

Examining the Quality of Pedagogy Through a Tooth Morphology Board Game

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Abstract: Quality is a fundamental focus in the South African higher education context, especially in terms of the deteriorating student results in the subject Tooth Morphology and low throughput rates. This prompted an investigation into the quality, content, delivery and assessment of the subject Tooth Morphology, through which a Tooth Morphology board game was developed. It was perceived that the game could make the morphological abstractions of the subject more tangible for first-year students in the Dental Technology diploma offered at the Durban University of Technology. Arguments for the potential benefits of games in higher education have generated an increasing volume of research. The general focus of these studies, however, is based largely on empirically documented work with little theorisation about the pedagogy of games, particularly in terms of providing students with epistemological access. Using a mixed methods sequential explanatory research design this study examined the quality of pedagogy through the Tooth Morphology board game in facilitating access to the target epistemology. Analysis of evaluations of preliminary work conducted from 2003 to 2006 (n=128) and pilot work conducted in 2007 and 2008 (n=62) suggested that the game enabled students to access morphological knowledge. In the main study conducted during 2009, 2010 and 2011 (n=83), data was gathered using surveys, pre- and post-tests, observational data, debriefing sessions and student focus groups. Quantitative analyses entailed using descriptive statistics, t-tests, factor analysis and cross tabulations. Qualitative analyses entailed using the conceptual frameworks of Bernstein's knowledge codes and Maton's Legitimation Code Theory (LCT) of Specialisation. Statistically, the results revealed that an integrated game design with an appropriate mix of instructional content and applicable game features and mechanisms facilitates the provision of epistemological access. An LCT (Specialisation) analysis revealed that the Tooth Morphology board game represented a knowledge code, hence students acquired access to morphological knowledge.

Keywords: epistemological access, board game, knowledge structure, knower structure, legitimation code theory

1. Background and context of the study

Internationally an accepted indicator of efficiency is the throughput rate of students, which measures the proportion of enrolments to graduates in a given year (Department of Education 1996). While this is not a representative indicator of quality in higher education, poor throughputs have implications regarding the credibility of qualifications offered in higher education institutions. In some instances, only 30% of students graduated with a three-year qualification, and this included those who took up to five years to do so (Scott, Yeld and Hendry 2007: 12-14). Low throughput rates in the National Diploma: Dental Technology at the Durban University of Technology (DUT) were largely attributed to a decline in students' performance in the subject Tooth Morphology. Tooth Morphology provides the underpinning conceptual knowledge needed to produce and repair various dental appliances such as crowns, bridges, dentures and orthodontic braces. Students expressed that they had difficulty in understanding and remembering morphological terminology and related concepts. Drawing exercises are typically used in practical sessions as a means of preparing students to carve morphologically correct teeth. Consistent with the difficulties mentioned above, assessments of students during these sessions showed that they were unable to recall the requisite knowledge discussed in lectures, and that they were unable to apply it to their drawing exercises and practical carving exercises. Consequently, it was assumed that students were unable to make connections between their theoretical classes and their practical sessions. Through probing the student learning, teaching and assessment practices in lectures and in workshops, an alternate teaching practice in the form of a Tooth Morphology board game (TMBG) was developed and introduced into the classroom.

There is consensus among many scholars from different disciplines that games redefine traditional understandings of what it means to be a literate student in the twenty-first century (see for example Coiro *et al.* 2008; Salen 2008; Janks 2010; Mallinson 2010). In board, computer, video or mobile games the way literacy and technology converge dismisses the conventional idea that literacy is a universal technical skill focused on print decoding and encoding. Several other studies (for example Allery 2004; O'Leary *et al.* 2005; Zagal, Rick and Hsi 2006; Bochennek *et al.* 2007; Wideman *et al.* 2007; Killi and Lainema 2008; Kovalik and Kovalik 2008; Hromek and Roffey 2009; Pivec 2009) have indicated that the salient features of games are that they are inherently student-centered and interactive, and generate enthusiasm, excitement and enjoyment. Regardless of these positive attributes, the literature is unclear as to what extent games enable students to make meaning and sense of their discipline-specific knowledge. This aligns with the concept of epistemological access, coined by Morrow (1993; 2007; 2009) as allowing access to the ways of constructing knowledge that are valuable to the discipline. According to Morrow (2007: 63), the aim of teaching for a profession is to systematically develop conceptual frameworks that render the world of work less opaque to students. The aim of this study is to examine the quality of pedagogy through the Tooth Morphology board game in facilitating epistemological access. The study objectives are to:

- Investigate the quality of teaching and learning in the subject Tooth Morphology using the board game, through surveys and interviews.
- Evaluate the efficacy of the board game by pre- and post-tests in assessing epistemological access in the subject Tooth Morphology in the Dental Technology programme.

