

From Dental Bite to Dental Bytes: Students' experiences of a game-based project

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Abstract: Globally, universities are focused on developing their graduates with attributes that will enable them to make a productive contribution to a knowledge-based economy. In responding to this, the Durban University of Technology in South Africa proposes four key graduate attributes that students need to exemplify: critical and creative thinkers who work independently and collaboratively; knowledgeable practitioners; active and reflective learners; and effective communicators. To facilitate the attainment of these skills lecturers are encouraged to use student-centred teaching practices. Project-Based Learning is one such approach that can facilitate the attainment of the aforementioned attributes. It is against this background that a web-based game project called Dental Bytes emerged. This involved the trans-disciplinary collaboration between a Dental Technologist, eight third-year Information Technology (IT) students and their lecturer. This paper uses the Framework for the Rational Analysis of Technology Education (FRATE) model, which is an adapted version of the Framework for the Rational Analysis of Mobile Education (FRAME) model, to explore students' interdisciplinary leaning experiences of designing and developing Dental Bytes. The developmental phase of the game is presented in order to demonstrate how project-based approaches foster highly engaging learning experiences that are problem-centred and pedagogically sound. A case study research design within a qualitative framework was adopted. Data was collected by means of students' reflective reports, which were analysed in terms of the Interaction Learning Intersection frame of the FRATE model. Essentially, this project facilitated the epistemological development of students by providing them with a real world scenario of working with a client to enhance their information technology knowledge. Furthermore, this project assisted with developing their skills, abilities and dispositions to help them make informed decisions; self-manage their tasks (including their learning of Dental Technology); and to act in a socially responsible way both within, and beyond, the classroom. Overall, the salient features of this paper show that the IT project facilitated the attainment of graduate attributes, which is a bedrock of student centeredness and engagement.

Keywords: Dental Technology, Unity 3D game, FRATE model, Graduate Attributes.

1. Background of the Study

The National Development Plan (NDP), specifically "South Africa needs to sharpen its innovative edge and continue contributing to global scientific and technological advancement" (The Presidency: Republic Of South Africa 2012: 22), requires South African universities to make a conscious effort to include this objective within their higher education agenda and purpose. In particular, and as outlined in the NDP document, "institutional arrangements to manage the information, communications and technology (ICT) environment need to be better structured to ensure that South Africa does not fall victim to a "digital divide" (The Presidency: Republic Of South Africa 2012: 23). The Quality Enhancement Project is one example of the efforts made by the Durban University of Technology (DUT) to align with the NDP goals. The aim of the project is to move DUT to become a student

centred university through the transformation of teaching and learning and the promotion of quality enhancement (Sattar and Cooke 2012; Durban University of Technology 2014). While addressing this, four key graduate attributes emerged that students need to embody: critical and creative thinkers who work independently and collaboratively; knowledgeable practitioners; active and reflective learners; culturally, environmentally and socially aware within a local and global context; and effective communicators. Students therefore need to be exposed to a wide range of learning experiences through which adaptability, creativity, language and interpersonal skills can be cultivated to help them prepare for their professional practice. Ultimately, acquiring such skills in addition to their discipline-specific knowledge and skills is vital for students to become part of a knowledge-based economy. Equally significant, the aforementioned graduate attributes underpin DUTs four strategic focus areas, namely:

- Building sustainable student communities of living and learning.
- Building research and innovation for development.
- Building a learning organisation.
- Building a sustainable university.

(Durban University of Technology 2015)

These four strategic focus areas encapsulate the core functions of teaching and learning, and are entwined with the fundamental strand of student-centeredness. Hence, students need to be provided with a teaching and learning milieu that will help in nurturing them to grow intellectually, socially and emotionally (Durban University of Technology 2015). In support of this, and to facilitate the attainment of the aforementioned graduate attributes, DUT lecturers are encouraged to use student-centred teaching practices such as Project-Based Learning (PJBL). It is against this background that a web-based game development project called Derminator emerged. This game involved the cross-disciplinary collaboration between a Dental Technologist (academic client: instructional designer), eight third-year Information Technology (IT) students (game designers/software developers) and their assigned supervisor.

