2017

VLE based analysis and design

Chetwynd, A.

Chetwynd, A. (2017) '
http://hdl.handle.net/10026.1/14141

The Plymouth Student Scientist
University of Plymouth

*The Plymouth Student Scientist, 2017, **10**, (1), 102-142*

VLE based analysis and design

Andrew Chetwynd

Project Advisor: Michael Buller, School of Engineering, Plymouth University, Drake Circus, Plymouth, PL4 8AA

Abstract

Students that are taught Structural Analysis and Design are confined to being shown a limited number of worked examples within an allocated lecture time. A Virtual Learning Environment (VLE) would offer students the opportunity to explore additional examples that cannot be considered during lecture time and also produce dynamic feedback and assistance. A broad review of learning and teaching styles was conducted. This was refined to engineers only with the two most predominant learning styles emerging as Assimilator and Converger. A critical review of VLEs was carried out, validating the necessity for a VLE focused upon Structural Analysis and Design. An initial set of focus groups held to identify the sub-topic that would benefit most from the implementation of a VLE revealed this to be 'Rigid Frames'. A set of desirable features were also ascertained, with each of these implemented into a VLE prototype. A secondary set of focus groups were then carried out to critically analyse the developed features. The VLE prototype proved effective amongst all participants. Each feature of the prototype was critically analysed, with further implementation options given, but the consensus was that this system was highly sought after. The project has highlighted the necessity for a VLE focusing upon Structural Analysis and Design, illustrating its unrestricted potential. The project has successfully determined the effectiveness of key features to optimise the learning for a civil engineering student.

Keywords: *structural analysis and design, virtual learning environment, e-learning.*

Project introduction

Aims and objectives

With deliverability in mind, the key aim of the project was to:

- Ascertain how a virtual learning environment (VLE) could optimise learning for a civil engineering student, while determining the effectiveness and significance of available features

For the aim to be achieved, it was necessary for the following objectives to be outlined:

i. A critical review to be conducted into the background literature available on:
   a. The categories of learning and teaching styles currently used
   b. How engineering students learn and are taught in higher education
   c. How a VLE can optimise student learning
ii. An initial set of focus groups to be formed, ascertaining which Structural Analysis and Design topic would benefit most from a VLE, as well as the desired features for implementation
iii. A prototype to be developed, encompassing the desired features that were attained through the initial focus groups
iv. A secondary set of focus groups to be run, testing the effectiveness of the key features used

As well as outlining the project aim and objectives here, the rationale for the project, a brief history of the topic and the scope and limitations of the project are summarised below.

An extensive literature review surrounding the topic has been carried out and is presented below. Several significant areas have been explored including: Classification of Learning and Teaching Styles; Learning and Teaching Styles in Higher Education; Learning and Teaching Styles for Engineers; Development and Availability of IT for E-Learning; and Virtual Leaning Environments. The review scrutinises and evaluates the main contributors within the field of teaching and learning. It goes on to uncover which technologies are readily available and how they can be used in the development of a VLE.

An account of the method that was undertaken is shown in the Methodology section. This section shows the procedure that was carried out for: the undertaking of the initial focus groups; the implementation of the VLE prototype; and the carrying out of the secondary focus groups. All key decisions are highlighted, with the rationale behind each choice substantiated.

The outcomes produced from both focus groups have been presented in the Results section. Any key observations that were made during the collection of data have also been stated. Due to the nature of the project, the results are comprised of a mixture of both qualitative and quantitative data.

The manipulation of the results has been shown in the Calculations section. Due to the characteristics of the collected data, the calculations carried out were relatively basic. This section extrudes and manipulates the quantitative data into a manageable form, enabling it to be utilised in the development of the VLE prototype.

The results and key findings are discussed in the discussion section. This section expresses the key findings of the project, linking them back to the information found in the background literature. It then goes on to critically appraise both the prototype and the project as a whole; making suggestions on how the project could have differed and what steps can be carried out to progress the project further.

The main findings of the project are summarised in the conclusion section. This section encapsulates the discussion, refining the key arguments made. Here the project as a whole is appraised, determining if the original aim and respective objectives have been achieved.

Rationale

Students in higher education are provided with a limited amount of face-to-face time with their teacher. Academics teaching Structural Analysis and Design are allocated a finite amount of time in which they can display a small number of worked examples in lectures. Contact time outside of the class is restricted due to the additional commitments of the academics: carrying out research; leading other courses; and offering equal support amongst all of their allocated students.

For many learners in higher education, the comprehension of their subject is founded upon repetition (Fry, et al., 2003). The amount of time that students have available to practice examples often strongly correlates to their competence within the subject. Inadequacies in their understanding at an early stage can lead to subsequent topics becoming far more laborious than necessary. Student’s misconceptions are challenging and onerous to correct, with students sometimes not even aware of their misapprehensions (Srinivas, 2015).

A virtual learning environment (VLE) is a web-based system that delivers learning resources to a student; these systems can often incorporate assessment tools and communication facilities (Oxford University Press, 2015). The production of a VLE would offer students the opportunity to undertake the additional worked examples that can’t be carried out in lecture time. A VLE would allow students to complete an unlimited number of examples, without being constrained to the scheduled lectures. Students would be able to learn actively from their mistakes, with dynamic feedback and assistance offered at key locations throughout the given example.

Scope

The earliest pure form of Structural Analysis and Design is introduced at an undergraduate level. Before higher education, the underlying principles are portrayed in the form of STEM subjects (Science, Technology, Engineering and Mathematics) (Institution of Civil Engineers, 2015). Despite the importance of the STEM subjects, the focus of this project is directed at Structural Analysis and Design at an undergraduate level, this is due to the increased complexity and nature of the material that is taught.

This project develops a virtual learning environment (VLE) prototype to aid in the understanding of a given topic with Structural Analysis and Design. As previously ascertained, the target audience of the VLE is undergraduate students within higher education. To determine the topic within Structural Analysis and Design that would benefit most from having a VLE, an initial set of focus groups were run. These groups also highlighted key features that they would like to see in the prototype. The outcome of the initial focus groups became the basis for the prototype. The effectiveness of the VLE was gauged by holding secondary focus groups, testing and critically analysing the prototype.

Limitations
Several restrictions heavily influenced the scope of this project. The principle limitation of the project was time. The project was allocated approximately seven months for completion, but not all of that time was functional. A key aspect of establishing the projects trajectory was gaining information from higher education engineering students. This data collection was restricted by having to avoid vacations and sensitive times through the semesters (examinations, coursework deadlines, etc.).

The cost was an additional limitation to the project. There are an extensive range of online resources available in the subject of Structural Analysis and Design, some of which were only available through a paid subscription. Due to the nature of the project, a limited number of associations allowed free access to their material, but a significant number did not.

History
There has been an extensive range of research carried out to comprehend the way in which people learn. Key psychologists such as Kolb and Fleming have fashioned the way in which learning styles are categorised, with their work being the basis of a multitude of studies and papers.

The concept of a virtual learning environment (VLE) began from the introduction of Web 2.0, which allowed users to interact dynamically with web pages. VLEs have become increasingly popular due to their versatility to convey a variety of information over a range of subjects. This popularity has led to a great interest in the topic of VLEs and consequently research into the subject.

The exploration of VLEs within a Structural Analysis and Design capacity is relatively minimal. Institutions, such as The Institution of Structural Engineers and The University of Bath, have begun developing VLEs to aid the learning of the subject. Despite these systems being in place, their functionalities are limited in respect to the full potential of a VLE. Also, these systems are predominantly concentrated on Structural Analysis, with Structural Design being overlooked. Further investigation into these models is carried out within the background literature section

Background literature

Classification of learning and teaching styles

A learning style can be defined as the *"cognitive, affective and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment*" (Keefe, 1979). The definition of a learning style holds little ambiguity, with numerous sources following the same rationale as Keefe and often even founded upon his text. Despite little conflict over the definition, the categorisation of learning styles has been conveyed in a multitude of ways, each with its bespoke mechanism of determining a learner's preference.

One of the most governing classifications of learning styles is Visual, Auditory and Kinaesthetic (VAK). The dominance of this classification is based upon its simplicity and adaptability (Clark, 2011). The classification of VAK is derived from the main sensory receivers: sight, sound and touch. A Visual preference is focused on graphical representation to portray information; this can be in the form of charts, graphs or diagrams. The Visual preference can be broken into two subcategories, with a secondary section aimed at Read-Write, producing the new acronym of VARK (Fleming, 2016). The Read-Write category is fairly self-explanatory, with the user preferring text through both reading and writing, instead of graphical representation. Both Visual preferences have the tendency to become distracted easily by visual aspects in their local environments, for instance, messy surroundings. An Auditory preference is motivated by listening to information; this is often a teacher or peer relaying information. These learners' understandings are strengthened by being able to interact; this would be to reply verbally with the teacher or peer within a discussion. A learner with this preference can often become distracted by sounds around them; this can come from inside or outside of the classroom. A Kinaesthetic preference is enthused through hands-on learning; this can be carrying out tasks such as laboratory experiments. A learner under this category can become distracted when there is a lack of activities available.

The majority of learners are shown to lean towards a particular style, but some are divided between two or even three of the categories, these learners are defined as multi-modal. A multi-modal learner is rarely split equally between categories; they are often split with a ratio of the two or three learning preferences, giving a greater understanding and in turn a greater portrayal of their learning type (Singh, 2013).

The concept of learning styles is widely accepted and with advances in technology, such as the use of Magnetic Resonance Imaging (MRI) technology, it has been possible to prove their existence. A study showed that learners who consider themselves to be Visual had the tendency to convert linguistically transferred information into a mental representation to suit their learning style; this was demonstrated by the increase in activity in the visual cortex of their brain (Thompson-Schill, et al., 2009). The study also revealed that learners who consider themselves to be Auditory learners would have a massive influx of activity within the region of their brain that is associated with phonological cognition, when they were exposed to graphically portrayed information.

Despite its general acceptance, the theory of learning styles does hold opposition. A study was carried out with a sample of Visual and Auditory learners; each learner was exposed to a mix of Visual, Audible and Visual/Audible information. The result of the study showed that visual information was beneficial for all learners, irrespective of how they were categorised (Constantinidou & Baker, 2002). The study strongly insinuates that what is often referred to as a learning style should be referred to as a learning preference.

However, it is argued that "*during a period in which an individual has strong style preferences, that person will achieve most easily when taught with strategies and resources that complement those preferences*" (Zapalska & Dabb, 2002). This is based on the works of (Dunn, 1993) and (Fleming, 1995) which stipulate that learning styles vary over time, as well as on the environment of the learner. It is also stated that the preference of a learner in digesting information may not match their preference for then expressing that information (Fleming, 1995). For example, a person who may prefer to intake visually may then wish to relay the information audibly.

Another of the most dominant models of learning styles was developed in the 1970s by David Kolb. "*Learning is the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping experience and transforming it*." (Kolb, 1984). Kolb constructed his theory upon the work of John Dewey, Kurt Lewin and Jean Piaget (Coffield, et al., 2004); following their belief that learning was enhanced through experiencing rather than just observing. His theory of experiential learning was put to the test using the Learning Skills Inventory (LSI), a purpose built device for testing his work (Coffield, et al., 2004). Kolb's theory is world renowned, with vast amounts of research founded upon it, for example, Honey and Mumford's Learning Style Questionnaire is fully reliant upon the work of Kolb (Talent Lens, 2016).

