High Educ (2016) 71:781–790
DOI 10.1007/s10734-015-9956-9

# Linking the 'know-that' and 'know-how' knowledge through games: a quest to evolve the future for science and engineering education

**A. Vahed**[1] · **S. McKenna**[2] · **S. Singh**[3]

Published online: 5 April 2016


**Abstract** This paper responds to Muller's notions of 'knowing-that' and 'knowing how'. The paper addresses how educational interventions that are designed in line with targeted discipline-specific subjects can enhance the balance between professional practice and disciplinary knowledge in professionally accredited programmes at universities of technology. The context is a Dental Technology programme at a University of Technology in South Africa. Teaching through discipline-specific games, conceptualised from a game literacies perspective, is proposed as an engaging, interactive pedagogy for learning disciplinary knowledge that potentially encourages access to a particular affinity group. The authors use concepts from Bernstein and Maton to investigate whether epistemic relations or social relations are emphasised through board and digital games designed for two Dental Technology subjects. This paper offers valuable insight into alternative pedagogies that can be adopted into science, technology, engineering, and mathematics education with the aim of paving a pathway towards Muller's Scenario 3.

**Keywords** Discipline-specific games · Dental Technology · Specialisation codes · Epistemological access

✉ A. Vahed
anisav@dut.ac.za

S. McKenna
S.McKenna@ru.ac.za

S. Singh
shalinis@dut.ac.za

[1] Department of Dental Sciences, Dental Technology Programme, Durban University of Technology (DUT), Ritson Campus, P.O. Box 1334, Durban 4001, South Africa

[2] Centre for Higher Education, Research Teaching and Learning (CHERTL), Rhodes University (RU), Grahamstown, South Africa

[3] Department of Operations and Quality Management, Faculty of Management Sciences, Durban University of Technology (DUT), ML Sultan Campus, P.O. Box 1334, Durban 4001, South Africa

This special issue is about what it means to be educated in science and engineering in higher education in the context of increased specialisation of knowledge, rapidly changing technology, and ongoing inequity in educational access and success. One way of teasing this out further is to look at the Universities of Technology (UoTs), where the objective is to connect the *episteme*, or know-that knowledge, and *technê*, or know-how knowledge, in response to, and fulfilment of, the needs of industry, community, and society (Gillard 2004, p. 36). Within the South African higher education arena, UoTs emerged through the restructuring and merging of technikons with a focus and ethos distinctive from their former selves and from traditional universities (Council on Higher Education 2006). Along with preparing graduates for the world of work (du Pré 2006), UoTs focus on technology with an emphasis on teaching and scholarship, innovation, research, and development. Consequently, and as described by Winberg (2005), the epistemology of Technology in UoTs is '…about theorising how different knowledge production functions, how work-based knowledge is different from academic knowledge, or how work and academic systems might productively interact' (p. 197). UoTs therefore aspire to train students with knowledge that takes into account the nature of technology and how it relates to the concept of a career-focused education. Many science and engineering lecturers, however, are confronted with finding the appropriate balance between training students for professional practice and educating them in the subject matter.

As Barnett (2006) argues, connecting workplace activity and disciplinary knowledge does not occur linearly; instead, it involves the crossing of various boundaries between bodies of knowledge, languages, people, and identities. This is a real tension as the crossing of boundaries shifts away from what Muller (2015) describes as scenario 1 that is traditionalism, where the focus is on content, towards progressivism, or scenario 2, where the focus is on 'practice' as skill, competence, or performance. Consequently, and as Muller (2015) points out in his think piece, there is a tendency to '…get stuck with an over-socialised and undifferentiated conception of knowledge as activity' (p. 412). From a UoT perspective, and as argued by Boughey (2010), the nature of applied knowledge is more than just the application of knowledge to practical contexts. She elaborated that applied knowledge and applied learning need to be appropriately conceptualised and contextualised in UoTs. Failure to do so will inevitably be to the detriment of students as they would then be unable to call on principled knowledge to adapt to frequent changes occurring in the workplace. To explore scenario 2 further, this paper uses an analysis of the Dental Technology games to focus on the specialisation of this laboratory practice within the faculty of Health Sciences at the Durban University of Technology (DUT). In particular, this article demonstrates how two differently structured subjects, Oral Anatomy and Tooth Morphology, were recontextualised into a digital game and board game, respectively. This paper also navigates the extent to which games foreground the recognition and realisation rules (Bernstein 2000) for students to speak and act appropriately within Dental Technology, and whether they are able to communicate such knowledge to others in the same context. Describing Dental Technology therefore provides a suitable point of departure for this paper.

