the students' learning. The resources were delivered to the students through a consistent layout on the module pages on the VLE, in line with findings in the first two studies of the current research and published work (Doyle & Jacobs, 2013; Geçer & Dağ, 2012; Ginns & Fraser, 2010; Graf *et al.*, 2010; Kabakci Yurdakul et al., 2012).

The use of personalised learning resources was found to have a significantly positive impact on students' achievement and therefore their progress on the module. The students noted enjoyment and engagement with the module as a result of the content, including the personalised learning resources, which helped them to understand the topics and discover how they learnt topics as a whole. The impact on the students' achievement on the module was calculated to be significantly different from not using such resources, and regression analysis showed a +18% increase on a student's summative mark. The use of ILS to produce personalised learning resources for students in a uniform module framework in this manner has received limited investigation, therefore it adds to knowledge in this area. The strands (ILS, consistent layout and personalisation) making up the approach in study three, have seen some research into their effectiveness, and the findings from the current research support its findings (Bailey & Tuohy, 2009; Bishop & Foster, 2011; Coole & Watts, 2009; Graf et al., 2010; Hu and McCormick, 2012; Jennings & Kachel, 2010; Kabakci Yurdakul et al., 2012; Kuh et al., 2008; Lo et al., 2012; Rodriguez & Armellini, 2013).

Study three led to the development of a model from the framework to gauge the impact of personalised learning resources on students' learning. The model used its findings, in particular the regression analysis and student feedback on the types of personalised learning resource. Due to the quantity of resources required each week in which there was a taught session, the model looked at just using two types, in line with the analysis and students' feedback. These were a support activity on the weekly topics, which could be in the form of a worksheet or activity task, and a revision video on a particular theory or process. The model also included formative weekly quizzes to help students revise the previous week's topics and ensure that they were happy with their level of understanding and to add to their engagement with the module. The model indicates a way of using technology through the VLE to provide support for students which complements the taught sessions, in keeping with research in this area (Beetham, 2012; Graf et al., 2010; Hannan, 2005; Karger et al., 2008; MacKeogh & Fox, 2009; Pemberton et al., 2006).

The model differs from established research in its indication that if personalised learning resources are used in the proposed manner then 45% of the variability associated with a student's grade can be controlled. The impact of the proposed model is specific to the population and case study involved in the current research, so the wider impact needs to

be tested as outlined in 8.3. However, within the context of this population the impact of the proposed model is significant. The approach taken to implement the personalised learning resources should aim to use an intermediate level of resources, as found in Study two, so as to not to attempt to replace traditional methods, whilst providing alternative and additional learning resources. How personalised learning resources are used and developed in this process and through the model is new, and other approaches have involved limited research, so the current research both adds to the field of personalised learning and provides a new area of research in this established domain of published work (Bakas & Mikropoulos, 2003; Ginns & Fraser, 2010; Graf et al., 2010; Jennings & Kachel, 2010; Jimoyiannis & Angelaina, 2012; Klašnja-Milićević et al., 2011; Krämer & Bente, 2010; Zajac, 2009). The development of the model and the findings from Study three differ from established research, as identified, and in doing so answer the third research question positively.

8.2 Limitations of the current research

Any research has limitations, and these should be considered when assessing the full extent of its impact and in relation to any potential future follow-up work. The limitations of this research suggest the context for the findings and a reason for conducting further studies. Its findings can add to current practice and knowledge in the field of technology-enhanced teaching and learning, yet they are indicative only as they only focused on a single cohort of students: first-year undergraduate sport science students at Middlesex University, with the typically high percentage of 18 to 21-year-old males. This could result in them being knowledgeable about technology, thus they could perhaps access and use the personalised learning resources more easily than another cohort. The age range was the same in both groups involved in Study three, so the effect of this limitation was controlled, to a degree, however a cohort with a different demographic might experience a different impact. The indicative nature of the results and link to only this cohort of students means further research needs to be conducted.

Research suggests that sports students can have a practical nature, and therefore be predominantly visual or kinaesthetic learners, in part due to the subject that they chose to study (BASES, 2018; HEFCE, 2018; UCAS, 2018b). A limitation was the researcher's role in

the Sports Science department, delivering the module used in the research. Due to the nature of the cohort, the students' way of learning and use of technology may potentially have given them an advantage under the approach taken in the research, as the tasks enabled them to be 'hands on' in data analysis. Again, because the impact of the proposed approach compared groups within the same cohort, this limitation was accounted for as well as possible. The groups' ILS and subject knowledge were compared prior to the intervention to ensure that there were no significant differences between them.

The level of knowledge among participants was an unavoidable limitation, as the module used in the research was a first-year module, therefore they would, to a certain extent, still be learning the University systems used to access the personalised learning resources made available to them. However, this would have been the same for the whole cohort. The higher the level of knowledge, the more the participants should be used to independent study, therefore the need to offer resources to support this learning might be reduced. Alternatively, due to the potential for increased independent study skills, as they would be familiar with using many tools and resources to improve their knowledge participants at a higher level might engage with the personalised learning resources at a greater rate.

The module chosen for the current research was on the subject of research methods. The topics could be viewed as highly suitable for the approach proposed in Study three. The resources produced for this study involved guiding students through techniques and theories relating to practical data analysis, mainly. A worksheet or revision video on such techniques could be deemed more intuitive, due to the nature of the topic. The module's assessment was well suited to Study three, comprising a quiz on research methods. This could pose a problem in trying to use the proposed model in other subject areas in which the content is less easily adaptable to the VLE or the summative assessment is not exam based. Moreover, the development of resources to support highly theoretical sessions, with a different summative assessment scheme, could be difficult and not have the same effect. This limitation arose from the syllabus. However, the module's level and subject, although they influence the online tools to be deployed in the personalised learning resources, involve methods and ideas that are appropriate to several topics, and most degree programmes run a research methods module.