2. Research design and methodology

As this study sought to understand the empirical and pedagogical values of the TMBG in the provision of epistemological access, a mixed methods sequential explanatory research design, consisting of two distinct phases, was used (Ivankova, Creswell and Stick 2006; Teddlie and Yu 2007; Teddlie and Tashakkori 2009; Creswell and Plano-Clark 2011).

The preliminary and pilot work of the TMBG (Vahed 2008) described the instructional and technical designs of the TMBG, as well as validated and tested the reliability of the survey. In particular, academic experts validated the preliminary study by reviewing the contents of the game. The findings of the preliminary work suggested that games assisted students to actively learn. For the pilot work, dental technology experts validated the contents of the game. The low alpha score ($\alpha=0.45$) obtained for the Tooth Morphology board game prompted improvements to be made to the survey for the main study. Ethical approval was granted via the Faculty of Management Sciences at DUT, and permission to collect data was obtained from Dental Sciences at DUT. Written consent was obtained from the participating students. Students were made aware that participation was voluntary and that anonymity and confidentiality of information would be maintained. Consequently, student names were not required on the surveys. Students also consented to be video-taped during game play.

2.1 Study population

In the main study, the target population consisted of first-year Dental Technology students who were registered for the first time in the subject Tooth Morphology in the years 2009, 2010 and 2011. From Table 1, although there were a total of 90 students the overall response rate to the survey was 88.6%. In line with Lewin (2011: 226), this response rate is deemed acceptable. The small student numbers in Dental Technology supported census sampling (Check and Schutt 2012: 96).

Table 1: Dental technology first-year students

	Total Target Population	Total number of respondents
2009	24	24
2010	39	35
2011	27	24
Total	90	83

2.2 Data collection and analysis

In the first, experimental, phase surveys, pre- and post-tests were used to practically assess the extent to which the TMBG impacted on student learning. Figure 1 illustrates the experimental design used to evaluate the efficacy of the TMBG. At the intervention phase, a 14-question survey was used post-game play to assess the TMBG. This survey included three main sections, namely:

- Section A, which asked for demographic details. Note that this study used the ‘race’ or ‘population group’ categories of Statistics South Africa, namely: Black African, Coloured, Indian or Asian, and White (Statistics South Africa 2003)
- Section B, a closed-ended question measured by a five-point Likert Scale (1 = Strongly Disagree; 5 = Strongly Agree) was used to gain information on students’ perceptions of the Tooth morphology subject.
- Section C, two closed-ended questions measured by a five-point Likert Scale (1 = Strongly Disagree; 5 = Strongly Agree) were used to gain information on the perceptions of students on the instructional and technical designs of the TMBG.

Three open-ended questions enabled free responses from students regarding learning through games and if any skills were acquired from playing the TMBG.