As several studies (Thomas 2000; Bell 2010; Council on Higher Education 2011; Moalasi *et al.* 2012) have noted, and based on the tenets of PJBL, the Derminator project aimed to facilitate the epistemological development of students by providing them with a real world scenario. For instance, to work with a client to enhance their IT knowledge while developing their skills, abilities and dispositions to help them make informed decisions, self-manage their tasks (including their learning of Dental Technology), and to act in socially responsible way both within, and beyond, the classroom. In order to assess these outcomes the FRATE (Framework for the Rational Analysis of Technology Education) model, which is an adapted version of Koole's (2009) Framework for the Rational Analysis of Mobile Education (FRAME) model (*Figure 1*), was used. Significantly, the FRATE model has the same components as the FRAME model, however it can be applied to any kind of learning technology, not just mobile technology.

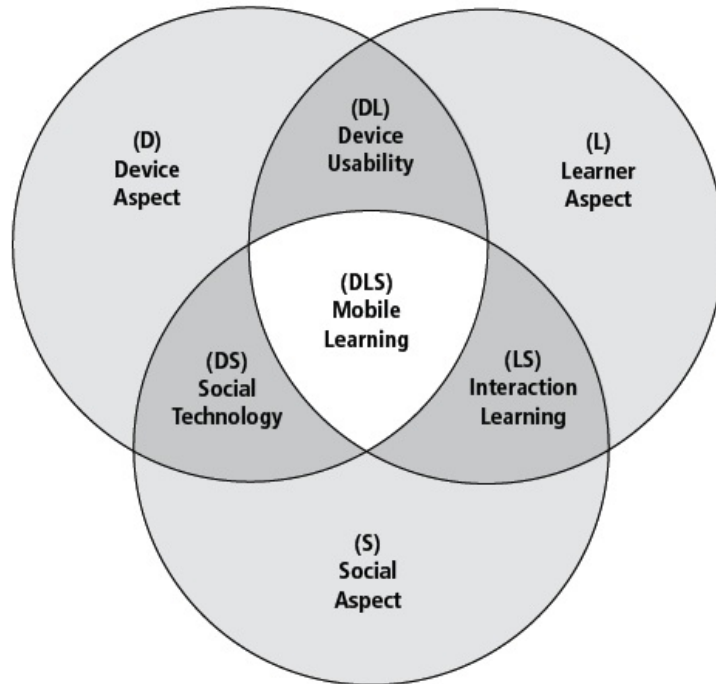


Figure 1: FRAME mobile learning model (Koole 2009: 27)

As illustrated in Figure 2, the FRATE model consists of a three-circle Venn diagram comprising the intersection of three fundamental aspects, namely: technology, learner, and social. The technology (T) aspect focuses on the physical, technical and functional characteristics of the technology used. The learner (L) aspect describes how learners use their knowledge and how they encode, store, and transfer information, knowledge and skills from context to context. The social aspect (S) of FRATE considers the social environment in which the learning takes place, and includes features required for conversation, co-operation and social interaction that is sharing/respecting socio-cultural aspects in order to pave way for amiable interactions. These aspects intersect to form sub-aspects in technology usability, social technology, and interaction learning. The Technology Usability (TL) intersection connects characteristics of the technology to cognitive tasks related to the manipulation and storage of information. The Social Technology (TS) intersection focuses on how the technology enables communication and collaboration amongst multiple individuals and systems. The Interaction Learning (LS) aspect describes how learning is collaborative with meaning negotiated from multiple aspects. The technology learning intersection (TLS) is the culmination of all the characteristics of the aspects and intersections.