The final limitation of the research was the timescale of the intervention in Study three. It was used for only the first 12 weeks and for only 2 hours a week, due to a placement in the second half of the year. The teaching took place in computer labs, as many of the techniques used computer software. In view of the limited availability of these rooms, timetabling the sessions was a challenge.

The time that participants needed to engage with the personalised learning resources may have meant that first-year students' lack of familiarity with University systems had a considerable impact. If the intervention could have been implemented over a longer period, this would have been negated and the impact of personalised learning resource may have been different. Increased contact time for the taught element of the sessions, again, could have impacted on the use and impact of personalised learning resources on the cohort and the findings of the current research. The impact would have been the same on both groups, so the intervention group might not have used the personalised learning resources until later on in the 12-week block, therefore their results would not be as high as if they had used them for the entire block. Conversely, the control group might have performed just as well without the personalised learning resources upon becoming familiar to HE system, yet this limitation affected both groups equally so the impact was controlled, to a degree. However, like the other limitations identified, these were unavoidable due to the nature of the programme and University where the researcher taught. For the research to have concluded with the level of impact shown, under the various constraints and resulting limitations, is testament to the positive outcomes possible when using personalised learning resources.

8.3 Recommended future research

Any future work with the proposed model and findings of the research needs to validate the model and address some of the limitations to extend its potential impact. Although the model has been proved to be statistically valid and complete, it needs to be used in a different practice setting to be considered a valid approach for all module teaching in HE. Future research into the use of the proposed model (Figure 6.5) should focus on a different module subject using the same cohort then be repeated on a different programme all together. The proposed model's underlying principles should be generalisable, due to the

nature of its subject matter, research methods. This is a module topic that establishes the principles, and represents a fundamental topic that is taught in most degrees at most universities.

The validation of the model could be achieved by using the same approach on a similar module on another degree programme, which could indicate that it had the same impact regardless of subject. The principles of the model should allow for impact on any taught model, as the support resources can easily be tailored to the subject and the formative element can be adapted to suit. The future work proposed here would increase the generalisability of the model and demonstrate that it can have an impact on various cohorts with learning traits different from the sports students' kinaesthetic trait dominance. As mentioned, the principles of the model allow for generalisability and this will help in its practical validation, in conjunction with the model guidance (see appendices). The model adds to knowledge in this area and the impact of using personalised learning resource has been demonstrated. The support that the model suggests the tutor provides online suits the increasing demands on modern students to be employed whilst studying, offering effective support both on and off campus. The results from this research are relevant in the context of the studies and could be in other subject contexts but this is not being claimed in this research, which is why further research is required to confirm this suggestion.

In summary, the suggested future work to develop the areas discussed above could involve a similar protocol to Study three. The suggested future directions could be investigated by simply using the model on a non-sports science programme, at a higher learning level, in both research methods and non-research methods modules, and by engaging with lecturers to obtain their views. Variations in the duration of the implementation and weekly contact time could also be included or represent a separate line of investigation. Moreover, future work could identify the impact on staff by assessing the time required to produce the extra resources and the knowledge to implement personalised learning resources. The views of the academic staff will give insights into the extent of resistance and any solutions. These additional areas of enquiry will further validate the use of the proposed model in HE teaching.

8.4 Implications for scholarship and practice

The current research has several implications for current practice in HE teaching and learning. The identification of approaches to technology implementation in module teaching through this research, which have a positive effect on the students' learning, will have a lasting impact on practice. The model provides clear guidance for lecturers in HE on how to use technology to provide support resources with a positive impact on the student learning environment (see appendices for model guidance). The approaches in the research are supported by data analysis conducted as part of the studies and students' views on how they would like to access information. The current practice of a varied approach to using the VLE, which is largely dictated by staff's personal preferences, can now be developed using an evidence-based approach. The research identifies various approaches that, although with different levels of impact, all have a positive result on students' learning compared to no approach. The intermediate approach established in this research was identified as the most effective, but the foundation and advanced levels were still better than not implementing technology at all. It is suggested that, no matter to what extent the model and findings are implemented at university, in future students' taught modules will benefit from this research.

The use of the same infrastructure in future work at the same institution would ensure control of the variables, keeping them consistent to allow for accurate comparison of the findings. The suggested future directions could all be investigated by simply using the model in a non-sport science programme at Middlesex University. The model could be implemented in both a research methods module and a non-research methods module on the chosen programme. The views of the lecturer and students involved could be recorded to establish their views on the intervention, in the same way as in Study three. The variations on the duration of the implementation and weekly contact could be included or made a separate line of investigation after validation through replication of the research on another degree programme.

The final part of the research looked at using the established approach to using technology to support students outside of the classroom in a more tailored way, through the use of personalised learning resources. The research looked at using learning styles to provide

various resources to students according to their learning style. The research found evidence for using technology to enhance the students' learning environment and therefore develop practice in the sector. This was supported by significant data analysis and positive student views on its use to enhance their learning environment. The final model (Figure 6.5) shows that the extra support resources, in the form of personalised learning resources, coupled with formative assessment, attendance and online engagement, have a positive impact on student performance. The model should be used as evidence to guide lecturers to use technology to support their students on taught modules both during contact time and between sessions, rather than them developing their approach through their tacit knowledge. The model with its guidance (see appendices) adds new knowledge to the TEL pedagogy research area.