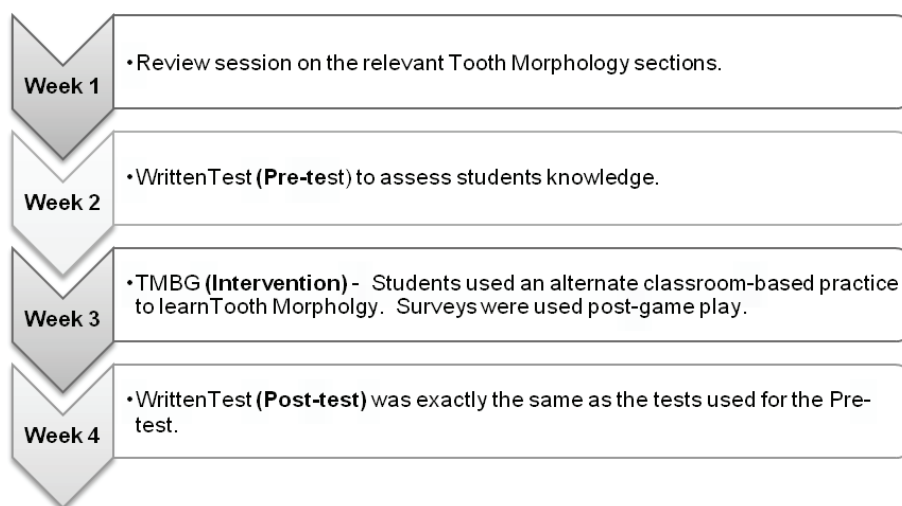


Figure 1: Pre- and post-tests experimental design

In determining the relationship between the TMBG and epistemological access, descriptive and inferential statistics were used to analyse the quantitative data. A paired t-test was used to analyse the pre- and post-test scores with $p < 0.05$ set as statistically significant (SPSS-Version 20[®]). Factor Analysis was performed for the data obtained from the Likert Scale to identify underlying variables, or factors, and to explain the pattern of correlations within a set of observed variables.

In the second, inferential phase, a qualitative case study strategy was adopted and data was generated through focus groups. Williamson (2005) maintains that focus group data helps to illuminate issues that surveys present in less accessible ways. There were twelve focus groups (Table 1), each of which included between eight to twelve students. Digitally recorded discussions of the focus groups were transcribed *verbatim*. The analysis that followed used Bernstein’s (2000) concepts of educational knowledge codes, classification and framing to understand the underlying knowledge structure of Dental Technology, and how it relates to the outcomes of the students’ learning experiences through the TMBG.

Dental Technology is typified as a region as it hinges at the interface between disciplinary knowledge and the field of professional practice. The term ‘recontextualisation’ is used by Bernstein (2000) to describe a ‘region’ where knowledge has been selected, de-contextualised and then placed into a new context. Essentially, recontextualisation involves a transformation of knowledge from its original form. For example, the specific learning outcome for Tooth Morphology is to acquire and apply scientific knowledge of morphological concepts (Dental Sciences Department 2013). This is recontextualised from the singular discipline of human anatomy to only that aspect of dental anatomy pertinent to Dental Technology. Furthermore, and as outlined

in the subject guide (Dental Sciences Department 2013), students need to acquire knowledge on the shape and morphology of teeth (the intellectual field of the discipline) in relation to carving practical work (field of external practice). In Maton’s (2014) term, Dental Technology represents a knowledge code. The focus on attributes (or dispositions) of the knower is minor in the course outline and assessments, whereas the focus on knowledge itself is very strong.

Bernstein’s (2000) notion of classification (C) refers to the strength of boundaries between categories of knowledge or contexts. Stronger and weaker values may be assigned for classification (+C/-C) depending, for instance, on the degree of differentiation of disciplines in a curriculum. In this study, classification is how bounded Dental Technology is from other programmes, or how bounded the discipline of Tooth Morphology within it is. By contrast, Bernstein (2000: 12) explains that framing (F), is concerned with ‘how’ meanings are to be put together and the forms by which they are to be made public (Figure 2). Hence, it was inferred that framing is the internal logic of the pedagogical practice because it involves methods that transform the knowledge into the messages of the curriculum. Stronger and weaker values may also be assigned for framing (+F/-F), depending on whether the lecturer or the student is in control (or in perceived control) of the communication.