Kolb's theory of learning styles was based upon what he believed to be the four stages of learning, as depicted in the Experiential Learning Cycle by McLeod (2010). Kolb believed that learning is best conceived as a process and not on what outcomes were produced (Clark, 2011). The learner would enter the cycle at any of the four stages, but would continue clockwise around the cycle indefinitely. For the benefit of explaining the cycle, the stages will be described clockwise from Concrete Experience. Concrete Experience is the process of a new experience being encountered or an existing experience being reencountered. It is not essential for the task to be successful, merely that the learner has experienced trying it. Reflective Observation is the process of the learner looking back over their experience, analysing what they have done and how they carried it out. This stage has particular importance, as it is believed this is when the learner solidifies the experience within their memory for future use (Kolb, 1984). Abstract Conceptualisation is the process of the learner critically analysing their observations, theorising what could be improved if the task were to be carried out again. This improvement could be a new idea or an adaptation of a previous idea, dependent on what was observed. Active Experimentation is the process of repeating the initial experience, but while applying the newly conceived approach. The outcome of this stage is the creation of a new Concrete Experience. For effective learning to take place, all four stages of the model need to be executed, there is no effectiveness in the model if three or fewer stages are undertaken separately (Kolb, 1984).

Table 1 - Matrix of Kolb's Learning Styles (McLeod, 2010)

	Doing (Active Experimentation - AE)	**Watching** (Reflective Observation - RO)
Feeling (Concrete Experience - CE)	**Accommodating** (CE/AE)	**Diverging** (CE/RO)
Thinking (Abstract Conceptualisation - AC)	**Converging** (AC/AE)	**Assimilating** (AC/RO)

Table 1 shows Kolb's four distinct learning styles, derived from the Experiential Learning Cycle, as previously outlined by McLeod (2010). Whereas previously the model applied to all learners, the learning styles now apply solely to a specific learner. These styles are outlined in (Kolb, 1984) and (Coffield, et al., 2004) as:

- The Accommodating style (Concrete Experience and Active Experimentation). This learning style refers to learners who like to do things actively, by carrying out plans and becoming involved in new experiences. They can adapt to changing environments and circumstances, as well as being able to solve problems through trial and error.
- The Diverging (Concrete Experience and Reflective Observation). This learning style refers to a more imaginative learner that will often view an experience from a multitude of perspectives. They adapt through observation, rather than action.
- The Converging (Abstract Conceptualisation and Active Experimentation). This learning style refers to the problem-solving learner, who is a strong decision-maker, capable of applying ideas practically.
- The Assimilating (Abstract Conceptualisation and Reflective Observation). This learning style refers to learners who enjoy creating theoretical models; their concern is over ensuring the idea is logically viable, rather than its application and practicality.

McLeod (2010) built upon the learning styles shown in Table 1, amalgamating them with the experiential learning cycle. It displayed how each stage of the learning cycle interacts with one another, as well as the learning styles. It could be seen that Active Experimentation and Reflective Observation lie at either end of the Processing Continuum. The Processing Continuum is the scale of how a learner approaches a task, with watching at one end of the spectrum and doing at the other. The same occurs with the Concrete Experience and Abstract Conceptualisation both lying at either end of the Perception Continuum. The Perception Continuum is the scale of the learner's emotional response to a task, with feeling at one end of the spectrum and thinking at the other.

Kolb defines three stages of the development of a learner within their lifetime: Acquisition, Specialisation and Integration. The Acquisitions stage takes the learner from birth to adolescence, where simple abilities and perceptions are developed. Specialisation takes the learner through education and their early working life, where the learner develops a tailored learning style, heavily influenced by social, work and personal factors. Integration takes the learner from mid-career through to later life, where the learner may change and try new learning styles. (Singh, 2013).

Kolb's learning styles can be easily compared to that of VAK. By primarily focusing on the Processing Continuum it is possible to see an overlap between the two theories. Kolb uses the Processing Continuum as a scale of how a learner would approach a task. Regardless of how the learner chooses to carry out the task, they will require the use of their main sensory receivers (VAK). When looking at Kolb's Perception Continuum, it can be seen that this is where the two theories start to differ. The Perception Continuum is how the learner feels about the task; this is not accounted for within the theory of VAK. It does not take into consideration what the learner does with the information that they gain after completing the task.

The way a person learns is often different to the way they are taught. Educators often teach in a Visual style, mainly through Read-Write. This practice is how society has dictated for them to teach, with the main forms of teaching and assessment carried out with the same style (e.g. textbooks and exam papers). There is also a historical influence, with current teachers using methods of teaching attained from their respective teachers (Fleming, 1995).

Learning and teaching styles in Higher Education

Higher Education institutes offer four types of course, dependent on the proportion of content delivered online, over that of content delivered face-to-face. The course types are defined as traditional, web-facilitated, blended or online. A traditional course type relies solely upon face-to-face contact, with all of the content either delivered within the text or verbally. The next course type is web-facilitated, 1 to 29% of this course type's content is delivered online. This course type is mainly a face-to-face, but utilises web-based facilities to share documents, for example, assignments and course details. The next course type is blended, also known as hybrid; this is becoming one of the most popular and prominent types in higher education (ICEF Monitor, 2015). In a blended course, a substantial proportion of the course content (between 30 and 79%) is delivered online in the form of course content and discussions, but there is still a face-to-face aspect. This course type is thought to include the best practices of both the traditional and online types, which is where the name 'hybrid' originates. The final course type is online; this is defined as when over 80% of the course content is delivered online. These courses typically have no face-to-face time at all. (Allen & Seaman, 2007).

A study was led by Case Western Reserve University to determine the learning styles of 288 undergraduate students that had just started higher education, over an array of subjects. The study showed that the vast majority of the participants were classified as Assimilators (Yamazaki, et al., 2003). This finding was attributed to the way in which the education system is devised. Assimilators are known for being strong theorists, enjoying designing models and pulling information together. Due to the way the education system recruits undergraduate students, these traits act preferentially, giving the candidates with an assimilating learning style an advantage over other styles. As current examinations favour Assimilators, there is concern over the future of the higher education system, requiring a change to accommodate for the other learning styles and in turn enriching the system (Yamazaki, et al., 2003).

It is imperative that teachers within higher education carry out a continuous professional development of how they deliver their content; this should be done in both the short and long term (Davenport, 2014). This continual professional development is known as action research. Action research allows educators the chance to adapt their teaching techniques to improve the quality of the taught material. There are two types of teachers, experienced and expert. Experienced teachers have normally been teaching for several years and have a set content, this content can be extremely robust, but may not be adapted to suit the learner. Expert teachers have the same quality of content, but look to evolve with time, trying new techniques and observing its effects (Hattie, 2003). Despite a positive change in the delivery of the content being the key aim, an expert teacher does not necessarily need to improve the teaching with change. If an expert teacher fails in improving their taught content, they just need to be able to adapt for a second time to strengthen the material once more (Davenport, 2014). "*Students who are taught by expert teachers exhibit an understanding of the concepts targeted in instruction that is more integrated, more coherent, and at a higher level of abstraction than the understanding achieved by other students*" (Hattie, 2003).

Learning and teaching styles for Engineers

Kolb ran a study using 436 undergraduate engineering students, finding that: 23.6% were classified as Accommodating; 11.5% were classified as Diverging; 33.3% were classified as Converging; and 31.7% were classified as Assimilating (Kolb & Kolb, 2005). Sharp carried out a study using 1013 learners, over a period of ten years, finding that: 13% were classified as Accommodating; 8% were classified as Diverging; 40% were classified as Converging; and 39% were classified as Assimilating (Sharp, 2001). Both studies show that the principal learning styles within engineering are Assimilator and Converger.

When a comparison is made between the typical traits of an engineer and the definition of the Assimilator and Converger learning styles, it is apparent that there is a strong association between the two. Both learning styles comprise of the stage of Abstract Conceptualisation; engineers require this to analyse critically the problem that they have been given and to conceive a solution to that problem. There is a clear link between this quality and how engineers work in practice. Engineers are tasked on a regular basis with problems that they have to analyse and produce a solution for; this could be designing an element of a building with dimensional or weight constraints, which would require a bespoke solution. Convergers are renowned for problem solving, decision making and applying ideas practically. Once again, it is easy to connect all of these characteristics with that of an engineer. Assimilators are best known for theorising and ensuring an idea is logically viable. Ensuring an idea is logically viable is a desired trait of an engineer, guaranteeing that a solution will be feasible before implementing it. Both Assimilator and Converger learning styles offer the valuable problem-solving skills necessary to an engineer, whether it is through attempting the task or by watching others carry it out.

Despite knowing the two prominent learning styles, the importance of incorporating their learning preferences into a learning program is relatively insignificant (Clark, 2011). It is more important to portray the nature of the subject within the program, ensuring that the learning methods and context are correct (Coffield, et al., 2004).

The curriculum and teaching methods of engineering courses have been heavily influenced by their desire to achieve accreditation (Fry, et al., 2003). Accreditation of degrees allows the student to graduate with the educational base required to become incorporated or chartered by their relevant discipline's governing body. To ensure that the course is suitable, the learning outcomes are agreed between the higher education institution and the relevant governing body; these need to be met while being flexible to the diversity of students (The Quality Assurance Agency for Higher Education, 2007). The design and delivery of the curriculum can be broken down into: the lecture, enquiry-based learning, practical work, e-learning, learning spaces and work-based learning (Fry, et al., 2003).

Historically, it has been traditional for lectures to be carried out as a one-way transmission to a large group of learners. Many academics see this as a time efficient method of transferring the bulk of the course content. While this is still deemed as an incredibly effective way of teaching, it is heavily dependent on the quality of the delivery by the academic (Fry, et al., 2003). Technologies have paved the way for a revolution in the way lectures are now held, enabling learners to participate and interact through activities. Virtual learning environments (VLEs) are used as a method of distributing core knowledge to the student, before the lecture, allowing the student to use the lecture as a time to test their understanding and to query any problems that they may have encountered. Additional methods increase the learner's attention to the lecture, such as providing skeleton notes and missing key information (Lambert, 2012).

Enquiry-based learning describes the method of the student-driven procedure of investigation to learn; this is made up of: problem-based learning; small scale investigations; and projects and research (Centre for Excellence in Enquiry-Based Learning, 2007). Problem-based learning takes a relevant scenario to drive the learning experience, resulting in learners becoming more invested within the topic and in turn, allowing them to have a greater understanding (Fry, et al., 2003). Small-scale investigations often comprise of field work or a relevant case study, drawing in the same advantages as problem-based learning. Projects and research encourage a research-based approach to learning to achieve the desired outcome, this provides a context for the learner and allows them to bring together and use knowledge from multiple disciplines. Enquiry-based learning is deemed to have a wealth of benefits for students. They become more engaged as they can perceive the content to be more relevant to their needs. They can expand on what they already know by carrying out further research. Learners can become more flexible in their approach towards their study. As well as students becoming more valuable to employers, due to the communicational skills gained in group situations. (Centre for Excellence in Enquiry-Based Learning, 2007)

Practical work for an engineering student is typically in one of three forms, all of which are referred to as laboratory sessions, these are: physical testing on the behaviour of given materials; physical testing of a theoretical concept; or virtual testing using a computer lab. Both physical testing labs are deemed to be expensive, due to the cost of materials, facilities, time and supervision (Fry, et al., 2003). Computer-based labs are considerably cheaper, with no materials required and less supervision also. Practical work could consist of: planning a testing programme; making links between theoretical and practical conceptions; gathering data; conducting risk assessments; and various other tasks. These tasks enrich the learner's experience, allowing them to make observations, analyse data and develop engineering judgement. Despite the cost-effectiveness of virtualisation, it is argued that a proportion of labs that are carried out should be physical, to get a greater understanding using a kinaesthetic approach (Clark, 2012).