The Dental Technology diploma programme at DUT trains students to become dental technicians who fabricate removable intra-oral dental appliances in a dental laboratory. This implies that a distinctive characteristic of Dental Technology is that it has both theoretical (or know-why) and practical (or know-how) knowledge. Drawing on Bernstein (2000), Dental Technology is typified as a region as it occupies the interface between multiple singular knowledge structures (organised as academic disciplines) and the field of external practice. This means that knowledge from its original form has been selected and placed into a new context, hence the term 'recontextualisation'.

For example, the specific learning outcome for Oral Anatomy is to acquire and apply scientific knowledge of anatomical concepts (Dental Sciences Department 2013). In particular, students need to acquire knowledge on the structural and functional anatomy of the muscles of mastication and facial expression (the intellectual field of the discipline) in relation to Dental Technology laboratory practice (the field of external practice). This is recontextualised from the singular disciplines of human anatomy and physiology to only that aspect of Oral Anatomy pertinent to Dental Technology. Similarly, the specific learning outcome for Tooth Morphology is to acquire and apply scientific knowledge of morphological concepts (Dental Sciences Department 2013). Once again, this is recontextualised from the singular discipline of human anatomy to only that aspect of dental anatomy relevant 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).

Bernstein (2000) maintained that work in a laboratory does not proceed only by a mechanical regulation of the procedures but also relies on acquiring a developed sense of the potential phenomenon arising out of practice. Wheelahan (2007), extending on Bernstein's work, asserted that students need to learn the systems of meaning instead of learning isolated and unconnected contents of disciplinary knowledge only. She further clarified that students should not only have an understanding of their disciplinary knowledge restricted to the level of events and experiences. This supports the argument of Muller's (2015) scenario 2 that there is a tendency to foreground an '…over-socialised and undifferentiated conception of knowledge as activity' (p. 412) or 'the technologies that mediate them' (p. 411), while backgrounding the specialised knowledge base. Equally significant, and analogous to the Science and Engineering courses aligning to the legal requirements of the Engineering Council of South Africa (*ECSA*) (Technology Programme Accreditation Committee 2013), there are also professional standards to be met for Dental Technology. This means that the university provision is subject to accreditation by a professional body, the South African Dental Technicians Council (*SADTC*). *SADTC* is clear that in conjunction with delivering an education within a specific framework, UoTs must educate and train students in line with the requirements of the relevant profession (South African Dental Technicians Council 2011). As is typical of regions, this shows Dental Technology has a strong focus on the profession. Furthermore, since there is a set curriculum with no electives, students enter a prescribed progression path. Regions have weakly classified subjects that are generally strongly framed, as the pace and order in which students acquire knowledge is centrally controlled with little room for individual negotiation on the curriculum.

In Maton's (2014) terms, Dental Technology represents a knowledge code. This means that the basis of achievement embodied by course outlines and assessments emphasises specialised knowledge, skills, and practices and downplays students' attributes or dispositions. The question that follows is to what extent is anatomical and morphological knowledge valued through games. Or are agent-centred experiences more valued than specialist knowledge, a concern expressed by Muller (2015) with regard to scenario 2. A discussion on game literacies is therefore necessary, as it is an underpinning concept that offers a nuanced perspective on games facilitating the provision of specialist knowledge.

## Game literacies

The way knowledge and technology converge in games such as board, computer, video, or mobile refutes the conventional idea that literacy is a universal technical skill focused on print decoding and encoding. Extending on the work of New Literacy Studies (Cope and Kalantzis 2000; Barton et al. 2000; Brandt and Clinton 2002; Street 2003), Gee (2003, 2007, 2010) considers games as sites for studying emerging literacies. Together with other educational theorists and researchers (Shaffer and Gee 2005; Squire and Giovanetto 2008; Mills 2010; Aarseth 2005), he argued that game literacies include a constellation of literacy practices that can potentially help students, particularly from culturally and linguistically different backgrounds, to prepare for life in an information/knowledge-rich economy. For example, in the Madison 2200 digital game, Shaffer (2005) demonstrated how teaching and learning through this game made his students develop ways of reading, thinking, and understanding the subject matter that are distinctive of their discipline. This game enabled his students to have enriching experiences as urban planners. It can therefore be gleaned that by creating experiences that mimic the professional practice, games can situate players in their professional roles. From a game literacies perspective, this supports the argument that games transcend traditional views of print and book-based literacies and provide students with an alternate teaching space in which to learn.