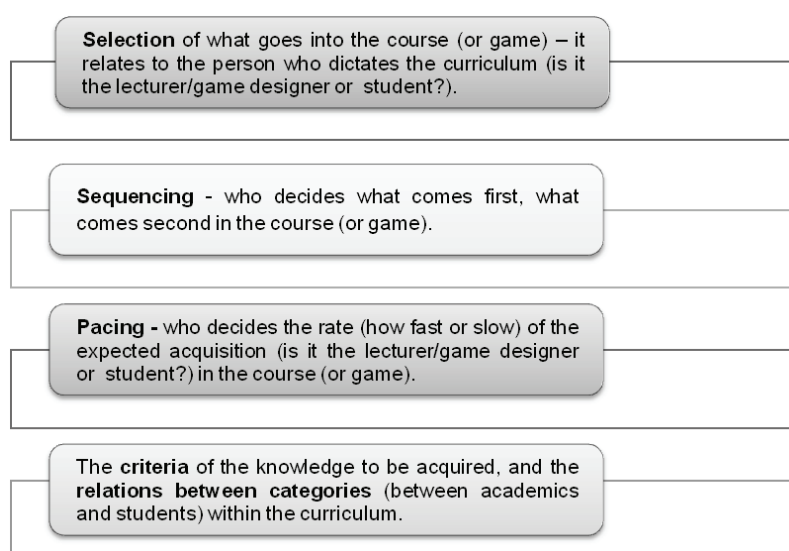


Figure 2: Framing the control within the game (*Adapted from Bernstein (2000)*)

Bernstein (2000) also points out that the strengths of classification and framing may vary independently of each other to such an extent that the differing strengths produce four potential knowledge codes (Figure 3), namely: +C, +F; -C, +F; +C, -F; and -C, -F. He clarifies that codes are the underlying principles that transform subjects into meanings in terms of two rules. The recognition rule is when the students “are able to recognise the specialty of the context that they are in” (Bernstein 2000: 17). The second realisation rule enables them to produce “the expected legitimate text” (Bernstein 2000: 17). To be able to speak and act appropriately in a particular educational context, it is necessary that the student is able to recognise the context (recognition rule). Following this, the student must be able to communicate what he or she knows in a way that is understandable and acceptable to people in this context (realisation rule). The concepts of recognition and realisation rules were deemed valuable to this study, as they facilitated an enriching understanding of the underlying structuring principles of the students’ learning experiences through the TMBG.

Maton’s (2014) conceptual framework named the Legitimation Code Theory (LCT) brings the structure of the knower (student or teacher) into the analysis. He argues that disciplinary knowledge practices may contain assumptions about who may become a legitimate knower, as well as their impacts on their qualities and the qualifications required to legitimately teach and learn a discipline. For LCT, knowledge and educational practice are conceived as ‘languages of legitimation’. Epistemological access is thus understood as students’ acquisition of such languages and the study is concerned with the extent to which they legitimately realised this through the TMBG. This study focused on the dimension of Specialisation, which is based on the premise that every practice, belief or knowledge claim is about or orientated towards something and by someone. Consequently, this sets up an epistemic relation [ER] to the object (what knowledge is being studied and how it is obtained - knowledge structures) and a social relation [SR] to the subject, author or actor (who is studying

the particular knowledge-knower structures). Notably, LCT Specialisation subsumes Bernstein’s knowledge codes as it uses the concepts of classification and framing to examine the strengths of the epistemic and social relations. As shown in Figure 4, each relation can exhibit relatively stronger (+) or weaker (-) classification and framing, and consequently the strengths between the relations generates four principal legitimization codes of Specialisation.

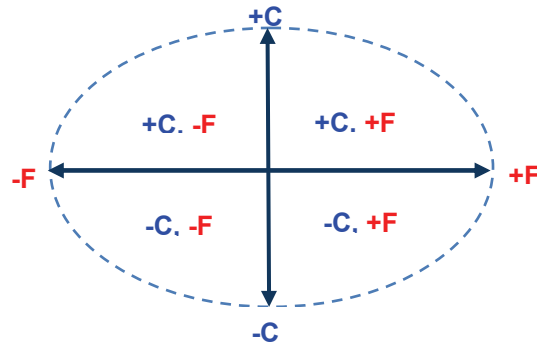


Figure 3: Knowledge codes (Adapted from Bernstein (2000))