E-learning is simply electronic learning; this typically involves the use of computers to partially or entirely deliver the content of a course (Virtual College, 2015). This topic is extremely broad and will be reviewed in detail in the Development and availability of IT for e-learning section.

Due to the age of most UK higher education institutes, the majority of learning spaces are tiered lecture theatres. The lecture theatres have commonly been adapted, introducing whiteboards and projectors to facilitate visual learning through graphical content. Due to the change in teaching culture, these learning spaces are often not appropriate for how the teacher wants to convey the taught content; it would be better suited to a flexible flat-floored room. These rooms would offer computer facilities, as well as an appropriate group working environment. (Fry, et al., 2003).

"*A Work Based Learning Programme is a process for recognising, creating and applying knowledge through, for and at work which forms part (credits) or all of a higher education qualification*" (Medhat, 2007). Within UK higher education this is typically applied in one of two ways. The most common way for work-based learning to be implemented is through an industrial placement, despite normally being non-compulsory, higher education institutes often support the idea of these placements and help their students gain positions within them. The second and more subtle form is through Sector Skills Councils; this is when key members of industry discuss with academia the current marketplace demands and what skills should be taught to fill these requirements (Fry, et al., 2003).

The delivery of the taught curriculum can be monitored qualitatively by the teacher, as well as quantitatively through assessment. Assessments can come in a multitude of forms, including written examinations, laboratory reports, analytical calculations and oral presentations. Feedback is crucial, as it acts as a way for the learner and teacher to know if the learning objectives are being met, as well as a form of quality assurance for external accreditation. "*If assessment is to be integral to learning, feedback must be at the heart of the process*" (Brown, 2005). Feedback must be constructive so that the learner can reflect upon what they have done and how they have done it, allowing them to improve when tasked with a similar assignment. Assessment is typically categorised into two methods, written examinations and coursework. Written examinations are best suited to testing the underpinning knowledge of engineering, whereas coursework is better suited to testing the learner's application of knowledge and skills development (Fry, et al., 2003). It is vital that the assessment is 'fit-for-purpose', this means that the allocated assignment or exam should match the module content and objectives, while following clear criteria for marking (Brown, 2005) (Fry, et al., 2003). The use of group assignments is also a strong indication of how a learner would behave and perform in a real-life scenario. Group work requires careful planning, as each member must be distinguishable from the produced result, for the assessor to understand what contributions each group member has made.

Development and availability of IT for e-learning

E-learning is becoming increasingly popular, offering learners flexibility in scheduling, geographic location and access to course resources (Bichsel, 2013). "*The 9.7 percent growth rate for online enrolments far exceeds the 1.5 percent growth of the overall higher education student population*" (Allen & Seaman, 2007). E-learning is provided in web-facilitated, blended and online course types, with its influence becoming respectively greater. It is reported that over six billion people around the world are connected electronically online through a mobile device; this is double the number of online connections through a typical computer (Learning & Development Agency, 2015). The vast quantity of devices that can access, communicate and share information is exceptionally large, which has fuelled the growth and popularity of e-learning. E-learning or web-based instruction proved to be 11% more efficient than classroom instructions (Sitzmann, et al., 2008) (Clark & Craig, 1992). E-learning has also been shown to be more time effective. A 12-hour course that was typically delivered using only face-to-face was taught through an e-learning version of the course, reducing the required time to 8.5 hours, a reduction of 30% (Hasebrook, 2002).

The rise of e-learning has been dependent upon the evolution of the internet and its increase in potential and capabilities. The increase in e-learning is often accredited to 'Web 2.0', despite the popularity of the phrase, there is some ambiguity in what it means, with some believing it is purely a marketing term used to sell new systems. Web 2.0 has been coined as the generation of websites that allows users to not only access information, but interact with it also (Anderson, 2007) (O'Reilly, 2015). Web 1.0 can be thought of as a primitive version of its successor 2.0, this earlier generation of website only allowed a one-way stream of information, giving the user access to information but little else. Not only is there Web 1.0 and Web 2.0, but the term of Web 3.0 is now becoming increasingly more popular, which refers to websites using 'smart systems', allowing personalised information that gradually changes according to the activity of the learner (EPN, 2008).

Web 2.0 has enabled the advances in e-learning that are available today. The interactive characteristics of this generation of website have allowed for a vast variety of features to enrich learning. It has enabled learners: to give, as well as receive information; to communicate with other learners and teachers; to make alterations to information and content; to complete online submissions of coursework and examinations; and undertake a variety of other actions.

M-learning, or mobile learning, is the form of learning that is carried out on mobile devices, such as: mobile phones, tablets, handheld computers and other mobile technologies (Learning & Development Agency, 2015). The concept of m-learning has been created as a by-product of e-learning. M-learning can be used inside and outside of the classroom to enrich the subject, as well as being used independently or blended with other teaching methods. This technology allows learners to access material theoretically anywhere, at any time, as well as communicating with course members and carrying out web-based activities. As with all advancing technologies, m-learning still carries some disadvantages. For the learning to be conducted the device must remain functional; this can be dependent on the access to the internet, the life of the battery and device compatibility with the course content. Due to the variety of functionality of mobile devices, they are also used for social purposes; this can easily cause distraction when social media and email notifications appear on the device. The price of mobile learning can also be a handicap; there is an initial set up cost of the device, as well as upgrades due to ever progressing technology. Despite these limitations, the disadvantages are far outweighed by the benefits. M-learning provides instant access to course content, wherever the learner may be. The overall cost of the learner's education is significantly lower than that of a learner enrolled on a course that requires more face-to-face time. The use of mobile devices also allows for an enhanced learning experience, mixed media types provoking multiple learning styles that can be utilised and used at the learner's convenience (Learning & Development Agency, 2015).

E-learning is delivered through an array of different devices, which need to be taken into consideration during the design of the content and features. The content must be the same, regardless of what device is being used, the manufacturer of that device and the screen size. Due to the heavy influence of learners using m-learning, course content must also show on mobile devices. The content must be user-friendly across multiple platforms, allow for keyboard use, mouse use or touch screen capabilities. For these requirements to be fulfilled the web-based platform used for e-learning must use dynamic code, adjusting to the device type and the way in which it is being used, all while delivering course content in a clear, unambiguous and user-friendly manner.

Careful consideration towards the kind of coding and its application is utilised in the design of websites for e-learning. The choice of coding language must complement the most popular devices, as well as their web browsers. HTML and CSS are the codes that are typically used in web design; HTML provides the framework of the web page, while CSS provides the interface. These codes are then combined with a programing language, typically for web page design this is JavaScript, this language adds the functionality to the web page, allowing interaction between the user and the content of the page.

Online communities have been formed (such as Bootstrap, W3Schools and Code Academy) sharing code at no cost. These communities were established to share code and best practices, increasing the efficiency of website design internationally. Users display their code, allowing other users to take that code, manipulating it for their personal use. Without these communities, website design would prove more time-consuming, expensive and require excessive resources.

Virtual Leaning Environments
Most universities have some form of virtual learning environments (VLE) at the centre of their e-learning programmes. VLE's have an enormous potential as a learning tool and offer many features including: communication facilities; document submissions; sharing information and resources; linking external sources; and embedding content in the form of videos and other materials (BBC Active, 2010). There is a broad range of communicational facilities that allow for the learner to communicate with the teacher, as well as other learners. The teacher can deliver feedback through the VLE, as well as create forums, voting polls and surveys. The information provided from these tools can be used by the teacher to change the VLE dynamically to the requirements of the learners. Documents can be submitted using the VLE; this provides learners with the flexibility of handing in their assignments from any location at a time that is convenient (before the set deadline). Currently, the most utilised feature of a VLE is the sharing of resources, allowing access to a variety of presentations, documents and technical files. Not only does the VLE act as a tool to store information, but it can also be used to direct learners to other sources of information through links. The teacher can handpick reputable and relevant links for the learners to follow; the teacher is also able to embed this information within the VLE. (BBC Active, 2010).

There are also drawbacks in using a VLE: higher education institutes security often warrants the learner to use login credentials each time the VLE is accessed; development of the VLE can be time-consuming for the teacher, who may have little or no website experience; and the VLE can act as a 'dumping ground' if not maintained and organised. The requirement of login credentials each time the learner accesses the VLE may seem trivial, but it prevents the real-time sharing of information to the learner's device. Despite the VLE most likely being created through a specialist IT team, the teacher is still required to deliver their course content onto the framework provided. The majority of teachers probably won't have experience in this area, making this task time consuming. The calibre of what is expected from the VLE by the learners is also extremely high, with companies such as 'Facebook', 'Twitter' and 'Google' producing fluid and dynamic web pages. Learners are often of a younger age, frequently accessing these sites, so using sites that have not been constructed with the same level of precision can cause the learner to become frustrated.

Companies such as Blackboard and Moodle have offered universities a solution to these problems, with these companies providing the framework required to develop a VLE. Their solutions use open source coding that allows the user to customise their VLE to the level in which they are comfortable at or require. Blackboard is used as a solution within numerous UK higher education institutes such as the University of Manchester, Imperial College London and the University of Derby (Blackboard, 2016). As a competitor, Moodle provides its solution to some institutes such as the University of Bath, Plymouth University and the University of Warwick (Moodle, 2016).

Plymouth University and the University of Bath both use a Moodle based VLE. Both universities use their particular VLE's as a means of: sharing course content;

communicating with learners; document submissions; and linking external sources. The interactivity of the University of Bath's VLE surpasses Plymouth University's. A section of the University of Bath's VLE has been dedicated to testing the learner's ability within structural engineering. There are numerous questions, each graphically displayed with accompanying text to illustrate the question; the user is then able to attempt to answer the question, by submitting an answer that is sent directly to the teacher. The reasoning behind this delayed feedback is that it is to be used as a tool to test learners, this way learners are unable to confer, as each learner is unsure of who has the correct answer. The disadvantage to this is that by the learner not receiving instant feedback; they could assume that their knowledge and understanding is correct, when that might not be the case. The learner also would not be able to use the VLE as a study tool, but merely an assessment tool. It is also apparent that group feedback and additional aid was given on a question where the learners did not perform to a level that the teacher was content with. This extra aid involved a hint about the most common area where learner's 'slipped up' as well as a link to a video explaining the process that should have taken place. The video contained a slightly different question, but with the same underlying principles, allowing the learner to attempt the question once more, after they were happy with the methodology. Despite offering the additional functionality, the user interface of Plymouth University's VLE is far more superior, the layout of the resources is far more intuitive and regimented. (Plymouth University, 2015) (University of Bath, 2014).

Methodology

To achieve the aims and objectives that have been outlined in the Project introduction, three main tasks were carried out. The tasks consisted of: forming initial focus groups, to determine the most beneficial topic area for a virtual learning environment (VLE) with Structural Analysis and Design, as well as the desirable key features; developing a working prototype of a VLE with the chosen worked example and key features; and a secondary set of focus groups, critically analysing the prototype.

Due to the nature of the data collection, it was necessary to acquire ethical approval from the Science and Engineering Faculty Research Ethics Committee; this was applied for and granted before any data collection was carried out.

To allow for a larger range of participants, it was chosen that the VLE prototype would be developed on a topic that had been taught within the first two years of undergraduate study at Plymouth University. Due to undertaking the same Structural Analysis and Design modules, it allowed participants to be chosen from the following programmes: BEng (Hons) Civil Engineering; MEng (Hons) Civil Engineering; BEng (Hons) Civil and Coastal Engineering; and MEng (Hons) Civil and Coasting Engineering.