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Appendices

Appendix A - Autobiographical reflection

Throughout my personal and professional career, I have always tried to use technology and I have been fascinated with its enhancement of tasks. My other passion is teaching and coaching and, where possible, I have attempted to combine these two aspects of my personal and professional life. My previous academic theses at both undergraduate and masters levels both involved the use of technology to potentially impact an area of interest. I have been fortunate in my professional career to work in two subject areas, sports science and latterly education, which allow me to pursue these passions together. Through the academic environment that I work in I have the opportunity to develop my research skills and further explore the use of technology to enhance practice.

The opportunity to influence practice at my own institute and have professional conversations to share knowledge is invaluable and provided a good platform to undertake this research. I had entered teaching in higher education at a time when a PhD was not a prerequisite and I had wide practice experience to supplement my credentials. However, even though I had always been involved in research projects and published with others, as the sector developed I felt the pressure grow to undertake my own work. Having reached this point in my career at which I felt that I needed to pursue my own thesis, I could take advantage of my environment for my research to increase my academic currency.

Starting this journey was not easy, as I had to adapt my perspective and my work schedule to allow time to study part time on my PhD whilst maintaining my job. This helped me to further develop my time management and organisation skills to ensure that I could keep on top of both elements of my professional life, whilst still having an active family life. When I started this journey, I never thought that it would have the impact that it has on my professional life and enrich my personal skills set, allowing me to discover new knowledge.

Through the development and competition of the research, I have learnt how to write more effectively and at the required level. The process was one of the hardest stages of my learning development, and often led to many days of frustration, but has enabled me to work through 'writer's block' periods and remain focused to continually progress. Goal setting was a key strategy for me during this journey, so setting a daily minimum word limit of 500 word, during a writing period, resulted in consistent engagement in the research and steady progress towards the end goal. This process meant that I was able to organise my time effectively and, despite personal issues beyond my control, to complete the chapters on time. The journey has taught me how to accept and use feedback effectively and to ask for it in a format that will to develop the work the most. This lesson was a key developmental point and, combined with being organised, helped to progress my writing quality and the overall completion of the thesis.

In order to complete this thesis, I developed skills and learnt new techniques, not only around my writing but also in advanced data analysis methods. The first study enhanced my knowledge of using quantitative methods on large data files (n=5000 data points), and developing the analysis through to a multiple regression. Although I had conducted regression analysis prior to this research, this was normally with smaller data files, so this was a useful learning experience. The second study in this research collected qualitative data, which meant I had to learn a new methodology to analyse the data and gain the findings. I undertook an NVivo training course to familiarise myself with the software available for this analysis. Once I had undergone this training, coupled with reading on the subject, I felt competent to complete the analysis for Study 2. Developing this new set of techniques has helped with my understanding of qualitative methodology, which has helped my teaching practice.

The final study involved both qualitative and quantitative data collection and analysis. My newly developed and practised data analysis techniques enabled me to fully analyse the data from Study 3 to answer the study question, however the development of a model from the findings involved learning a new set of techniques. The use of SEM techniques allowed me to develop the model, which is the product of this research, but I had to take online seminars and supplementary reading to do so. The learning process was highly beneficial as it is a technique that is useful in advanced analysis, and has helped my

professional role and enhanced my teaching. Overall, the data analysis part of my thesis was a rewarding period of time as it developed my existing knowledge and I gained new knowledge in this area, which will have lasting impact on my career.

The research in this study has produced some solutions to problems and questions that I had long held through teaching in higher education. The way in which I support students through technology is now more focused, as I feel that I have the evidence to support a particular approach rather than my previously adopted trial and error approach. The way in which I prepare content for my teaching sessions is more organised, due to my renewed focus. The depth and quality that I give to the resources has not changed, but the allocation of time on the elements that I have found to be most beneficial has altered. Through the completion of the current study, the knowledge gained has given me renewed confidence in my professional role, as a learning and teaching lead. I feel that I am now in a position to speak with confidence about the approaches that my colleagues and peers should be taking to the use of technology in their teaching practice.

The study has been an invaluable and enriching personal learning experience. The many months of research have enhanced my understanding of the process, and the individual nuances often led to unexpected questions. The way in which each question is thought about and the evidence I found for the solution or answer has been very rewarding. The process has seen me develop into a researcher and understand that it can be incredibly frustrating, at times, and equally wonderful at others. On the whole, the developmental journey that I have been on through this thesis has been very rewarding and cathartic. I feel that the findings will impact on my own practice and help to develop my team, as well as the wider HE community. My personal values and approach to teaching have been affected by my increased knowledge of the research process and, as a result, I feel, my teaching has improved. My approach to my teaching is now more rounded and I feel I am more able to give an overall picture of both the practice and the research elements of a topic.

Appendix B - Study 2 sample focus group questions

1. What E-learning tools did you use on your programme or module studies?

2. What do you understand by the terms e-learning?

3. Has the use of e-learning changed your programme / module learning? If so, how?

4. What E-learning tools did you use to support your module learning?

5. Please identify positive changes to your Learning as result of e-learning?

6. Please identify any issues or problems you have experienced with the use of E-learning?

7. What impact- if any – do you think these changes have had on your learning experience?

8. What other improvements would you make to the online learning experience?

Appendix A - Study 3 sample focus groups questions

1. Has the use of individual personalised digital materials (IPDM) changed your learning experience? If so, how? (ease of use)