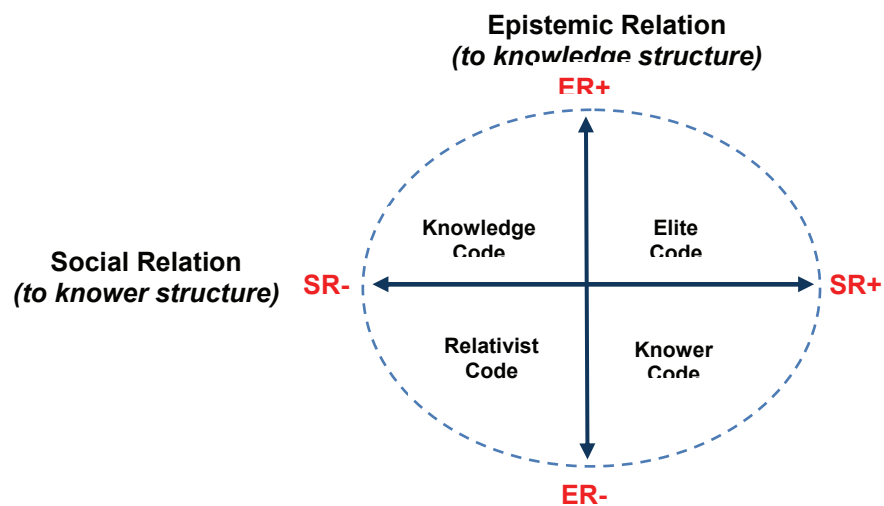


Figure 4: Legitimation codes of specialisation (Adapted from Maton (2014: 30))

Of importance, Dental Technology students’ perception of knowledge is central to LCT in terms of demonstrating possession of specialist knowledge (knowledge code); attributes and dispositions (knower code); both (elite code); or neither (relativist code). The specialisation code of the discipline would thus have a direct influence on the appropriateness of games as an alternate pedagogy because if the game is to enhance access to the epistemology it needs to align to the knowledge-knower structure of that epistemology.

2.3 Validity and reliability

In the experimental phase, content validity ensured that the survey focused on concepts and constructs that emerged from the review of literature on games. The internal consistency of the survey was assessed through Cronbach’s alpha. After the students played the game and completed the survey, a debriefing session followed. Debriefing, together with the video recordings and digital images, was used to enhance the validity of the students’ opinions. Trustworthiness of the qualitative results and inferences was corroborated by the use of a peer examiner during the student focus group discussions. Methodological and data triangulation techniques further aided in strengthening the reliability of the study.

3. Results and discussion

To supplement the analysis of the perceived efficacy of the TMBG, the null hypothesis proposed was:

H_0 : Students will not acquire epistemological access to Tooth Morphology through the board game.

It is worth noting the direction of the differences in student performances in Table 2, particularly the mean values of the pre- and post-test results. The 2-tailed t-tests revealed that students' performance improved significantly after playing the TMBG ($p < 0.05$). The alternate hypothesis (H_1) was therefore accepted, as results suggest that students acquired access to morphological knowledge through the TMBG. The overall reliability of the survey was acceptable ($\alpha=0.794$).

Table 2: Hypothesis test results-TMBG

TMBG	2009	2010	2011
Mean: Pre-test	44.95	58.89	50.89
Mean: Post test	49.80	72.76	84.19
p-value	0.037	0.000	0.000

From the rotated varimax Factor Analysis, the average loading of items per theme was above the acceptable Eigen values (> 0.5). Overall, 95.65% students indicated that the TMBG enabled them to access the content knowledge that was relevant to their study (Graph1). The following written student comments further support this:

"Helped me learn different morphological concepts".

"It had contents that are very important to understand morphology, for example, the ability to distinguish between 1st and 2nd molar".