Initial focus groups

To fully optimise the focus groups, it was decided that two different focus groups would be run, each with six different members in accordance with Bryman (2012). As required by the grant of ethical approval, each participant was informed of the study both verbally and by text (Appendix A). Each participant then completed a Participant Consent Form to comply with ethical approval (Appendix B). It was decided that the focus groups would be carried out with anonymity to attain a truthful representation of the course content without fear of reproach.

To generate an unbiased result, the researcher had minimal influence in the running of the focus groups. The researcher verbally communicated the information depicted on the Project Information Sheet (Appendix A) and collected completed consent forms from all participants before allowing the focus groups to commence. The focus groups were given the following resources: 23 topic areas covered in the first two years of Structural Analysis and Design on individual cards; corresponding information sheets for each topic; and a task information sheet.

Each focus group was given the following definition of a virtual learning environment (VLE) to allow them to carry out the tasks appropriately: "*A **virtual learning environment (VLE)** is a system for delivering learning materials to students via the web. These systems include assessment, student tracking, collaboration and communication tools.*" (Oxford University Press, 2015).

The group was then given the first task: "*The topic titles within Structural Analysis and Design are printed on cards in front of you. Please rank in order of how effective you would have found a VLE in the understanding of the topic. Discuss and justify your thought process*."

Once the focus groups had carried out the first task, the researcher took note of the outcome and allocated the second task: "*For the top 5 topics selected, please discuss what you would expect or want within a VLE system*". This task continued until the focus groups were content that all of their ideas had been discussed.

Participants of the focus groups were recorded from the submission of their consent forms until the end of the session, by starting the recording after the consent was given, this allowed for any participants wishing to withdraw the chance to do so without rendering the recording moot. The participants were recorded, which allowed the researcher to ensure that all of the discussions points had been collated.

Prototype design and development

To ascertain which topic was to be developed, a simple calculation was carried out in the Calculations section, based on the data gathered in the initial focus groups. The design for the prototype was developed and constructed from the desired features of the virtual learning environment (VLE) collected in the initial focus groups (Appendix D). Each desired feature was implemented into the design, exhibiting its potential and effectiveness.

Google Chrome was chosen as the default browser for the development of the prototype, due to its current popularity within the global market. As of March 2016, Google Chrome was the most used browser with 69.9% of the market, with its competitors' portions as follows: Microsoft Internet Explorer, 6.1%; Mozilla Firefox, 17.8%; Apple Safari, 3.6%; and Opera, 1.3% (w3schools.com, 2016). An indisputable set of trends shows both of Google Chromes' main competitors (Internet Explorer and Mozilla Firefox) in rapid decline.

The prototype was then developed using a mix of Hyper Text Markup Language (HTML), Cascading Style Sheets (CSS) and JavaScript (JS). These coding types were chosen to utilise the resources available from (Bootstrap, 2016). Bootstrap offers: faster development, using customisable ready-made blocks of code; responsiveness, allowing for cross-platform use of a website; consistency, giving the same appearance through a series of different browsers; and customisability, allowing code to be tailored to the desired outcome (Bootstrap Bay, 2014).

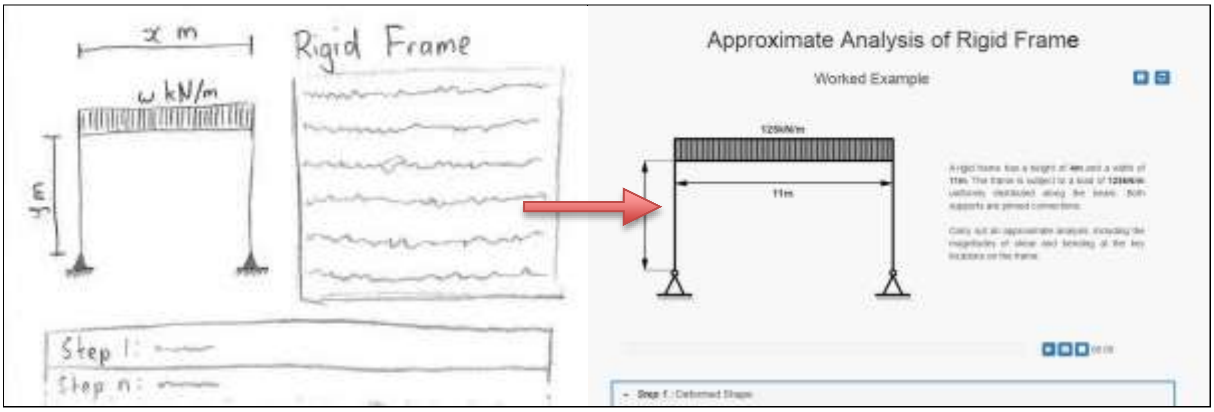

Figure 1 - Storyboard to Implementation of Worked Example

Figure 1 displays the transition of the worked example question, from storyboard to implementation of the prototype. Throughout the implementation of the prototype, the design naturally developed, with new features becoming apparent. It can be seen that two buttons have been integrated into the design, the first displaying information on how to complete the question, the second to regenerate the numbers used within the question. The second alteration from the original storyboard was the application of a progress bar and a stopwatch, it was originally anticipated that these features would be too complex to put into the prototype, but a greater understanding of the coding allowed these features to be added.

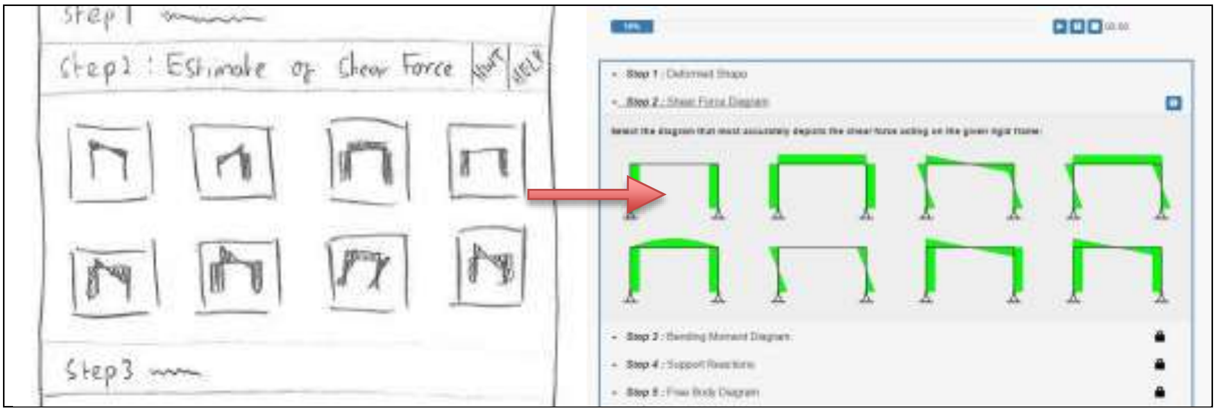

Figure 2 - Storyboard to Implementation of Shear Force Diagrams

Figure 2 displays the transition of the shear force diagram multiple choice, from storyboard to the implementation of the prototype. The development of this panel saw little change, apart from the removal of the 'hint' button and the inclusion of a locking mechanism for the future panels.

After the prototype had been developed, a series of testing was carried out, before the secondary focus groups, to ensure the prototype was robust. The prototype was tested on multiple screen sizes, to ensure it was responsive. The functionality of the prototype was also tested, with multiple combinations of correct and incorrect answers inputted into the web page, ensuring the appropriate protocol was carried out.

Secondary focus groups

For the focus groups to be optimised, it was chosen that the study would be run in two sections. The initial section allowed the participant to test the prototype by themselves; this section was used to see how intuitive the prototype was at the same time as collating their individual opinions. The subsequent section saw two participants use the prototype together; creating a discussion over features and potential improvements that could be implemented. A group size of two was determined to allow all users to have a valuable contribution in using the prototype, at the same time as being able to discuss the prototype with an unbiased person.

The same participants from the initial focus groups were used to undertake the secondary focus groups. The allocation of the participants within the focus groups was governed by their availability. To ensure that ethical approval requirements were maintained, each participant was re-informed of the study both verbally and by text.

To generate an unbiased result, the researcher once again had minimal influence in the running of the focus groups. The researcher verbally communicated the information depicted on the information sheet. The researcher then presented the participant with the prototype and requested that they talk their way through the worked example, illustrating strengths and weaknesses within the prototype. Once the participants had completed the worked example individually, they were paired together and requested that they narrate their way through the worked example, illustrating strengths and weaknesses within the prototype (this time discussing with the other participant). This task continued until the focus groups were content that all of their ideas had been discussed.

Participants of the secondary focus groups were recorded during both aspects of the study, allowing the researcher to ensure that all of the discussions points had been collated.

Results

Initial focus groups quantitative data

Table 2 - Initial Focus Groups Topic Ranking

Structural Analysis and Design Topic	**Group Rank**	
	1a	**1b**
Actions and Reactions	-	-
Deformed Shapes, Shear Force Diagrams & Bending Moment Diagrams	-	1
Neutral Axis, Section Modulus & Second Moment of Area	-	-
Gravity Structures	8	-
Statically Determinate Structures (Beams/Arches)	4	-
Bending, Axial & Shear Stress	-	2
Torsional Stress	6	-
Pin-Jointed Frames	3	5
Rigid Frames	2	4
Approximate Analysis	5	3
Slope Deflection	-	-
Buckling Instability	-	-
Dynamics	9	-
Beam Deflection	-	-
Shear, Shear Flow & Shear Stress	1	-
Plastic Analysis	-	-
Unsymmetrical Bending	7	-
RC Slab Design	-	8
RC Beam Design	-	-
RC Column Design	10	10
RC Foundation Design	-	9
Steel Beam Design	-	6
Steel Column Design	-	7

Initial focus groups qualitative data

The key observations from the Initial Focus Groups have been stated below, with the complete findings shown in Appendix E:

- A better understanding of a topic was acquired when the rationale behind the topic was explained extensively, prior to learning the technical content.
- Confusion arose when teachers used different notation and terminologies to describe the same attributes.
- A virtual learning environment (VLE) would have been more beneficial for learning Structural Analysis rather than Structural Design, as Structural Design is built upon the fundamentals of Structural Analysis, so this was the topic of higher importance at the early stages of the course.
- A VLE would have complemented a Structural Design question, due to the lengthy nature of the topics. A VLE would have been able to confirm that the learner was answering a question correctly at key locations in the question, rather than at the end.

The key desirable features within a VLE that were ascertained from the Initial Focus Groups have been stated below, with the complete findings shown in Appendix F:

- A visual representation of the learner's progress in the current topic example, as well as an overview of their progression in the subject as a whole.
- A dynamic nomenclature, which would clarify any technical symbols or phrases, as well as their origins.
- Randomly generate a set of variables to create unique examples and to prevent the VLE being used as a calculator.
- Provide links to external documents, allowing the learner to read around the topic area. Also, provide a description of precisely where to look if it is a large or challenging technical document.
- A clear and unambiguous topic diagram, with all known attributes, clearly labelled. Where possible, all of the information should be displayed on one diagram.
- Provide a large number of answers when using multiple choice functionality, minimising the chance of selecting a correct answer by luck.
- A clear step-by-step breakdown of each question, allowing the learner to understand the process fully.
- Provide video tutorials outlining the basic principles behind each topic, providing bookmarks for locations in the tutorial at each respective stage of the worked example.

Secondary focus groups qualitative data

The key observations from the Secondary Focus Groups have been stated below, with the complete findings shown in Appendix G:

- Having the accordion panels locked to begin with, unlocking a step at a time, allowed the user to focus on that particular aspect of the question without trying to look too far ahead.
- Allowing an optional timing feature makes it appeal more to a wider audience of users. A small amount of the users were discouraged by having their first attempt at the question timed, but would like it as a future option.