2. Please identify positive changes to your module learning as result of the implementation of the IPDM.

3. Please identify any issues or problems experienced with the use IPDM?

4. What impact - if any – do you think this implementation had on your module learning and achievement?

5. Do you think the resources helped you with the data analysis assessment?

6. Do you feel the resources helped your personal development?

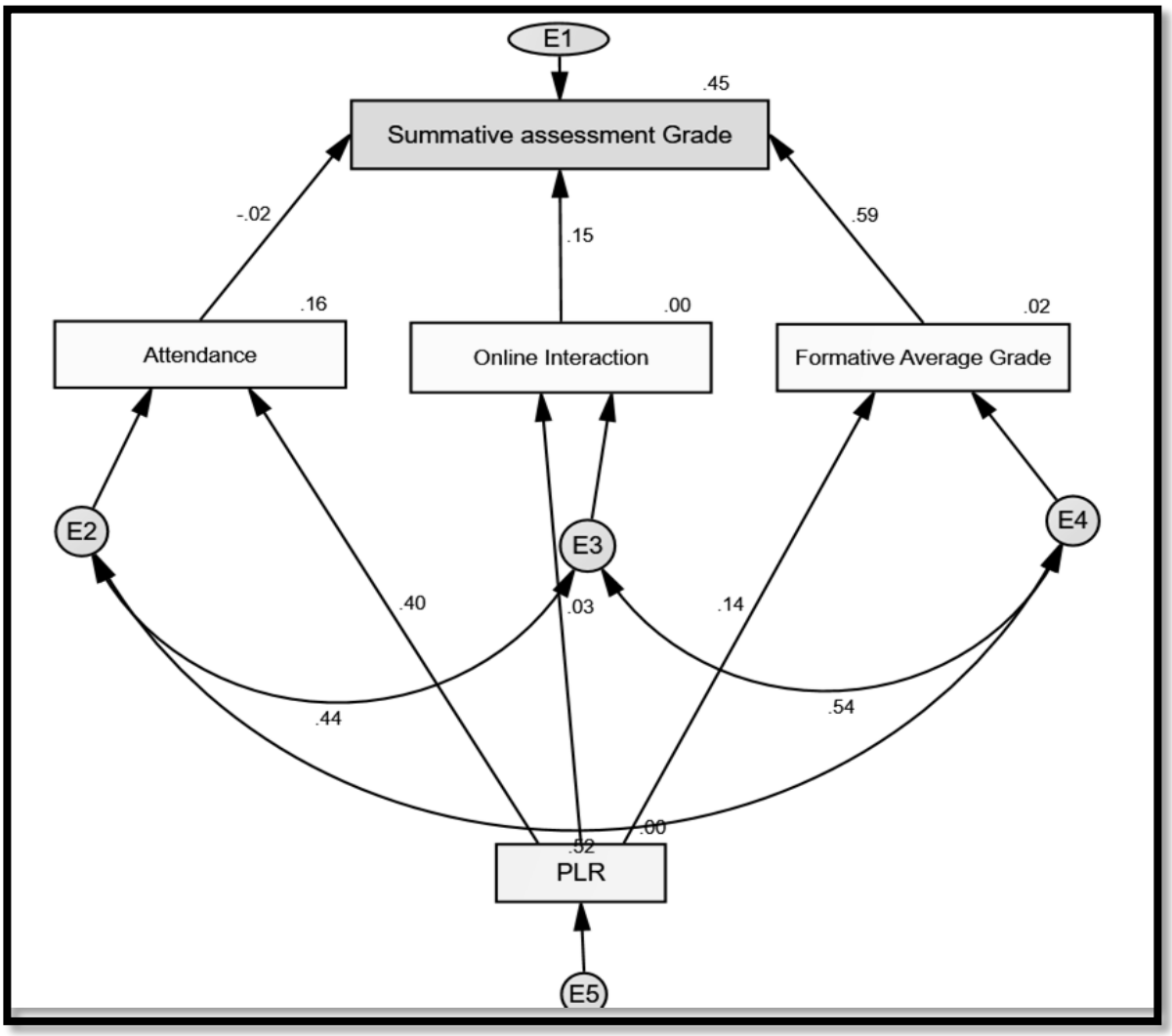
7. Did you feel the resources were personalised to how you study? If so, in which week(s) did you find the resources most useful?

8. What improvements would you suggest to the IPDM for wider use on your course?

9. How have you found the learning support materials for this section of the module?

Appendix D - Guidance for using the model

Some practical guidelines follow for the use of the proposed implementation model in taught models. The guidance will go through its key components to give examples of how they can be created and the frequency of delivery.



Attendance

The module attendance should be monitored, where appropriate, as the finding from this research was that class attendance was a key parameter for success, when coupled with other components of the model.

Online interaction

The amount of time a student engages with the online support materials and environment helps to increase the effectiveness of the model and their grade. The online engagement

goes hand in hand with the resources made available online, so the use of good personalised learning resources should increase students' online engagement.

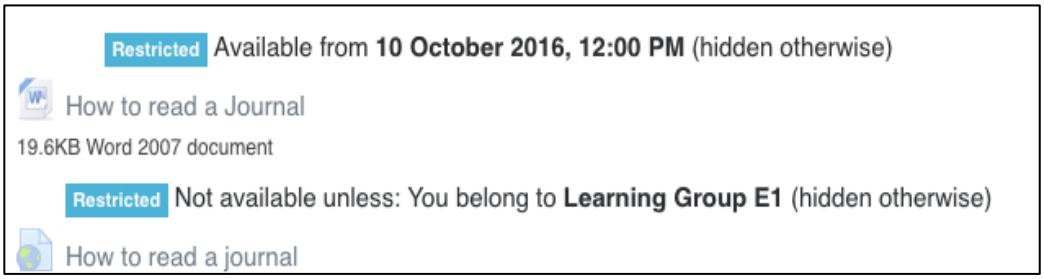
Formative assessments

The use of weekly quizzes helped the students to check their knowledge and reinforce their learning. In this research, the quizzes were multiple choice, randomly generating 10 questions from a bank of 20. The formative quizzes opened after every taught session and allowed the student to repeat them as many times as they wished, and at the end each quiz gave them an indication of where they needed to improve. Students were encouraged to complete or engage with the personalised learning resources and then do the quiz, as they were linked, but this was their choice.