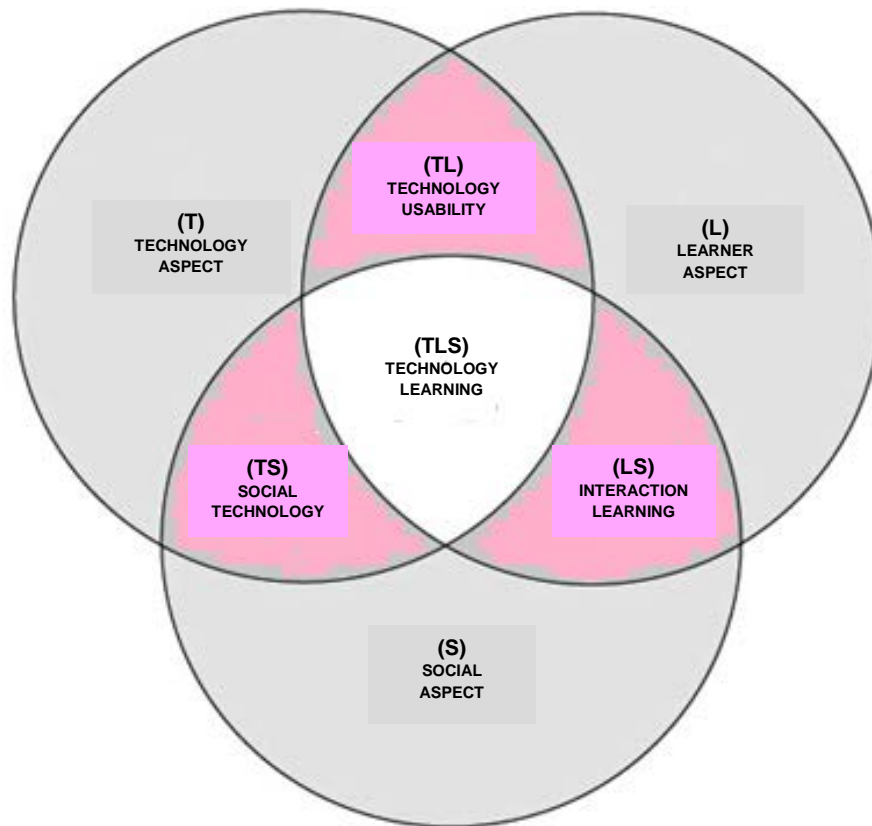


Figure 2: FRATE technology learning Model
(Adapted from Koole (2009))

2. The Design and Development of Dental Bytes

In the first semester (February – June 2015), specifically on the 21 February 2015, the first debriefing session regarding the project occurred between the students and the client, who is the author of this paper. At this initial meeting potential designs of the web-based game, which aimed to test Dental Technology students' knowledge of definitions related to the Tooth Morphology and Oral Anatomy subjects, were discussed. The client also clarified that the educational purpose of the game is to allow students to have rich experiences of their domain-specific knowledge by enabling them to access and acquire discipline-specific knowledge and skills. This is consistent with Bawa (2011: 1), the former Vice-Chancellor and Principal of DUT where this study was conducted. He acknowledged that the university attracts a large number of students who come from marginalised socio-economic backgrounds. Students may therefore come from families that do not have the educational capital or resources to support them in their academic studies. His observation is commensurate with the South African Survey of Student Engagement institutional report (2010), which shows that 75% of Black African students at DUT are first-generation students who have English as a second language. Consequently, they have not been widely exposed to the experiences, discourses and expectations associated with higher education.

In view of most DUT students have English as their second language, another objective of the game was to assist students to improve the spelling of the different discipline-specific terminologies. Subsequently, regular bi-weekly meetings were held between the client and the IT students to clarify and refine the instructional and technical designs of the project. During this time, students also reported to their IT supervisor, who was also their mentor, to clarify their position and responsibilities within the project. Consequently, students were placed into two groups: the game team and the web team. Every member of each team was given a role and had to fulfil tasks corresponding to their assigned position, which were coding, software development (game development) and art direction.

2.1 Details of the Game

By the end of March 2015, the details of project Derminator, a web-based game consisting of five mini sub-games designed around morphological and anatomical knowledge, were clarified. Each game is to be linked to a cusp tip of a mandibular first molar (*Figure 3*). The level of difficulty of each game increases according to the size of each cusp. The Game starts by clicking on the smallest cusp (*Game 1; Level one*). Students worked towards deploying the first sub-game, 'Dental Bytes'. Entry into this game begins by first answering a question related to the discipline-specific content of Tooth Morphology and Oral Anatomy. Dental Bytes is designed around discipline-specific terms related to the aforementioned subjects. The aim of Dental Bytes is to reinforce students' knowledge of dental terminologies and in the process enable him/her to improve the spelling of the various terminologies.

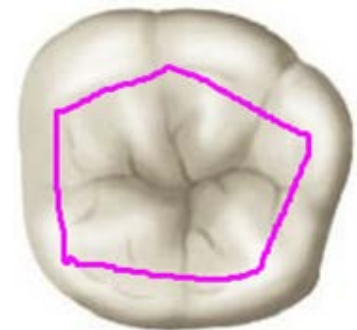


Figure 3: Mandibular First Molar

2.2 Instructional Design: How to play 'Dental Bytes'.

After successfully entering 'Dental Bytes' there is an option to play one of three levels of the game, namely: Basic; Intermediate or Advanced.