- Offering a range of correct answers, dependent on the calculation method, allowed the users to attempt the question in a preferred method.
- Displaying which aspects of a multiple answer question were correct or incorrect allowed the user to determine where their mistake could have been made.
- Conveying additional material using short and concise videos is a quick and easy way to access the information.
- Having an optional nomenclature available for the technical notation allowed the user to understand the content quicker and enabled for them to keep a focus on the worked example, rather than research the meaning of the notation in an external source (e.g. textbook or search engine).

The key potential further options for the virtual learning environment (VLE) prototype that were established from the Secondary Focus Groups have been stated below, with the complete findings shown in Appendix H:

- There was a risk of the user clicking each of the multiple choice answers until the correct answer was selected. This was dependent on the enthusiasm of the learner, to whether they wanted to learn or just progress in the question. A system could be generated to minimise the amount of attempts that could be taken before the answers would refresh or lock.
- A scoring feature could have been implemented alongside the progression toolbar. The progression bar alone gave a false sense of success to the user, with the user possibly taking several attempts to answer a question correctly, but still capable of achieving 100%. A score alongside the completion would have given the user a realistic view of how well they did.
- If a scoring feature had been implemented, it could have worked in a multitude of ways. A suggested method was to have a three strike method; this would have allowed the user to have three attempts at each question segment, before locking the question and pointing the user in the direction of additional content on that subject. Another method would have been to award a score for each element that progressively descended from 100% each time the user had a new attempt (e.g. the user only got 80% of the available marks as they took two tries to answer a question element correctly).
- It would have been beneficial to request the units alongside each numerical answer, ensuring that the learner gets into the habit of stating units.
- The video help feature could have given the subtitles as an optional extra. Whereas some users preferred the text, others found it to prove as a distraction, detracting from the video.
- Dependent on which method of calculation the learner used, not all of the information required was readily accessible, with some of the information in previously completed accordion panels. The initial question diagram could have been updated to show all of the information currently calculated or the information could have been shown in the current step.
- At the end of the question, a personalised feedback should have been generated. The feedback should have given a report with a full worked example, highlighting the sections that the user was not able to do or took a

few attempts to complete. The feedback should also generate a list of worked examples and further reading that would be appropriate for the user, given the questions that they struggled with.

Calculations

A simple calculation of ‘$Group\ Score = 11 - Group\ Rank$’ was used to convert the Group Rank results from Table 2 into the Group Score that is shown in Table 3. Figure 23 shows a graphical representation of Table 3 (Appendix C). The Rigid Frame topic was a clear choice, so no further calculations or data manipulation was required.

$$Dynamics\ Group\ Score = 11 - Dynamics\ Group\ Rank$$

$$Dynamics\ Group\ Score = 11 - 9 = 2$$

Table 3 - Initial Focus Groups Topic Scoring

Structural Analysis and Design Topic	**Group Score**		
	1a	**1b**	**Σ**
Actions and Reactions	-	-	-
Deformed Shapes, Shear Force Diagrams & Bending Moment Diagrams	-	10	10
Neutral Axis, Section Modulus & Second Moment of Area	-	-	-
Gravity Structures	3	-	3
Statically Determinate Structures (Beams/Arches)	7	-	7
Bending, Axial & Shear Stress	-	9	9
Torsional Stress	5	-	5
Pin-Jointed Frames	8	6	14
Rigid Frames	9	7	16
Approximate Analysis	6	8	14
Slope Deflection	-	-	-
Buckling Instability	-	-	-
Dynamics	2	-	2
Beam Deflection	-	-	-
Shear, Shear Flow & Shear Stress	10	-	10
Plastic Analysis	-	-	-
Unsymmetrical Bending	4	-	4
RC Slab Design	-	3	3
RC Beam Design	-	-	-
RC Column Design	1	1	2
RC Foundation Design	-	2	2
Steel Beam Design	-	5	5
Steel Column Design	-	4	4

Discussion

A set of desired features for the virtual learning environment (VLE) prototype was outlined during the initial focus groups. The majority of these features were implemented into the VLE prototype and tested within the secondary focus groups. The features considered by the secondary focus groups to be the most effective have been appraised below, followed by the elements which hold opportunities for further development. Future progression options for the project in its entirety have then been outlined in the final subsection of the discussion.

Effectiveness of the prototype

It was determined that the worked example should be comprised of variables that have been randomly generated. This would prevent the user from subconsciously memorising the numbers within the question and encourage them to learn the method instead. This feature was successfully implemented within the virtual learning environment (VLE) prototype, with the frame dimensions and loading conditions randomly generated. As designed in Figure 24, the loading variable will generate within a given range, to an increment of 5kN/m. Similarly, the frame dimensions were implemented to generate to the nearest 0.5m, with both the frame width and height dimensions created within certain ranges. The upper and lower bounds for the width dimension were calculated as ratios of the chosen frame height value, preventing an unusually shaped frame. The solutions for the worked example have been computed from these three variables.

This aspect of the VLE prototype was shown to be effective, with its presence unknown until the user reattempted the worked example. It was noted that when the user reattempted the worked example, they instinctively tried to reuse their previously used hand calculations. Once the user realised that all of the figures had altered, they put aside the old hand calculations and started a new set. This feature had the desired effect of preventing the user from relying upon their notes and driving them to tackle each example as a new question.

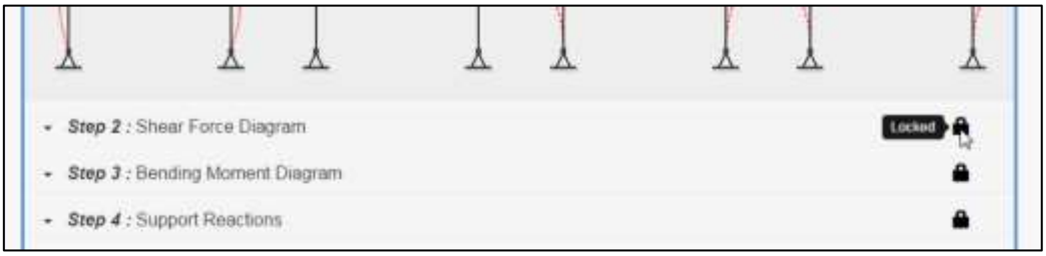

Figure 3 - Prototype Screenshot of Locked Accordion Panel

It was decided that the worked example should be separated into a manageable step-by-step process. The VLE prototype was implemented in such a way that the full worked example was spread over several accordion panels, as depicted in Figure 3. A lock feature was implemented, which prevented the user from accessing the next step of the example until the step that they were currently on was fully completed. As the user progressed through the question, the previous panels would remain unlocked, allowing the user to revisit these panels if they so desired.

This characteristic of the panels was deemed to be advantageous to the user, enabling them to focus on the current step without becoming overwhelmed by the calculations ahead. This regimented layout avoided the faults visible within the VLE at the (University of Bath, 2014); with cluttered windows, housing multiple worked examples and inconsistency in the way the questions were conveyed.

Figure 4 - Prototype Screenshot of Stopwatch

It was established that the majority, but not all, of the users wanted a feature that would time how long they took completing the worked example. Due to the varied output from the initial focus groups, it was decided to implement this as an optional feature, as shown in Figure 4.

This part of the VLE prototype proved to be more popular during the testing, than the initial focus groups. The users that had previously stated that they did not want a timing feature backtracked on their original views. As the timer was an optional feature, they were content in completing the worked example for the first time without using it. After completing the question once, they were then confident that they understood the main principles of the example and then wished to utilise the timing feature to determine their efficiency.

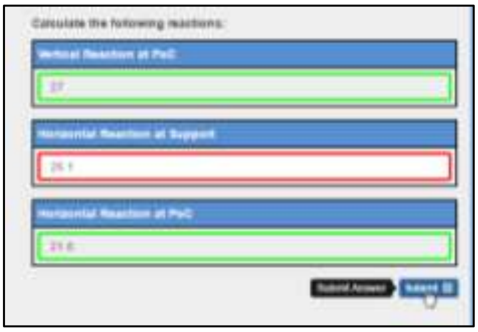

Figure 5 - Prototype Screenshot of Partially Correct Answer

The VLE prototype was constructed so that each of the numerical answers that were inputted by the user were analysed individually, allowing partially correct answer as illustrated in Figure 5. Due to the nature of the example, some of the answers could have been calculated using different methods, producing minor discrepancies. The VLE prototype took this into account, checking the users input against each possible answer.

These features proved to be effective throughout testing. When the user submitted a mixture of correct and incorrect answers, they were able to logically decipher the location of their mistake and act accordingly to provide a correct answer. This could be perceived as the Reflective Observation stage of Kolb's Experiential Learning Cycle, with the user able to reflect upon their experience. The user would then enter the Abstract Conceptualisation stage, concluding upon their reflections. They would then move through the Active Experimentation and Concrete Experience stages, trying out what they have learnt and then attempting the question for a following time. This process would be repeated indefinitely until the question has been completed. (Kolb, 1984). The VLE developed by the (University of Bath, 2014) does not possess this function to generate instant feedback, preventing their users from entering Kolb's Experiential Learning Cycle and learning effectively.

It was not apparent to the user that they were able to enter different answers, dependent on the way they calculated it. This allowed the user to calculate the answer in a method that was preferential to them, demonstrating that the VLE prototype can accommodate a range of learning styles. Throughout the testing, it was noted that a range of calculation methods were used across the users, with the VLE prototype fluidly accounting for these.

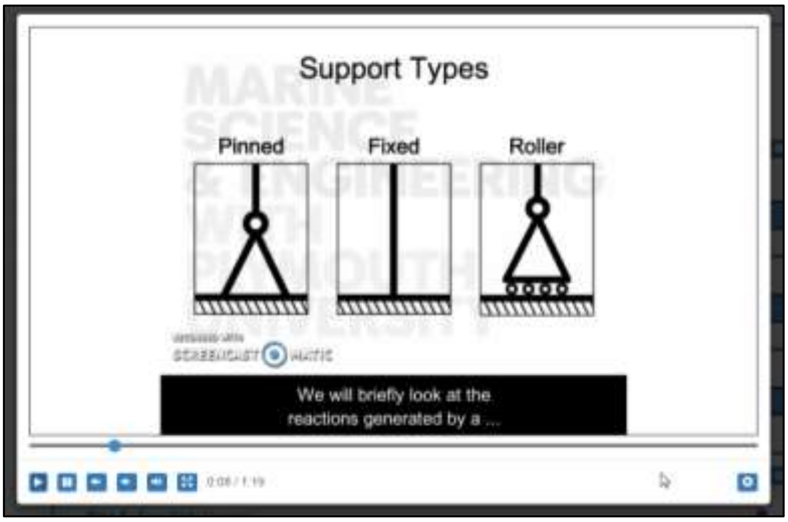

Figure 6 - Prototype Screenshot of Video with Subtitles

It was ascertained that an effective form of help that could be implemented into the VLE prototype was a short and concise video tutorial; this is displayed in Figure 6. On selection of the help option, a new window is opened over the worked example, with the background fading to draw attention to the newly opened window. To ensure familiarity for the user if they were to access the VLE prototype from different devices or browsers, the default video attributes were disabled and new controls were implemented. Basic video controls were employed, allowing the user to: navigate through the video; start and stop at any point; adjust or remove the volume; toggle between a standard window and full screen; and view the current time and duration of the video. If playing, the video content was also suspended on the selection of the close button.