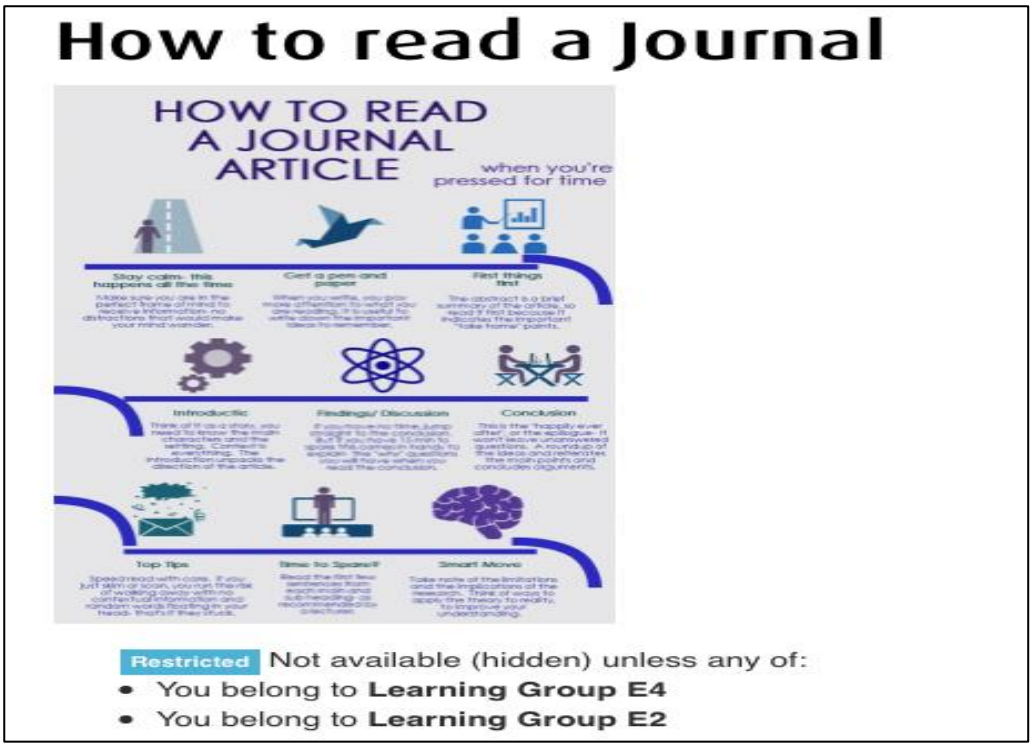
Personalised learning resources

This the key component of the above model. Each week a personalised learning resource was released to the students to support the content of the taught session after this had ended. The number of resources was reduced through the analysis and development of the final implementation model. The range of resources should be made available to all students so that they can self-personalise their learning. The recommended resources to be produced to support the taught session, in addition to the slides, are:

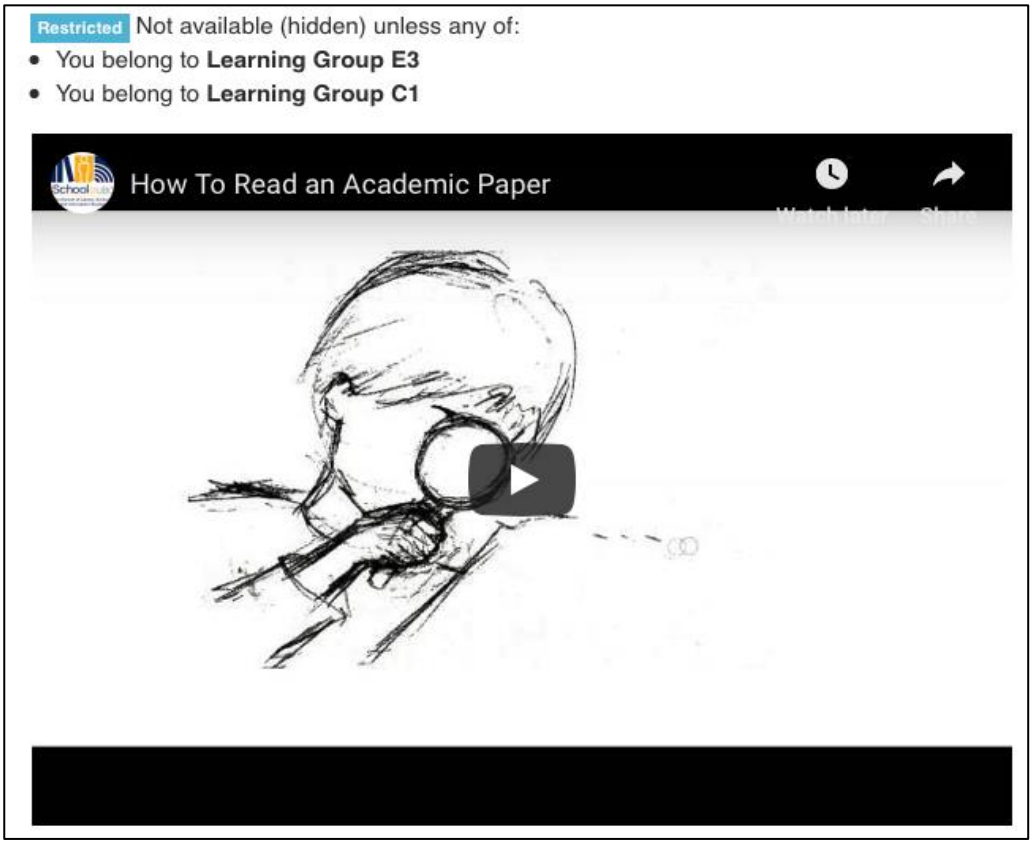
1) An interactive activity that encourages students to work through some of the theories or techniques covered in the taught session, which could take the form of a worksheet or a PBL task. The activities should be produced for each taught session and released after the session has ended (see image below).