- At each level, the player will read a computer-generated scrambled word, which needs to be unscrambled (*Figure 4*).
- At the Basic level, every correct answer scores 5 points.
- At the Intermediate level, every correct answer scores 10 points. As this is a timed game the answer must be given in 20 seconds.
- At the Advanced level, every correct answer scores 15 points. As this is a timed game the answer must be given in 10 seconds. Note that for every incorrect answer 10 points will be deducted and the time will be reduced by 5 seconds.
- An overall score of 75% and above is needed to progress to Game 2.



Figure 4: Screen Snapshot of Dental Bytes

2.3 GAME 2: 'Crown it or Frown it' (yet to be developed)

This game is designed around multiple choice questions. The game starts with a virtual person within a denture set-up (Figure 5). Each tooth represents a multiple choice question (MCQ), hence there are 32 MCQs.

- For every correct answer a tooth turns gold = 'crown it'.
- For every incorrect answer the tooth decays = 'frown it'.
- Negative marking will apply.



Figure 5: A set of dentures

A point deserving mention is that the debriefing sessions also enabled the client to acquire the IT knowledge from the IT students, which is highlighted in the subsequent section.

2.4 Technical Design Aspects

An Application Programming Interface created by Unity 3D was used to design the game. Labschütz *et al.* (2011) pointed out that Unity is mainly based on drag and drop with occasional adapting of scripts rather than writing code, hence the student benefits from using this game engine. They further asserted that Unity combines visual simulation capabilities with interactive functions and is easy to use, as it provides multiple built-in shaders and effect, and numerous scripts which can be dragged onto 3D models. Basically, this application allows data to be

sent and received from a server by randomly selecting a word from the database and to introduce into the game. Here, the game breaks down the data string into individual characters. For each character in the string a 3D alphabetic cube is formed, which is randomly arranged. The user is required to unscramble this random arrangement by forming a word. Other features included: post scores, save game feature, posting data to the server, and linking the user to the web page.

Game objects such as 3D alphabetic cubes were created using Blender, an open source 3D creation suite. Derminator's functionality was programmed using the C# programming language. The Integrated Development Environment used was Visual Studio 2013. The Scrum process methodology was used as it involves continuous delivery of working software, as well as customer collaboration to produce software in an iterative and incremental fashion. An iteration can be seen as a predefined time period in which certain features and functions of the software product will be produced whilst an increment can be seen as a steady increase of complex features and functions.

Using the process of Agile Scrum, students were required to develop their software in the form of sprints. A total of four sprints, Sprint 0 in the first semester (February – mid-June 2015) and Sprints 1-3 in the second semester (mid-July – mid-November 2015), were conducted where students presented their project to the client, IT lecturers and industry stakeholders. The processes behind each sprint are briefly outlined below.

- *Sprint 0*: Students were required to scaffold and define the requirements for their work. The phase concluded with a portfolio submission and a presentation. A computer-based collaborative learning tool called Microsoft Team Foundation Server facilitated the interaction.
- *Sprints 1 – 3*: Students were required to submit working prototypes at the end of each sprint.
- Figure 6 presents the improvements and revisions that were required after each sprint.

The game prototype was completed in time for the final sprint, which occurred on Friday, 9 September 2015. A noteworthy point is that from the 36 projects, Derminator was placed amongst the top seven for the subject "Development Software III".



Sprint 0

- Red text in the game overview isn't clear.
- "New game" button should be renamed to "Dental Bytes" with a picture.
- The randomizer needs to be made more random so it doesn't bring in the same word many times in a row.
- When a score of 20 in the "intermediate level" is reached display a message informing the user that they have to click on the AIs that appear on the screen for extra time.
- Faster playing music needs to be added on timed levels.
- Blocks needs to be adjusted to accommodate for the longer word so they can fit onto the screen.
- Rephrase line at the bottom of the "Times Up" menu. Game needs to be saved per person.
- Game should be authorized so that only when you are logged in you should be allowed to post your score.
- To clarify that the score is used to purchase TIME in the Advanced level.
- Achievements should be saved per profile & Security!