The video tutorial feature was determined to be an effective help tool for the user. The customised controls proved to be intuitive amongst the users, with the modified close button proving popular. Users were able to switch between the video and the worked example swiftly, without having to take note of their position within the video. Users expressed their preference to the information being conveyed through a video, over standard text. As ascertained through (Fleming, 2016), a learner with a visual preference can easily become distracted by disorganised and messy surroundings. To ensure a visual preference learner could not be distracted, the background window was faded, preventing the user from losing focus on the video content.

Figure 7 - Prototype Screenshot of Multimedia Help Dialogue

A mixture of textual and graphical content was highlighted as an additional form of effective help; this is shown in

Figure 7. In the same way as the video tutorial, on the selection of this help option, a new window is opened over the worked example, with the background fading to draw attention to the newly opened window.

Once again, as the video tutorial, this help option was emphasised by the user as being preferable to standard text. It was however noted that the user thought that the text could be reduced, focusing more upon the diagrams and formulas. The video resource was preferred in relation to this resource, due to the speed in which data could be relayed. This preference of the user may change if the content of the help option were to be optimised as suggested by the user, as the key content of the feature would be more prominent. Regardless of the video being the preferred media, it is more imperative that the content is conveyed to portray the nature of the subject (Coffield, et al., 2004); this may be more appropriate through other media.

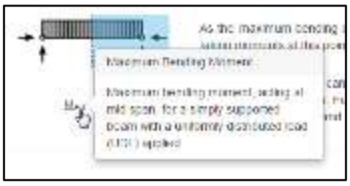

Figure 8 - Prototype Screenshot of Nomenclature

It was decided that the worked example should provide a dynamic nomenclature, defining any notation or abbreviations; this is shown in Figure 8. This feature was implemented into the VLE prototype and was activated by the user clicking upon the notation or abbreviation.

The user deemed this tool as highly sort after, introducing clarity for the definition of an attribute. It was also thought that this would engage a wider range of users into using the VLE prototype, as the worked example could act as a training tool in addition to an exercise tool. It was stated that the effectiveness of this feature was highly dependent upon the information that was put within it. There was concern built around the consistency between lecturers for displaying notation, as different notation would undermine the efficiency of this tool. As previously touched upon, (Davenport, 2014) stated that it was crucial for teachers to carry out continuous professional development on their taught material, more commonly known as Action Research. This would include the collaboration required to ensure that all notation used within the VLE prototype is the same as taught through all lectures.

Further development opportunities of the prototype

The stopwatch was also subject to some criticism during the testing of the virtual learning environment (VLE) prototype. The user believed that it was not clear to what the feature was, due to the way that it had been presented. A title or symbol could be attached to increase the prominence of the timer. Household names such as ‘Facebook’, ‘Twitter’ and ‘Google’ are some of the most heavily used websites in the world (Alexa Internet Inc, 2016); with users accustomed to their instinctual layouts and functionalities. Expecting this high calibre of website, it was easy to detect why the user became irritated when the VLE prototype was not displayed in the intuitive way they anticipated.

An additional outcome of the initial focus groups was to log the recorded times produced by the stopwatch, allowing the user to make comparisons on the times they took to undertake the worked example. This feature was not executed into the VLE prototype due to the scope of the project. To provide this function, a login system would have needed to be created, allocating each of the user’s times to a unique identification for that user. The resources required to set up such a system exceeded those available within this project. However, the concept offers vast potential if the project was to be carried forward. The process of the user timing them self can also be adapted to suit Kolb’s Experiential Learning Cycle. The user can: experience the worked example; reflect upon how they carried out the example; conclude on their experience; and plan to undertake the worked example again. The user can repeat this process until they can complete the worked example in a time that they find satisfactory.

Several other desired features that were outlined in the initial focus groups were not employed for the VLE prototype. The scope of VLE prototype was a single worked example, whereas these desired features were reliant upon a catalogue of numerous examples and the aforementioned login system. With the provision of a login system and a catalogue of worked examples, it would have been possible to implement the following features: an overview of the user’s progress through certain subjects; dynamic performance feedback generated to the teacher; and a tool to question the integrity of the website and the material. It would have also been possible to structure the worked examples, ascending in difficulty and complexity.

Despite the popularity of the video tutorial, testing of the VLE prototype identified several shortcomings of the feature. It was found that although the video audio was delivered at an acceptable pace, the speed of the subtitled transcript was too fast for users to utilise. It was suggested that only key phrases were displayed within the subtitles, giving the user more time to read and intake the given information. It was also established that users with the preference of viewing the video without using the subtitles, found their presence to be a distraction. This feature could be adapted to provide optional subtitles, ensuring neither preference of the user is adversely affected. Read-Write is often depicted as a subcategory of the visual learning preference, separating those who prefer reading in favour of graphical representations (Fleming, 2016). It is the users with a Read-Write preference that chose to display the subtitles and it is important that this preference is not forced upon users without this preference, detracting from their experience.

Figure 9 - Prototype Screenshot of Video Scroll Bar

A scroll bar was implemented as part of the video controls, allowing the user to navigate through the tutorial; this is focused upon in Figure 9. It became apparent that this element of the video controls was not as intuitive as desired. It was clear that some users tried to drag the scroll bar, but the bar only changed position through clicking the desired location. To ensure that this element is instinctive for the user, the coding should be adapted, allowing the user to carry out either action. This issue is emphasised by the user's expectations of an instinctive website, set by the 'Inter net Giants' (Google, YouTube, etc.).

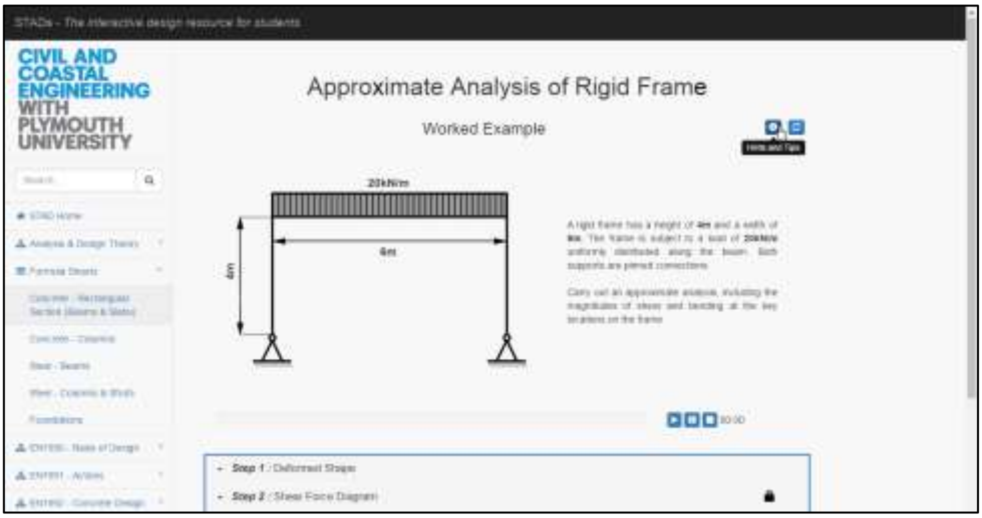

Figure 10 - Prototype Screenshot of Starting Screen

When VLE prototype was instigated, the user would view the window as shown in

Figure **10**. The developed prototype has everything positioned to the right of the navigation panel, with the website framework taken from (Buller, 2014). This aspect of the VLE prototype contained the worked example, in addition to several other features. Two buttons were located at the top right of the window, giving the user access to an information dialogue, as well as the option to re-generate the variables within the question. Beneath the worked example is the progress bar, stopwatch and the accordion panels that contain the step-by-step workings for the worked example. To suit both sub-categories of a visual learner, it was decided that each element of information for the worked example would be conveyed in both graphical and textual form.

This aspect of the VLE prototype was found to be frustrating to the user. It was demonstrated through testing that it was not apparent to the user what the features were and in fact how they should undertake the worked example. Some of the features were initially overlooked, before the user attempted the worked example, rendering aspects like the stopwatch feature moot.

To overcome this flaw in the VLE prototype, there are a few obvious solutions. A simple resolution would be to change the content of the page, including text within each of the buttons, as well as a small body of text above the worked example instructing the user on how to commence the question. However, the increase in the text could have a detrimental effect upon the VLE prototype if it were to be accessed via a mobile device, likewise with the increased size of the buttons. Another option would be to provide the user with a concise video tutorial, outlining the key features of the VLE prototype and in turn how to complete the given worked example. The tutorial could be implemented in a way that it automatically plays to the user once the worked example is initiated. This may prove frustrating to a user that is attempting the example multiple times, as they would only need to view the video once. A more efficient solution would be reliant upon a login system; with the video only playing automatically if the VLE prototype had determined the user to be logging in for the first time. Another option would be to have the tutorial on a home screen, allowing the possibility for the user to watch it before engaging with the worked example.

The VLE prototype contained several steps that consisted of multiple-choice options, with a selection process illustrated in Figure **11**. This particular example shows the users selecting two incorrect options, before choosing the correct answer. As the user hovered the cursor over an option, its border would change to yellow. Then dependent on if a correct or incorrect answer was selected (via a single click); the border would change to green or red respectively. On selection of the correct answer, the user was no longer able to make any more selections and the cursor would change to unavailable when hovered over any options.

Figure 11 - Prototype Screenshot of Multiple Choice Selection

It was ascertained that several improvements could be carried out to further develop this feature. It was observed that the effectiveness of this type of question was dependent upon the enthusiasm of the user. It was apparent that there were two ways in which the user would attempt a question of this nature, depending on whether the user wanted to learn or simply progress through the question. Those users who wished to learn took their time analysing the options, before making an informed selection. Whereas some users simply wanted to progress, this was apparent when they clicked several options in quick succession until the correct answer was selected. One method to prevent users from misusing the multiple-choice would be to have a finite number of attempts, with the user forced to restart the question from the beginning. An alternative method would be to enforce a delay between each selection, pushing the user to make a more informed subsequent selection to avoid waiting for the duration another time. Another flaw in this feature was that the positions of the choices were static, allowing the user to subconsciously memorise the position of each correct answer. To prevent this from occurring, the positions of the choices could be randomly generated. It was also suggested that the images should be taken from a larger library of images, so the remaining incorrect answers would not remain the same on each attempt.

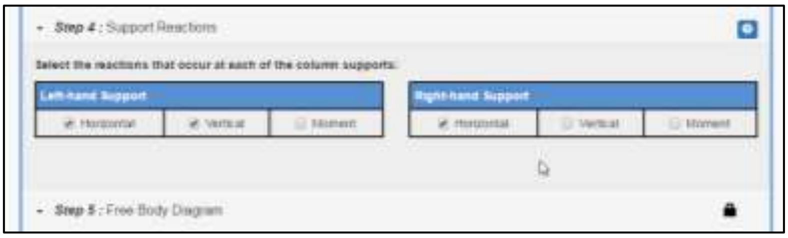

Figure 12 - Prototype Screenshot of Checkbox Selection

Another form of answer submission within the worked example was checkboxes, with an example shown in Figure 12. A correct answer could consist of multiple elements, once those specific elements were chosen the user was able to progress. The VLE prototype would check the set of given answers every time a checkbox was selected or unselected, until the correct combination was given.

This form of submission proved irritating to the user, as the user was unable to see which aspects of the question that they had answered incorrectly. Some users did not find the input method intuitive and were unable to ascertain whether their submission had been accepted. The application of a submit button for this question would make the question more intuitive for the user. Once the answer has been submitted, a graphical response could take place, illustrating to the user whether the answer was correct or incorrect. Due to the nature of the question, it is not appropriate to highlight the correctness of each element, as the user would be able to know the answer through the process of elimination and not engineering judgement.