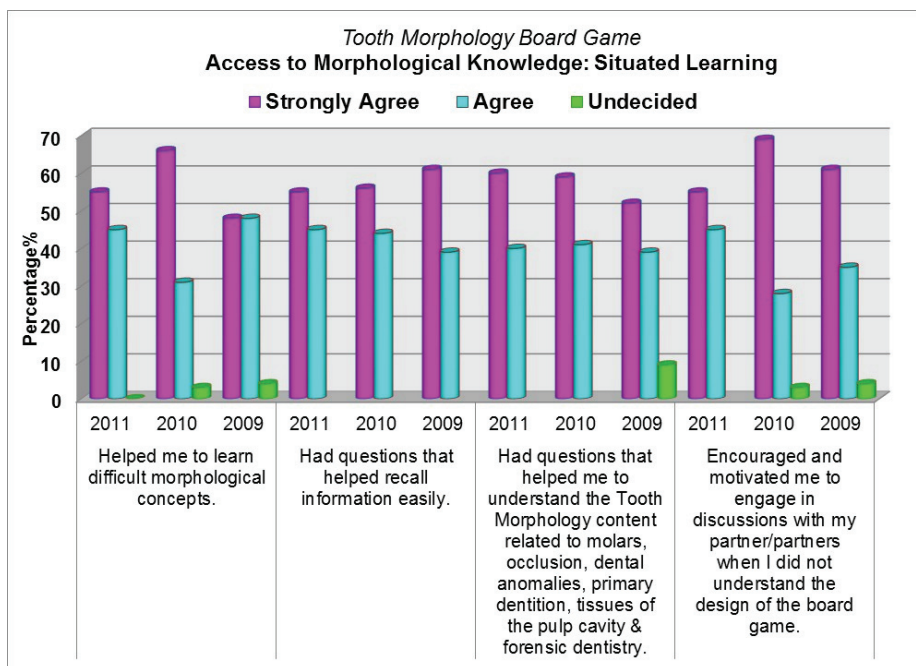


Figure 5: Access to morphological knowledge – situated learning

Consistent with Lean *et al.* (2006: 230), it can be inferred that the key elements of the TMBG involved interaction within a predetermined morphological context. Students maintained that the game: *"had questions that assisted with recalling the information easily"* and *"encourages me to engage with the material"*. From an instructional design perspective, and as is shown from Figure 6, 90% of the students agreed that while they were able to get help from the instructor 75% of them did not necessarily need this assistance.



Figure 6: Instructional design - lecturer's guidance

From Figures 7 and 8, the predominantly positive student responses on the perceived effectiveness of the TMBG suggests that the use of applicable game tools (cards, models and playing tokens) and attractive colours enhanced an understanding of the multiple choice questions. This finding can be supported by Beylfield and Struwig (2007) and Girardi *et al.* (2010), who noted that creative game design elements served as a bridge to access knowledge in a playful way.

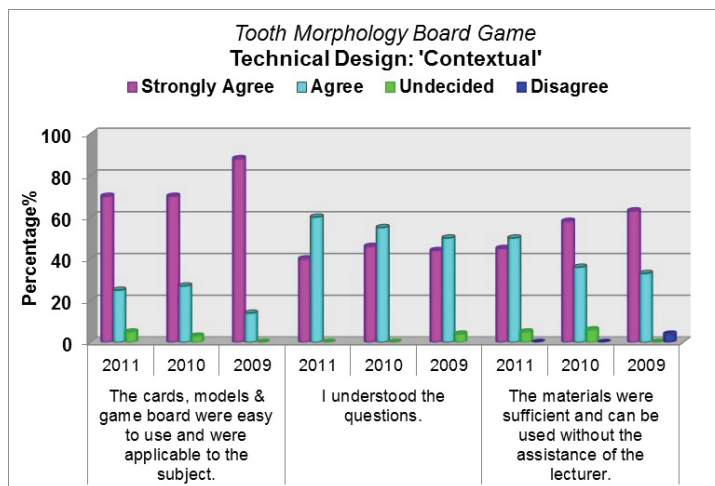


Figure 7: Technical design – contextual

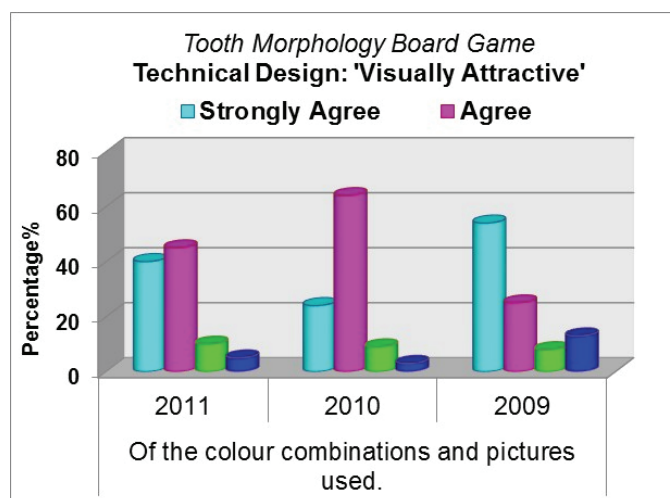


Figure 8: Technical design - visually attractive

Qualitatively, and in line with Dental Technology being typified as a region, classification manifested in the study as the strength of boundaries between theoretical (know-why) knowledge and practical (know-how) knowledge of Tooth Morphology. Many of the students said that they could see the games: *“help to connect theory to practice”*. Students generally agreed (comment below) that they could recognise the morphological content of the TMBG as it was relevant to the professional field of Dental Technology:

“Every profession requires you to have a certain amount of knowledge and understanding in order for you to get into that profession, so it’s important for us to have the knowledge of our teeth and, um, the way you use your knowledge to manufacture the different appliance...”