2) Each module should have a thematic diagram to which the students can refer, showing how each taught session fits into the overall module's theme, aims and or concepts (see image below).



3) A short summary or revision video should be sourced to support the content of the taught session. The video could cover a key technique in SPSS, or recap a particular complex theory. The video should be released after each taught session has ended (see image below).



Appendix E - Study 1 Statistical output SPSS

1) Engagement

Correlations

		elearning_level	VLE_Engagement
elearning_level	Pearson Correlation	1	.800**
	Sig. (2-tailed)		.000
	N	3515	3515
VLE_Engagement	Pearson Correlation	.800**	1
	Sig. (2-tailed)	.000	
	N	3515	3515

**. Correlation is significant at the 0.01 level (2-tailed).

Regression analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the	Durbin-Watson
1	.800[a]	.640	.639	21.30106	.487

a. Predictors: (Constant), elearning_level
b. Dependent Variable: VLE_Engagement

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2828146.598	1	2828146.598	6233.037	.000[b]
	Residual	1593970.886	3513	453.735		
	Total	4422117.484	3514			

a. Dependent Variable: VLE_Engagement
b. Predictors: (Constant), elearning_level

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.278	.460		9.295	.000		
	elearning_level	25.252	.320	.800	78.950	.000	1.000	1.000

a. Dependent Variable: VLE_Engagement

2) Attendance

Correlations

		elearning_level	Module_attendance
elearning_level	**Pearson Correlation**	**1**	**.710****
	Sig. (2-tailed)		**.000**
	N	**3515**	**3515**
Module_attendance	**Pearson Correlation**	**.710****	**1**
	Sig. (2-tailed)	**.000**	
	N	**3515**	**3515**

****. Correlation is significant at the 0.01 level (2-tailed).**

Regression analysis

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the	Durbin-Watson
1	.710[a]	.504	.503	25.82568	.334

a. Predictors: (Constant), elearning_level
b. Dependent Variable: Module_attendance

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2376867.879	1	2376867.879	3563.702	.000[b]
	Residual	2343051.288	3513	666.966		
	Total	4719919.167	3514			

a. Dependent Variable: Module_attendance
b. Predictors: (Constant), elearning_level

Coefficients

Model		Unstandardized		Standardized	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.631	.558		2.923	.003		
	elearning_level	23.150	.388	.710	59.697	.000	1.000	1.000

a. Dependent Variable: Module_attendance

3) Module grade

Correlations

		Final_sit_grade	elearning_level
Final_sit_grade	Pearson Correlation	1	.124**
	Sig. (2-tailed)		.000
	N	3515	3515
elearning_level	Pearson Correlation	.124**	1
	Sig. (2-tailed)	.000	
	N	3515	3515

**. Correlation is significant at the 0.01 level (2-tailed).

Regression

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the	Durbin-Watson
1	.124[a]	.015	.015	6.353	1.460

a. Predictors: (Constant), elearning_level
b. Dependent Variable: Final_sit_grade

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2210.689	1	2210.689	54.766	.000[b]
	Residual	141806.624	3513	40.366		
	Total	144017.313	3514			

a. Dependent Variable: Final_sit_grade
b. Predictors: (Constant), elearning_level

Coefficients

Model		Unstandardized B	Unstandardized Std. Error	Standardized Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	7.808	.137		56.887	.000		
	elearning_level	.706	.095	.124	7.400	.000	1.000	1.000