Sprint 1

- Audio playback needs to be provided to assist the student to correctly enunciate terminologies. Edit the description of the game so the player knows how to access the audio playback function. Freeze the time when player selects the audio playback. There is no audio playback for Advanced level.
- Time purchase works with the current score and not score to be generated. To purchase 20 seconds will cost the player 5 points. When an AI is clicked, 5 seconds will be added to the player's time. An AI is only available to the player at the Intermediate level. AIs encourage curiosity and helps to keep the player engaged.
- Change the polling system into ratings so it is available to everyone online.



Sprint 2

- Web: Category and difficulty needs to be drop down lists.
- Achievements need to be coded in the website.
- Describe web portion to client.
- Include a search bar in the word dictionary.
- Game
- Sort out user feedback.
- Within subject eg. Tooth morphology, add levels of difficulty.
- Make timer more visible and size larger.
- Need to make randomizer more random.
- Change "New Game" to "Dental Bytes".
- Include a counter to indicate the number of answered questions and questions that still need to be answered.
- Achievements should be saved per profile.
- Make a Youtbue video of the game.

Figure 6: Evidence of Peer Scrutiny in Sprints 0-2

3. Methodology

The design of discipline-specific digital games aims to foster higher levels of student engagement in learning (Labschütz *et al.* 2011; Connolly *et al.* 2012; Li *et al.* 2012), while providing students with skills to participate in their disciplines and to prepare them for their subsequent roles and responsibilities in professional practice (Squire *et al.* 2004; Shaffer and Gee 2005; Begg 2008; Gee 2010). There is, however, less evidence on the students' interdisciplinary learning experiences in developing discipline-specific digital games in higher education. A case study research strategy (Remenyi 2013) was therefore adopted to aid an in-depth exploration of the students' experiences of designing and developing Dental Bytes. This approach is within a qualitative framework as it aims to holistically "understand the case in depth, and in its natural setting, recognising the complexity and its context" (Punch 2014: 120).

The eight third-year IT students who were involved in developing Dental Bytes were purposively selected for the study. Data were collected by means of students' reflective reports that were submitted at the end of each semester. Students were made aware that the anonymity and confidentiality of information would be maintained. At the end of the first semester (*June 2015*) students reflected on their Sprint 0 experiences, and in the second semester (*November 2015*) they reflected on their Sprint 1-3 experiences, together with their personal experiences of working with the client per semester. The Interaction Learning (LS) Intersection frame of the FRATE model (*Figure 2*), particularly the learner aspect (L) was used to analyse the data. The analyses entailed assessing all possible types of interactions that emerged during the development of Dental Bytes. These interactions included: learner-learner; learner-client; learner-content; and learner-mentor/industry, and to what extent students are transforming through these interactions.

Trustworthiness of the data was achieved through frequent debriefing sessions with the assigned supervisor (Crookall 2010). Peer scrutiny of the research project by colleagues, IT lecturers and industry stakeholders through Sprints 0-2 (*Figure 6*) further enhanced the credibility of this study (Cohen *et al.* 2007) by enabling students to improve the design of the game.

4. Findings

The salient features of students' accounts of their experiences in Semester one can be summarised as follows:

- Higher levels of satisfaction were expressed for learner-client interaction.
- Satisfactory levels of learner-content interaction were relayed.
- Mixed emotions were experienced for the learner-learner interaction.
- Little or no evidence of learner-mentor/industry interaction.

As summarised in Table 1, students declared that in Semester two they were intellectually stimulated and cognitively challenged in making the necessary improvements to both the web and game aspects. As presented in Figure 7, they clarified that they found the intricacies of the game such as including a timer was undoubtedly challenging and time consuming.

Table 1: Improvements made to Dental Bytes

Refinements to Web Design	Improvements to Game Design
<p>1. Improvements were made to the:</p> <ul style="list-style-type: none"> ❖ Repository pattern; ❖ E-mailing system; ❖ Contact page; ❖ History Page; ❖ Leader board; and ❖ Register page. <p>2. A polling system was introduced.</p>	<ul style="list-style-type: none"> ❖ Game countdown timer, which was coded in line with the requirements of the game. ❖ An in-game purchasing system was coded to allow players to purchase time using their score. ❖ Included sliders that interacted with the score and timer to make the game visually appealing. This further facilitated the player in viewing their score and time. ❖ Game deployment online – to save and load the game. ❖ Designing an online game user manual.