A consistently recurring theme in the data was the role of the lecturer in framing the game. Students perceived that the lecturer, as the game designer of the TMBG, controlled the selection, sequencing and pacing of content knowledge through the design elements of the game. Students clearly and enthusiastically indicated that the lecturer’s knowledge strongly framed (selecting and sequencing) the game:

“The game covers morphology, dentition...basically, the structure of how tooth morphology is brought to us, it’s perfect. It is encouraging because...our lecturer knew her work.”

Students positively conveyed that the design of the games enabled the lecturer to arrange and deliver the subject content of Tooth Morphology in a highly structured way:

“For your lectures it’s more about organisation, the structure, the presentation, your organisation...in the games made learning easier.”

They also felt that by professionally making the content explicit in the games, the lecturer motivated them to understand the value of the morphological and anatomical content in the context of Dental Technology:

“The lecturer...all I can say is tooth morphology was laid in our memories in a professional manner...if it was not for that lecturer I don’t think I would have been here...”

Students generally agreed that to win the game depended on their knowledge of Tooth Morphology. The pace was set by the game itself, as each person or team had a turn and they had to proceed according to this structure.

Connected to and in support of the analytical results of the quantitative phase, students also reported that they not only recalled morphology concepts but that they could see the connection of the morphological knowledge to laboratory practice:

“I remembered it from the game – I thought of it Curve Wilson, uh, Spee, and then from the game it came back...”

Three overarching themes emerged, namely: (1) the games promoted access to morphological knowledge; (2) the guidance of the lecturer was crucial in person and through the design of the games; and (3) the learning was fun and challenging. With regard to the first two themes, students accessing knowledge through games emerged in terms of them: following a pre-determined sequence of learning; keeping pace by aiming to win; and seeking to correctly understand content knowledge. In addition, and as declared by the students, having prior content knowledge and the lecturer’s instructional guidance were considered to be valuable resources in the facilitation of legitimate knowledge. Students concluded that by designing the games the lecturer engaged them to learn morphological content. This further suggests that students experienced a hierarchy (strong framing) in the pedagogical relationship that was augmented by the strong selection and sequencing of the content, as noted above. Moreover, the design of the games also critically enabled students to access discipline-specific knowledge. The descriptions of accessing morphological knowledge and using their notes to learn indicate that students experienced successful learning through games as they accessed legitimate knowledge. Noticeably, the focus groups included very little data related to social relations. Instead, the data valorised knowledge over knowers as students predominantly reported that:

“You have to have an idea of a background of morphology...to be able to play the game and enjoy the game.”

Although the students valued the social nature of learning through the TMBG, they did not strongly perceive the TMBG as developing any particular dispositions or set of lenses or gaze (Maton 2014). The TMBG was therefore regarded as exhibiting a relatively weak SR to the knower. The weaker focus on social relations is steered by the design of the TMBG which foregrounds the object (knowledge) and backgrounds the subject

(knower). Most significantly, what this shows is that the TMBG is aligned to the nature of the target subject and to Dental Technology as a whole, which is a knowledge code with stronger ER and weaker SR.

4. Conclusions

The use of pedagogical games is generally described in the literature as having a positive impact on learning because it leads to increased student engagement. The quantitative data indicated that the TMBG did indeed lead to increased student participation and also provided epistemological access to key morphological knowledge. We have argued that it was the alignment of knowledge and knower structures of the TMBG (ER+, SR-) with the knowledge and knower structures of the target subject that is a central explanation for the positive quantitative results in this study. The qualitative analysis revealed that the students' experiences of learning through the TMBG gave access to specialist knowledge and skills. This is more important to legitimate participation in the TMBG than the possession of personal attributes and dispositions because for Dental Technology the basis of specialisation is an extensive grasp of morphological knowledge that is appropriately presented in professional practices. The design of games for other target subjects therefore needs to take into account the knowledge and knower structures of such subjects.

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