a. Dependent Variable: Final_sit_grade

4) Overall ANOVA

Tests of Between-Subjects Effects

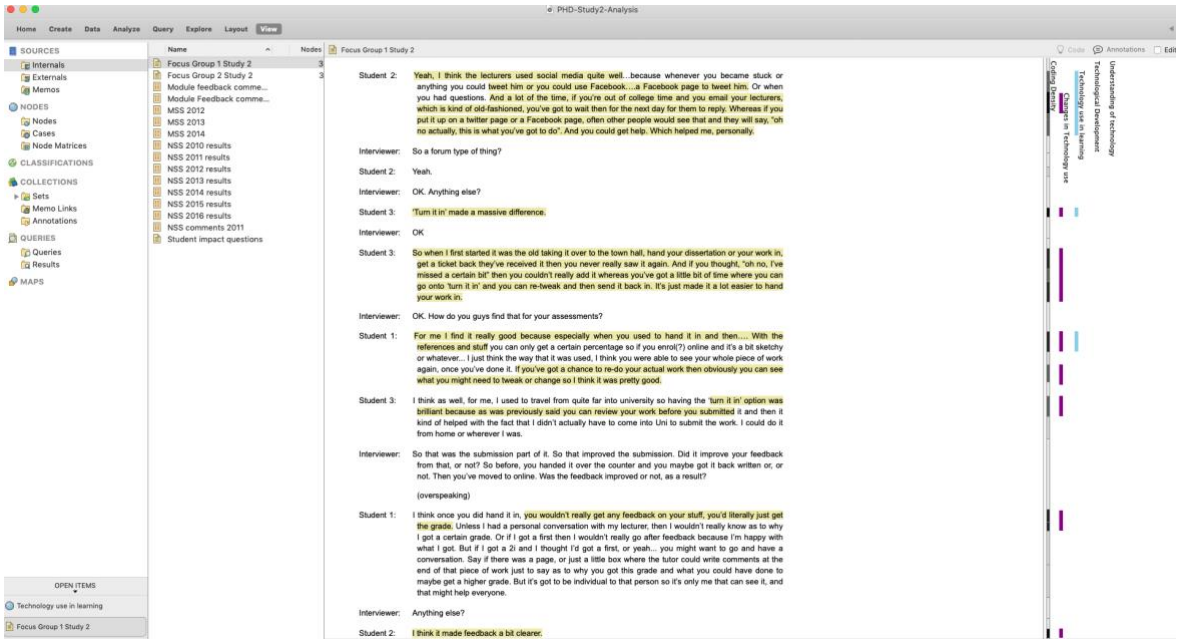
Source	Dependent	Type III Sum	df	Mean	F	Sig.
Intercept	Final_sit_grade	172941.677	1	172941.677	4288.456	.000
	Module_attendanc	3809589.112	1	3809589.112	6532.149	.000
	VLE_Engagement	4752002.856	1	4752002.856	12907.941	.000
elearning_level	Final_sit_grade	2428.299	3	809.433	20.072	.000
	Module_attendanc	2672282.595	3	890760.865	1527.352	.000
	VLE_Engagement	3129558.009	3	1043186.003	2833.623	.000
Error	Final_sit_grade	141589.014	3511	40.327		
	Module_attendanc	2047636.572	3511	583.206		
	VLE_Engagement	1292559.475	3511	368.146		

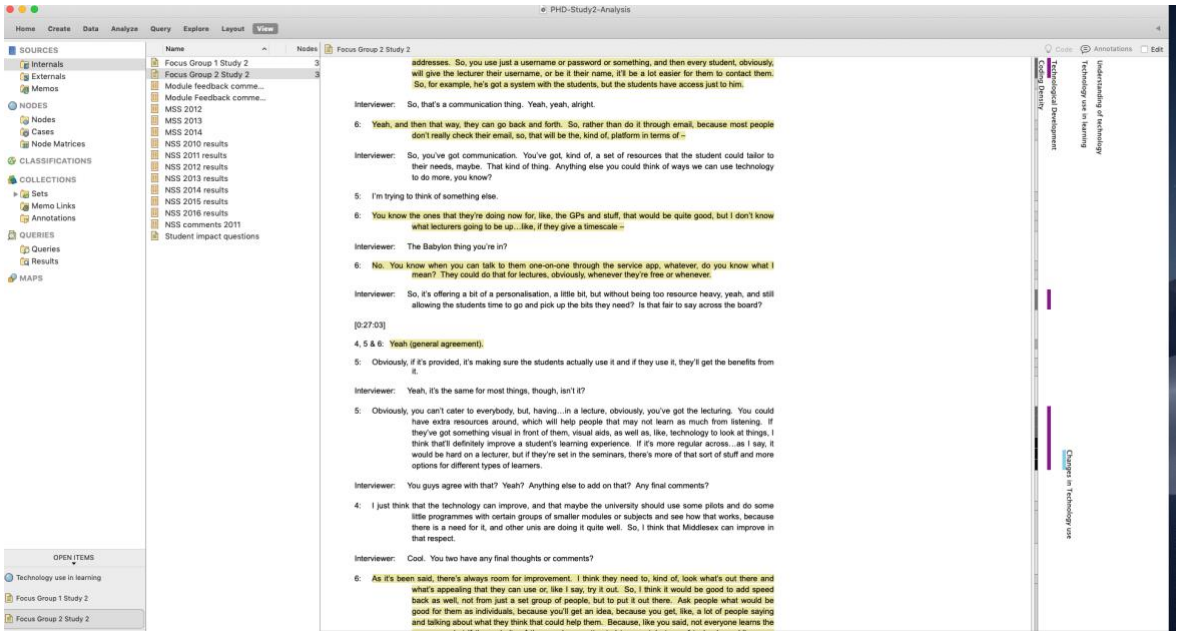
Pairwise Comparisons

Dependent Variable	(I) elearning_level	(J) elearning_level	Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower	95% Confidence Interval Upper
Final_sit_grade	Pre moodle	foundation	-1.112	.266	.000	-1.813	-.410
		intermediate	-.832	.414	.267	-1.926	.261
		advanced	-2.228	.300	.000	-3.020	-1.437
		Pre moodle	1.112	.266	.000	.410	1.813