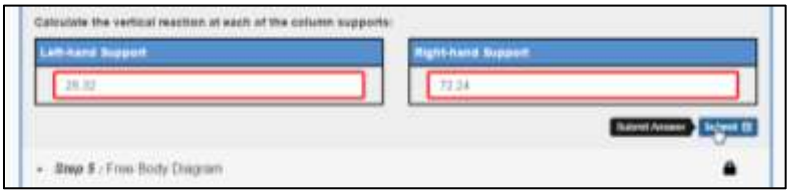

Figure 13 - Prototype Screenshot of Incorrectly Submitted Answer

It was noted that the user was unsure whether their submission had been accepted if they submitted two incorrect answers in succession, this is shown in Figure 13. There was nothing in place within the VLE prototype to differentiate between each answer, with the border remaining red throughout. An animation could be implemented, fading or reducing the border to allow the user to distinguish between each attempt.

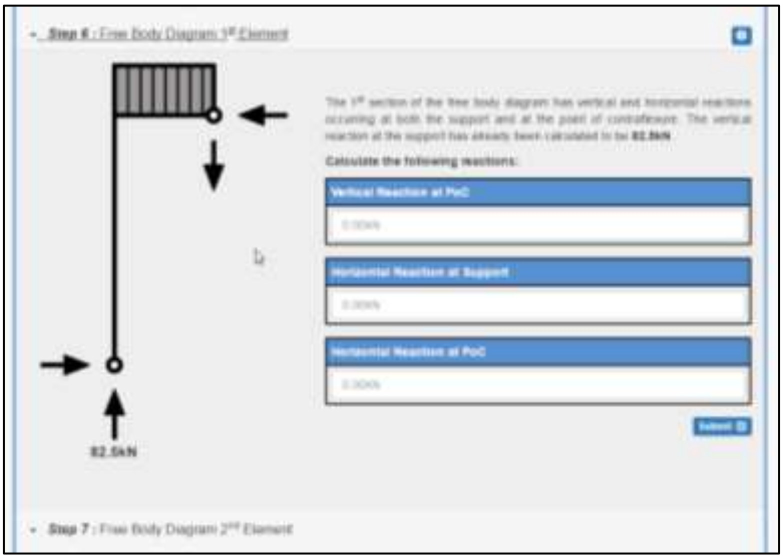

Figure 14 - Prototype Screenshot of Free Body Diagrams Element

It was established that where appropriate, relevant information should be collaborated and presented in the form of diagrams, as shown in Figure 14. These diagrams would dynamically display previously answered information, preventing the user from having to look back through the previous accordion panels.

It was detected that not all of the required information was displayed on this diagram, with the user having to look back at a previous accordion panel. This caused frustration to the user, as they sometimes had to search through multiple accordion panels to acquire the piece of information that they required. This error within the VLE prototype is easy to remedy. A more thorough testing process was required, ensuring that each step within the question was achievable with the current information, as well as the original data provided in the question. As stated by (Hattie, 2003), an 'expert teacher' must evolve their taught content over time; they must not be content with their first effort. This is mirrored upon the development of the VLE prototype; it must never be viewed as a finished product, but an ever evolving system.

It was also indicated that it would be beneficial for the user to provide the units alongside each of their given numerical answers. This would ensure that the user would 'get into the habit' of stating their units in general practice.

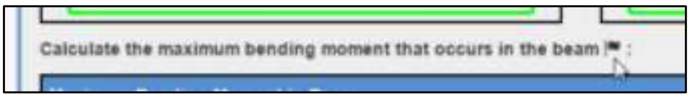

Figure 15 - Prototype Screenshot of Cautionary Flag

It was decided that the most challenging aspects of the questions should be signposted, giving the user warning that more care should be taken, an example of this is shown in Figure 15.

It was apparent through testing that the flags were not prominent enough and did not convey enough information with regards to the difficulty of the question. It was suggested that an altered system could be used, displaying multiple flags or a single flag with a relevant colour code (e.g. red = difficult, amber = average and green = simple). It has been noted that there is a risk in using this feature without careful consideration towards what constitutes as 'difficult'. This feature is currently implemented using the judgement of the developer, so would not portray a consensus. To effectively implement this feature, a further study would be required, determining which aspects of the worked example are statistically the most challenging amongst users. Alternatively, the VLE prototype could be developed to collect this data from users; combining data on how long the user took and how many attempts were made. From this data, an up-to-date warning system could be implemented, changing dynamically dependent upon the latest statistical results. This in itself is a 'smart system', a feature that gradually changes according to the activity of the learner (EPN, 2008). This feature shows the progression required to reach Web 3.0.

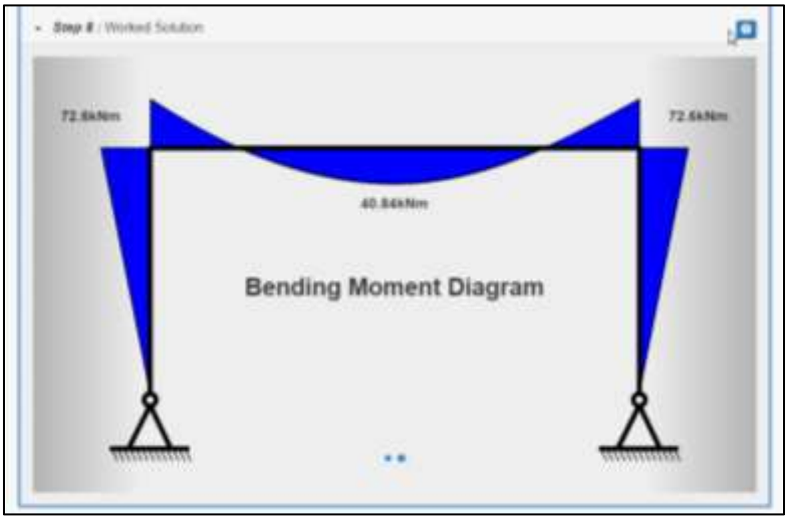

Figure 16 - Prototype Screenshot of Worked Solution

It was decided a diagrammatic solution, using the figures previously calculated, should be displayed in the final step of the worked example. As part of this example, two diagrams were exhibited on a carousel, allowing the user to scroll through the results of their calculations; this is shown in Figure 16.

At this stage it was identified that the user would like a detailed account of the calculations that they had carried out, in the form of a 'model solution'. This solution could be developed to dynamically produce a report, showing a model worked solution and highlighting any aspects that the user may have struggled with (i.e. taken more than one attempt to answer). The importance of this feedback is highlighted by (Brown, 2005), implying the overall effectiveness of the system would be undermined if the feedback was overlooked. The information produced here would shape the way the user would view the question in the future, so it is imperative that it is constructive, allowing the user to build upon their mistakes.

Figure 17 - Prototype Screenshot of Additional Content Dialogue

It was ascertained that a reading list should be available at the end of the worked example, offering the user further reading around the subject; this is shown in Figure 17. This list was made available through the help button on the final step and displayed a reading list for a mixture of resources on the subject of the worked example.

When tested, it was observed that the external link would open in the current window, taking the user away from the VLE prototype, this, in turn, lost the worked example that they had just completed. A simple solution is to ensure that the external link opens a new window, allowing both the VLE prototype and external resource to be active simultaneously.

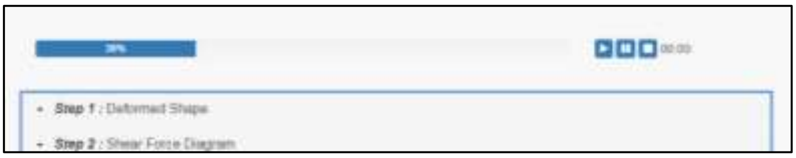

Figure 18 - Prototype Screenshot of Progression Bar

It was established that the VLE prototype should encompass a progression bar for the user to monitor their development through the worked example; this can be seen in Figure 18. The progress bar displays the user’s progress both graphically and with the use of text.

It was concerned that the progression bar gave the user a false sense of accomplishment, as it was easy for the user to misconstrue the progression as a score. Rather than remove this feature, it was decided that it would be more beneficial for a score to be implemented alongside it. A simple method of implementing a scoring system would be to allocate marks to each answerable aspect of the worked example. The marks would then be awarded dependent on how many attempts the user took to answer that element. 100% of the marks could be awarded for answering the question on the first try and then progressively declining the percentage of marks available for each additional attempt made.

Figure 19 - Prototype Screenshot of Cross Platform Compatibility

As outlined in the Methodology, the prototype was developed and tested using a Google Chrome web browser, due to Chrome being the most significantly used browser globally. Figure **19** shows the VLE prototype being tested on two browsers, the left being Google Chrome and the right being Mozilla Firefox (Google Chrome's closest competitor). It can be seen that the prototype was not cross-platform compatible, despite working fluidly on Chrome; it did not perform as was expected on Firefox. It can be noted that the web page was fully functional, except the image files.

Figure 28 (Appendix J) clearly shows that Google Chrome has been the most popular web browser since early 2012 and is now over three times as widespread as its nearest rival, Firefox. There is, however, some ambiguity in the figures that have been provided from (w3schools.com, 2016). W3Schools is a website where a community of users share code freely amongst one another and it was this website's traffic that was monitored to ascertain the usage of browsers. Users from this website would be typically more likely to have switched from their default browser, giving a biased set of results. It must be noted that the data has been collected on a global scale; this may not be representative of the localised region of users or even the institution where the VLE is being implemented.

As Chrome is freely available to the general public, it could be an accepted solution for the prototype to solely run on this browser. Another option could be to orchestrate a localised study on browser usage, ensuring that the VLE is fully functional on the most popular browsers.

It was ascertained through a review of background literature that engineers typically fell into the Kolb's learning style classification of Assimilator or Converger (Sharp, 2001) (Kolb & Kolb, 2005). Regardless of knowing the two main learning styles, their influence upon the design of the VLE is relatively minimal in comparison to the output of the initial focus groups. It was deemed far more important to ensure that the depicted methods and contexts were accurate, than tend to the requirements of these learning styles.

The potential of a VLE is far greater than what has been applied within this prototype. There is an array of options that could be implemented if the project were to be progressed further. Communication facilities, document submissions and information sharing are a few of the possibilities that could be undertaken to enrich the VLE prototype. VLE's hold a huge potential to be used as a learning tool (BBC Active, 2010), these possibilities need to be fully explored to ensure the optimum VLE is produced.

Further development opportunities of the project

For the participants to be able to reflect upon their personal experiences, it was chosen that both focus groups should be run using third-year students who have experienced the initial two years of teaching in Structural Analysis and Design. Whereas this selection of participants is relevant for the initial focus groups, it may not have been the most appropriate choice for the secondary focus groups. The outcome of the initial focus groups determined the topic that the prototype should model, with a topic chosen that is taught in the first year of the programme. A more suitable set of participants for the secondary focus groups could have been first-year students, for whom the prototype was designed.

The use of first-year students would have offered significant extra information towards the development of the prototype, as the participants would have no prior knowledge of the topic content and would be entirely reliant upon the effectiveness of the prototype. Further studies could be carried out, pitching the prototype against traditional methods of teaching, in turn gaining quantitative data to further develop the prototype. The quantitative data collected from this type of study could prove more robust, as qualitative can often be open to interpretation.

The study was carried out using just twelve participants. The use of so few participants would make the project susceptible to producing a biased set of data, with the possibility of the focus groups being directed by a few of the most vocal members. The project could have been enhanced by using a larger set of participants, minimising this effect. An increase in participants would have led to a rise in the credibility of the collected data. Dependent upon their programme contents, it may have also been possible to expand the range of participants by obtaining them from other institutions.