Figure 7: A snapshot of the timer and the right design (slider) to implement the in-game timer of Dental Bytes.

5. Discussion

In terms of the learner-client interaction students clarified that the client “...knew exactly what she wanted, and described in great detail what she expected from the group”. They were of the opinion that despite the client’s high expectations of them, she “...instilled life skills” and was “the driving force behind a good team as she has taught us good team spirit”. Students were motivated by the client’s valuable feedback and constructive critique of their work. Others expressed that the client “...provided us with a good training ground not only in Information Technology but in Dental Technology as well”. This facilitated learner-content interaction as students declared that this project placed them in a real-world scenario, especially as they “...had to sign a non-disclosure agreement which made me realise how serious and confidential we have to be, when we are involved in a project.”

Additionally, students felt that the learner-content interaction was challenging, particularly from the perspective of having to learn “how to use Unity from scratch” and “...to work with software that is self-study and most of the time we are limited in the development of Derminator, because of lack of knowledge in using the software to its full potential.” Nonetheless, students acknowledged that ongoing collaboration and communication with all stakeholders, together with prototyping the product, helped them to “...improve the clients as well the development teams understanding as to what is required...eliminate uncertainty and move the project progressively forward.” This supports the argument of Koole and Ally (2006) that the social aspect is integral to both the interaction learning (IL) intersection and the technology-learning process (TLS), overall.

Some students valued learner-learner interaction as they recognised that teamwork would enable them to manage the project. In turn, they “...managed to pick up tips and learned different types of skills, from learning to communicate and dealing with our client, to reading and deciphering many different types of plans”. Some of their written accounts, however, suggested that barriers in communication caused unnecessary tension and personality clashes between group members. Consequently, they failed to present the coding and functionality of the game to their mentor.

Students’ feedback on their experiences in Semester two predominantly centred on learner-content interaction and learner-client interaction. From the perspective of learner-content interaction, it was evident that Sprints 2 and 3 created learning spaces that pushed the students beyond their boundaries. Encouragingly, students also recognised that they had “...increased knowledge in Dental Technology (which I must say is no joke). Furthermore, students reiterated that the “Unity Game engine was something new to us, which we had to self-study and learn from tutorials.” In spite of this, teamwork through paired programming enabled them to learn from each other, whilst acquiring skills on how to communicate with the client. Students conveyed that while working on the project they “...have learnt not only fundamental principles as a game coder but I also have learnt many valuable life skills along the way...worked on many aspects of the game and web service e.g. the player history table, hints, contact page etc. On certain aspects we worked in pairs (aka paired programming) or as a team enabling us to interact with one another as we would in the real working environment.” This supports

DUTs graduate attributes, specifically to be critical and creative thinkers who work independently and collaboratively while aspiring towards becoming knowledgeable practitioners.

Students also prominently acknowledged the hard work and efforts made by both the client and their mentor, who “... believed in us and pushed us to get the work done, and if it wasn’t through their persistence, the game wouldn’t have been completed on time and we wouldn’t have been in the top 7 for Development Software 3.” Moreover, students emphasised that a graphic designer needs to be part of the game development team as this will facilitate the inclusion of “...more eye catching graphics”, which is outside their area of training. Graphic and fine art designers are to be sought for future improvements to the game. They also highlighted that the Agile Scrum methodology is inappropriate when designing a web-based game. “For example with the game, there are many processes such as developing concept art, modelling, lighting, animation, rigging (if your game has characters), scripting and testing. If the game has to communicate with a website or other external services the methodology should also allow for integration testing.” Finally, and apart from acquiring critical thinking and problem-solving skills, developing Dental Bytes evidently motivated students to take responsibility for their own learning and to be open and effective communicators when working in a culturally diverse team.

6. Conclusions

The prominent features of this paper show that a possible novelty of PJBL is to develop games to attain graduate attributes, which underpins student centeredness and engagement. Students are more likely to drive their own learning through inquiry and using technology skills to become proficient communicators and advanced problem solvers. Ultimately, games as pedagogical vehicles and epistemic constructs can effectively help students develop in ways of knowing, acting and being, while interacting with industry stakeholders. A future direction of this study is to increase the impact and scalability of Derminator and to use Dental Bytes in the teaching, learning and assessment of Dental Technology. The FRATE model will be used to holistically understand the extent to which Dental Bytes facilitates the provision of epistemological access.