	foundation level	intermediate	.279	.445	1.000	-.895	1.454
		advanced	-1.117	.341	.006	-2.016	-.217
	intermediate	Pre moodle	.832	.414	.267	-.261	1.926
		foundation	-.279	.445	1.000	-1.454	.895
		advanced	-1.396	.466	.016	-2.626	-.166
	advanced	Pre moodle	2.228	.300	.000	1.437	3.020
		foundation	1.117	.341	.006	.217	2.016
		intermediate	1.396	.466	.016	.166	2.626
Module_attendance	Pre moodle	foundation	-25.289	1.011	.000	-27.958	-22.621
		intermediate	-77.717	1.575	.000	-81.875	-73.560
		advanced	-61.848	1.140	.000	-64.857	-58.838
	foundation level	Pre moodle	25.289	1.011	.000	22.621	27.958
		intermediate	-52.428	1.691	.000	-56.893	-47.963
		advanced	-36.558	1.296	.000	-39.979	-33.137
	intermediate	Pre moodle	77.717	1.575	.000	73.560	81.875
		foundation	52.428	1.691	.000	47.963	56.893
		advanced	15.870	1.772	.000	11.193	20.547
	advanced	Pre moodle	61.848	1.140	.000	58.838	64.857
		foundation	36.558	1.296	.000	33.137	39.979
		intermediate	-15.870	1.772	.000	-20.547	-11.193
VLE_Engagement	Pre moodle	foundation	-39.710	.803	.000	-41.830	-37.590
		intermediate	-74.906	1.251	.000	-78.209	-71.602
		advanced	-68.993	.906	.000	-71.384	-66.602
	foundation level	Pre moodle	39.710	.803	.000	37.590	41.830
		intermediate	-35.196	1.344	.000	-38.743	-31.648
		advanced	-29.283	1.030	.000	-32.001	-26.565
	intermediate	Pre moodle	74.906	1.251	.000	71.602	78.209
		foundation	35.196	1.344	.000	31.648	38.743
		advanced	5.913	1.408	.000	2.197	9.628
	advanced	Pre moodle	68.993	.906	.000	66.602	71.384
		foundation	29.283	1.030	.000	26.565	32.001
		intermediate	-5.913	1.408	.000	-9.628	-2.197

Appendix F – Study 2 Coding NVivo





Appendix G – Study 3 Statistical output SPSS

1) Overall ANOVA

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum	df	Mean Square	F	Sig.
Intercept	Online_Engagment	228309.211	1	228309.211	77.442	.000
	Module_Attendance	41.445	1	41.445	838.780	.000
	Weekly_Quiz_Average_Grade	5.138	1	5.138	118.066	.000
	Data_assessment_Grade	22.544	1	22.544	593.280	.000
Study_group	Online_Engagment	37675.871	1	37675.871	12.779	.001
	Module_Attendance	.041	1	.041	.826	.365
	Weekly_Quiz_Average_Grade	.188	1	.188	4.328	.040
	Data_assessment_Grade	.224	1	.224	5.884	.017
Error	Online_Engagment	356726.093	121	2948.150		
	Module_Attendance	5.979	121	.049		
	Weekly_Quiz_Average_Grade	5.266	121	.044		
	Data_assessment_Grade	4.598	121	.038		

Pairwise Comparisons

Dependent Variable	(I) Study_group	(J) Study_group	Mean Differenc	Std. Error	Sig.[b]	95% Confidence	
						Lower	Upper
Online_Engagment	Control - No	Intervention -	-43.838*	12.263	.001	-68.116	-19.560
	Intervention -	Control - No	43.838*	12.263	.001	19.560	68.116
Module_Attendance	Control - No	Intervention -	-.046	.050	.365	-.145	.054
	Intervention -	Control - No	.046	.050	.365	-.054	.145
Weekly_Quiz_Average_Grad	Control - No	Intervention -	-.098*	.047	.040	-.191	-.005
	Intervention -	Control - No	.098*	.047	.040	.005	.191
Data_assessment_Grade	Control - No	Intervention -	-.107*	.044	.017	-.194	-.020
	Intervention -	Control - No	.107*	.044	.017	.020	.194

2) PLR Correlations

		Online_En	Module_A	Weekly_Q	Data_asse	Mock_Dat
Online_Engagment	Pearson	1	.304*	.309*	.417**	.524**
	Sig. (2-tailed)		.014	.012	.001	.000
	N	65	65	65	65	65
Module_Attendance	Pearson	.304*	1	.272*	.495**	.488**
	Sig. (2-tailed)	.014		.028	.000	.000
	N	65	65	65	65	65
Weekly_Quiz_Average_Grade	Pearson	.309*	.272*	1	.433**	.360**
	Sig. (2-tailed)	.012	.028		.000	.003
	N	65	65	65	65	65
Data_assessment_Grade	Pearson	.417**	.495**	.433**	1	.558**
	Sig. (2-tailed)	.001	.000	.000		.000
	N	65	65	65	65	65
Mock_Data_Quiz_Grade	Pearson	.524**	.488**	.360**	.558**	1
	Sig. (2-tailed)	.000	.000	.003	.000	
	N	65	65	65	65	65
*. Correlation is significant at the 0.05 level (2-tailed).						
**. Correlation is significant at the 0.01 level (2-tailed).						

3) PLR Regression

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	Study_group =			
1	.589[a]	.346	.314	.16573

a. Predictors: (Constant), Weekly_Quiz_Average, Attendance, VLE_Count

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.888	3	.296	10.778	.000[c]
	Residual	1.676	61	.027		
	Total	2.564	64			

a. Dependent Variable: Final_Data_assessment

b. Selecting only cases for which Study_group = Intervention - Personalised

c. Predictors: (Constant), Weekly_Quiz_Average, Attendance, VLE_Count

Coefficients

Model		Unstandardized Coefficients		Standardized	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.229	.075		3.049	.003
	Online_Engagment	.000	.000	.117	1.017	.313
	Module_Attendance	.232	.102	.256	2.280	.026
	Weekly_Quiz_Average	.212	.101	.222	2.097	.040
	Mock_Data_Quiz_Grade	.241	.105	.292	2.303	.025

a. Dependent Variable: Data_assessment_Grade

b. Selecting only cases for which Study_group = Intervention - Personalised