Conclusion

This project successfully met the aim to ascertain how a virtual learning environment (VLE) could optimise learning for a civil engineering student, while determining the effectiveness and significance of available features.

A critical review was successfully carried out, ascertaining the categories of learning and teaching styles. Blended learning was found to be the most prominent course type within higher education, delivering between 30 and 70% of the course material online, while preserving the face-to-face aspect of traditional learning. This review was then refined, focussing on engineering students within higher education. It was established that engineering students typically place within one of two learning styles, Assimilator or Converger. A review of the background literature on VLE's enforced the relevance of the project aim, recognising the need for a VLE focusing on Structural Analysis and Design.

Focus groups were held, identifying 'Rigid Frames' as the topic area that would benefit most from a VLE being implemented, as well as the features that could be employed. A VLE prototype was successfully developed, encompassing each of the features outlined in the initial focus groups. This prototype was then subjected to further testing, determining the effectiveness of the features, with each feature evaluated in Section 0, Further development opportunities of the prototype.

It is recommended that the project is developed as two key areas, the VLE prototype and the project as a whole. The VLE prototype should be advanced to offer a catalogue of worked examples, in addition to incorporating standard features of a VLE such as login credentials that can enrich the users experience and scope of the project. The project should be strengthened by obtaining a larger set of participants from multiple higher education institutes. An additional enhancement would be to change the participants of the secondary focus groups to the students that are currently undertaking the topic chosen by the initial focus groups. Further studies could be carried out, pitching the prototype against traditional methods of teaching, in turn gaining quantitative data to further develop the prototype.

Acknowledgements

I would like to express my gratitude to everyone that has contributed towards completing this report. Particular acknowledgement is given to my project supervisor, Michael Buller, whose guidance and support has enriched the trajectory of the project.

Additionally, I wish to show my appreciation to the participants who have donated their time and ideas towards the study. Without their contribution, it would not have been possible to analyse critically or even develop a suitable virtual learning environment (VLE) prototype.

Reference list

Alexa Internet Inc, 2016. *Alexa.* [Online]
Available at: http://www.alexa.com/topsites
[Accessed 24 April 2016].

Allen, I. E. & Seaman, J., 2007. *Online Nation: Five Years of Growth in Online Learning.* 1st ed. Newburyport, MA: The Sloan Consortium.

Anderson, P., 2007. *What is Web 2.0? Ideas, technologies and implications for education,* Bristol: JISC Technology and Standards Watch.

Ashby, M., 2005. *How to Write a Paper,* Cambridge: University of Cambridge.

BBC Active, 2010. *Why you should use a Virtual Learning Environment.* [Online]
Available at:
http://www.bbcactive.com/BBCActiveIdeasandResources/WhyyoushoulduseaVirtualL

earningEnvironment.aspx
[Accessed 28 December 2015].

Bichsel, J., 2013. *The State of E-Learning in Higher Education: An Eye Toward Growth and Increased Access,* Washington, DC: Educause.

Blackboard, 2016. *Blackboard.* [Online]
Available at: http://uk.blackboard.com/index.aspx
[Accessed 2 February 2016].

Bootstrap Bay, 2014. *Top 5 Reasons to use Bootstrap.* [Online]
Available at: https://bootstrapbay.com/blog/reasons-to-use-bootstrap/
[Accessed 2 April 2016].

Bootstrap, 2016. *Bootstrap.* [Online]
Available at: http://getbootstrap.com/
[Accessed 01 March 2016].

Brown, S., 2005. Assessment for Learning. *Learning and Teaching in Higher Education,* Issue 1, pp. 81-89.

Bryman, A., 2012. *Social Research Methods.* 4th ed. Oxford: Oxford University Press.

Buller, M., 2014. *Structural Analysis & Design for Students.* [Online]
Available at: http://www.estad.co.uk/_pages/index.php
[Accessed 25 October 2015].

Centre for Excellence in Enquiry-Based Learning, 2007. *What is Enquiry-Based Learning (EBL)?.* [Online]
Available at: http://www.ceebl.manchester.ac.uk/ebl/
[Accessed 22 March 2016].

Clark, D., 2011. *Visual, Auditory, and Kinaesthetic Learning Styles (VAK).* [Online]
Available at: http://www.nwlink.com/~donclark/hrd/styles/vakt.html
[Accessed 4 October 2015].

Clark, R. C., 2012. *Are Virtual Labs As Good as Hands-On?.* [Online]
Available at: https://www.td.org/Publications/Blogs/L-and-D-Blog/2012/06/Are-Virtual-Labs-as-Good-as-Hands-On
[Accessed 12 March 16].

Clark, R. E. & Craig, T., 1992. Research and theory on multi-media learning effects. In: M. Giardina, ed. *Interactive multimedia learning environments: Human factors and technical considerations on design issues.* New York: Springer-Verlag, pp. 19-30.

Coffield, F., Moseley, D., Hall, E. & Ecclestone, K., 2004. *Learning styles and pedagogy in post-16 learning: A systematic and critical review,* London: Learning Skills and Research Centre.

Constantinidou, F. & Baker, S., 2002. Stimulus modality and verbal learning performance in normal aging. *Brain and Language,* 82(3), pp. 296-311.

Davenport, C., 2014. *Action Research in Education* [Interview] (3 March 2014).

Dunn, R., 1993. Teaching Gifted Adolescents Through Their Learning Style Strengths. In: R. Dunn, ed. *Teaching and Counselling Gifted and Talented Adolescents.* Westport, CT: Greenwood Publishing Group Inc, pp. 37-67.

EPN, 2008. *Evolution Web 1.0, Web 2.0 to Web 3.0.* s.l.:Youtube.

Fleming, N. D., 1995. I'm different; not dumb. Modes of presentation (VARK) in the tertiary classroom. *Research and Development in Higher Education, Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia (HERDSA),* Volume 18, pp. 308-313.

Fleming, N. D., 2016. *VARK a guide to learning styles.* [Online]
Available at: http://vark-learn.com/
[Accessed 29 February 2016].

Fry, H., Ketteridge, S. & Marshall, S., 2003. *A Handbook for Teaching and Learning in Higher Education.* 3rd ed. London: Routledge, Taylor & Francis Group.

Hasebrook, J. P., 2002. Co-operative and Interactive Distance Learning: Application of Team-Oriented and Selective Learning Strategies in a European Bank. *Journal of Universal Computer Science,* Volume 8, pp. 834-47.

Hattie, J., 2003. *Teachers Make a Difference: What is the research evidence?.* Melbourne, Australian Council for Educational Research.

ICEF Monitor, 2015. *Blended learning moving to centre stage in higher education.* [Online]
Available at: http://monitor.icef.com/2015/07/blended-learning-moving-to-centre-stage-in-higher-education/
[Accessed 11 March 2016].

Institution of Civil Engineers, 2015. *What subjects should I study?.* [Online]
Available at: https://www.ice.org.uk/careers-and-professional-development/under-16s/what-subjects-should-i-study
[Accessed 19 April 2016].

Keefe, J. W., 1979. Learning style: An overview. In: J. W. Keefe, ed. *Student learning styles: Diagnosing and prescribing programs.* Reston, VA: National Association of Secondary School Principals, pp. 1-17.

Kolb, A. Y. & Kolb, D. A., 2005. *The Kolb Leaning Style Inventory - Version 3.1.* Boston, MA: Hay Group.

Kolb, D. A., 1984. *Experiential Learning: Experience as the source of learning and development.* 1st ed. New Jersey: Prentice-Hall Inc.

Lambert, C., 2012. *Twilight of the Lecture: The trend toward "active learning" may overthrow the style of teaching that has ruled universities for 600 years..* [Online]
Available at: http://harvardmagazine.com/2012/03/twilight-of-the-lecture
[Accessed 12 March 2016].

Learning & Development Agency, 2015. *New Trends in Education and Learning - M-Learning.* [Online]
Available at: http://www.lsda.org.uk/new-trends-in-education-and-learning-m-learning.html
[Accessed 12 January 2016].

McLeod, S., 2010. *Kolb - Learning Styles.* [Online]
Available at: http://www.simplypsychology.org/learning-kolb.html
[Accessed 12 November 15].

Medhat, S., 2007. *The Path to Productivity: The Progress of Work-based Learning Strategies in Higher Education Engineering Programmes.* London, New Engineering Foundation (NEF).

Moodle, 2016. *Moodle.* [Online]
Available at: https://moodle.org/
[Accessed 2 February 2016].

O'Reilly, T., 2015. *What Is Web 2.0.* [Online]
Available at: http://www.oreilly.com/pub/a/web2/archive/whatisweb20.
[Accessed 11 January 2016].

Oxford University Press, 2015. *Learn about Virtual Learning Environment/Course Management System content.* [Online]
Available at: http://global.oup.com/uk/orc/learnvle/
[Accessed 1 December 2015].

Plymouth University, 2015. *Digital Learning Environment.* [Online]
Available at: https://dle.plymouth.ac.uk/
[Accessed 21 September 2015].

Sharp, J. E., 2001. *Teaching teamwork communication with Kolb learning style theory.* Nashville, TN, Vanderbilt University .

Singh, H., 2013. *Kolb's Learning Styles & it's comparison to the VAK style of learning.* [Online]
Available at: https://prezi.com/2puraeoc8c1y/kolbs-learning-styles-its-comparision-to-the-vak-style-of-learning/
[Accessed 12 December 2015].

Sitzmann, T., Ely, K. & Wisher, R., 2008. Designing Web-Based Training Courses to Maximize Learning. In: K. L. Orvis & A. L. R. Lassiter, eds. *Computer-Supported Collaborative Learning.* 1st ed. Hershey, PA: Information Science Publishing, pp. 1-19.

Srinivas, H., 2015. *Factors affecting Learning.* [Online]
Available at: http://www.gdrc.org/info-design/instruct/learning-factors.html
[Accessed 19 April 2016].

Talent Lens, 2016. *Honey and Mumford: Learning Style Questionnaire.* [Online]
Available at: https://www.talentlens.co.uk/develop/peter-honey-learning-style-series
[Accessed 12 January 2016].

The Quality Assurance Agency for Higher Education, 2007. *Code of practice for the assurance of academic quality and standards in higher education: Section 9: Work-based and placement learning,* Gloucester: The Quality Assurance Agency for Higher Education.

Thompson-Schill, S., Kraemer, D. & Rosenberg, L., 2009. *Visual Learners Convert Words to Pictures in the Brain And Vice Versa, Says Penn Psychology Study.* [Online]
Available at: https://news.upenn.edu/news/visual-learners-convert-words-pictures-brain-and-vice-versa-says-penn-psychology-study
[Accessed 11 January 2016].

University of Bath, 2014. *Structures at Bath.* [Online]
Available at: http://blogs.bath.ac.uk/structures/
[Accessed 26 October 2015].

Virtual College, 2015. *What is e-learning?.* [Online]
Available at: http://www.virtual-college.co.uk/elearning/elearning.aspx
[Accessed 12 October 2015].

w3schools.com, 2016. *Browser Statistics and Trends.* [Online]
Available at: http://www.w3schools.com/browsers/browsers_stats.asp
[Accessed 25 March 2016].

Yamazaki, Y., Murphy, V. & Puerta, M., 2003. *Learning Styles and Learning Skills in Higher Education: An Empirical Study of their Relationship Using Kolb's Experiential Learning Theory,* Cleveland, OH: Case Western Reserve University.

Zapalska, A. M. & Dabb, H., 2002. Learning Styles. *Teaching in International Business,* 13(3-4), pp. 77-97.

Appendices for this work can be retrieved within the Supplementary Files folder which is located in the Reading Tools menu adjacent to this PDF window.