7. References

- Bawa, A.C. (2011) *VC talks: Communique regarding student protest action*, Durban University of Technology, Durban, South Africa.
- Begg, M. (2008) Leveraging game-informed healthcare education, *Medical Teacher*, Vol 30, pp 155-158.
- Bell, S. (2010) Project-based learning for the 21st century: Skills for the future, *The Clearing House*, Vol 83, No 2, pp 39-43.
- Cohen, L., Manion, L. and Morrison, K. (2007) *Research Methods in Education*, 6th ed, London & New York, Routledge Taylor & Francis Group.
- Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T. and Boyle, J.M. (2012) A systemic literatue review of empirical evidence on computer games and serious games, *Computers & Education*, Vol 59, pp 661-686.

Council on Higher Education. (2011) *Work-Integrated Learning: Good Practice Guide*, HE Monitor No.12 ed, Pretoria, CHE Press.

Crookall, D. (2010) Serious Games, Debriefing, and Simulation/Gaming as a Discipline. *Simulation & Gaming*, Vol 41, No. 6, pp 898-920.

Durban University of Technology. (2010) *Institutional Report 2010: Durban University of Technology*, [online], www.dut.ac.za.

Durban University of Technology. (2014) Quality Enhancement Project - Institutional Submission 2014, Durban University of Technology, Durban, South Africa.

—. (2015) DUT Strategic Plan 2015-2019: Towards Relevance, Responsiveness and Resilience, Durban University of Technology, Durban, South Africa.

Gee, J.P. (2010) *New Digital Media and Learning as an Emerging Area and "Worked Examples" as One Way Forward*, [online], London, England, The MIT Press, https://www.dmlhub.net/sites/default/files/New_Digital_Media.pdf.

Koole, M.L. (2009) *A Model for Framing Mobile Learning*, Edmonton, AU Press.

Koole, M. and Ally, M. (2006) *Framework for the rational analysis of mobile education (FRAME): A model for evaluating mobile learning devices: a proceedings volume from the MDE thesis, Athabasca University, Athabasca*, Citeseer.

Labschütz, M., Krösl, K., Aquino, M., Grashäftl, F. and Kohl, S. (2011) Content creation for a 3D game with Maya and Unity 3D, *Institute of Computer Graphics and Algorithms, Vienna University of Technology*.

Li, Q., Tay, R. and Louis, R. (2012). Designing Digital Games to Teach Road Safety: A Study of Graduate Students' Experiences. *The Journal of Canadian Game Studies Association*, 6 (9): 17-35.

Moalasi, R., Molokwane, S. and Mothibedi, G. (2012) Using a design-orientated to attain graduate attributes. *Design and Technology Education: An International Journal* [online], Vol 17, No. 1, pp 30-43, https://www.researchgate.net/publication/234061246_Using_a_design-oriented_project_to_attain_graduate_attributes.

Punch, K.F. (2014) *Introduction to Social Research: Quantitative & Qualitative Approaches*, 3rd ed, London, SAGE Publications Ltd.

Remenyi, D. (2013) *Case Study Research: The Quick Guide Series*. 2nd ed, United Kingdom, Academic Conferences and Publishing International Limited.

Sattar, K. and Cooke, L. (2012) A conceptual framework for the quality assurance of programme design at the Durban University of Technology. *South African Journal of Higher Education*, Vol 26, No. 2, pp 372-390.

Shaffer, D.W. and Gee, J.P. (2005) Before every child is left behind: How epistemic games can solve the coming crisis in education. *Wisconsin Center for Education Research* [online], pp 1-18. http://www.wcer.wisc.edu/publications/workingpapers/Working_Paper_No_2005_7.php.

South Africa. (2012) *Executive Summary - National Development Plan 2030 - Our future - make it work*, Government Gazette No. 500, 29 January 2016, Pretoria, Government Printer.

Squire, K., Barnett, M., Grant, J.M. and Higginbotham, T. (2004) *Electromagnetism Supercharged! Learning Physics with Digital Simulation Games: a proceedings volume from the The Sixth International Conference of the Learning Sciences: Embracing Diversity in the Learning Sciences*, Mahwah, Lawrence Erlbaum Associates.

Thomas, J.W. (2000) *A review of research on project-based learning*, [online], http://www.bie/index.pho/site/RE/pbl_research/29.