Furthermore, game scholars (Coiro et al. 2008; Gee 2003; Jenkins et al. 2009; The New London Group 2000) have intimated that another dimension of game literacy is multimodal literacy. They describe this literacy genre as using different modes of communication, such as visual, audio, spatial, and gestural modes, to enrich, augment, and modify words. Jenkins et al. (2009) reported that multimodal literacy does not displace printed texts with images. Instead, it develops more complex vocabulary for communicating ideas that require students to be equally adept at reading and writing through images, texts, sounds, and simulations. Multimodal literacy also includes interacting with multimedia and digital texts. In particular, Gee (2003) posited that games are multimodal texts that operate within a semiotic domain. He defined this as any set of practices that recruit one or more modalities, such as oral or written language, images, equations, symbols, sounds, gestures, graphs, artefacts, and others, to communicate distinctive types of meanings. Significantly, multimodal literacy enhances situated learning that is the ability to associate a concept or word with specific images, actions, experiences, or dialogue, in ways that enable one to apply the word/concept in specific contexts to solve problems or accomplish goals. For instance, Gee (2007) typifies the Supercharged! game as a specific game developed to help students learn electrostatic physics. He uses this game to illustrate where the game succeeds, where it does not, and how to understand this in educational terms. In the game Supercharged! students explore electromagnetic mazes by piloting a spaceship that has the power to adopt the properties of charged particles. They build their conceptual understandings of electrostatics by working through a series of maze-based levels where each level contains obstacles common to electromagnetism texts. This includes points of charge, planes of charge, magnetic planes, solid magnets, and electric currents. Consequently, and as initially reported by Squire et al. (2004), students, particularly lower achieving students, developed better conceptual knowledge of electric fields and the influence of distance on the forces that electrical charges experience. They also showed improved understandings of why representations in their textbooks appeared the way they did. Subsequently, Squire (2005, 2008) proposed that discipline-specific games situate students to recall experiences, and challenges, that are part of game design and game play. This enabled them to gain improved understanding of fundamental discipline-specific concepts.

For Gee (2003, 2007, 2010), the association of students in a given semiotic domain is described as an ‘affinity group’. He explained that irrespective of race, class, socio-economic status, or background, students have an affinity for the content of a domain and are likely to share endeavours with regard to that content. This is consistent with Paideya and Sookrajh’s (2014) study on student engagement through supplemental instruction (SI) sessions, which aimed to increase performance and retention among engineering students by engaging them with their Chemistry discourse. They described SI sessions as being cognitive, physical, and safe cultural spaces that helped students to relate, create, and reflect on how they ‘get to know what they know’ about Chemistry. SI sessions closely compare to affinity spaces as they enable students, from diverse backgrounds with differing academic abilities and secondary school experiences, to develop deep interest and engagement in Chemistry, as well as to interact in groups with others who share common interests. Arguably, the concepts of affinity group and semiotic domain offer a different perspective with which to look at classrooms and other learning sites. Essentially, these underpinning concepts could potentially empower lecturers to help students prepare for future learning, as well as to solve problems within, and sometimes outside, the specific domain of science, technology, engineering, and mathematics (STEM).

It is evident from the research work of the aforementioned authors, particularly Gee (2008a, b, 2010), that games have the potential to immerse players into an environment that is engaging, challenging, fun, and most importantly, educational. In particular, these authors explain that the ability to decode information is analogous to the ability to acquire knowledge. From a game literacies perspective, to be able to decode information is also akin to being able to play a game and to participate in the social and communicational practices of play. This suggests that teaching through games facilitates an engaging and interactive environment for students to discuss, understand, and learn subject-specific knowledge. Having foregrounded the concept of game literacies, the subsequent section provides an analysis of the Dental Technology games. In particular, to determine whether an emphasis on knowledge or knower was made through the Tooth Morphology board game and Oral Anatomy multimedia game.

## Legitimation code theory: specialisation

Maton’s (2014) conceptual framework named Legitimation Code Theory (LCT) brings the structure of the knower into the analysis. He argues that disciplinary knowledge practices may contain assumptions about who may become a legitimate knower, as well as their impact 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’. Access to knowledge is thus understood as students’ acquisition of such languages and the extent to which they legitimately understood this. Hence, the dimension of specialisation was used, which is based on the premise that practices and beliefs are about or orientated towards something and by someone. They thus take account of relations to objects and to subjects. The first is the epistemic relations [ER] to the object or in Maton’s term what knowledge is being studied and how is it obtained. The second is the social relations (SR) to the subject, author, or actor, that is who is enacting the practices.

The LCT dimension of specialisation extends and integrates Bernstein’s notions of pedagogic codes as it uses the concepts of classification and framing to examine

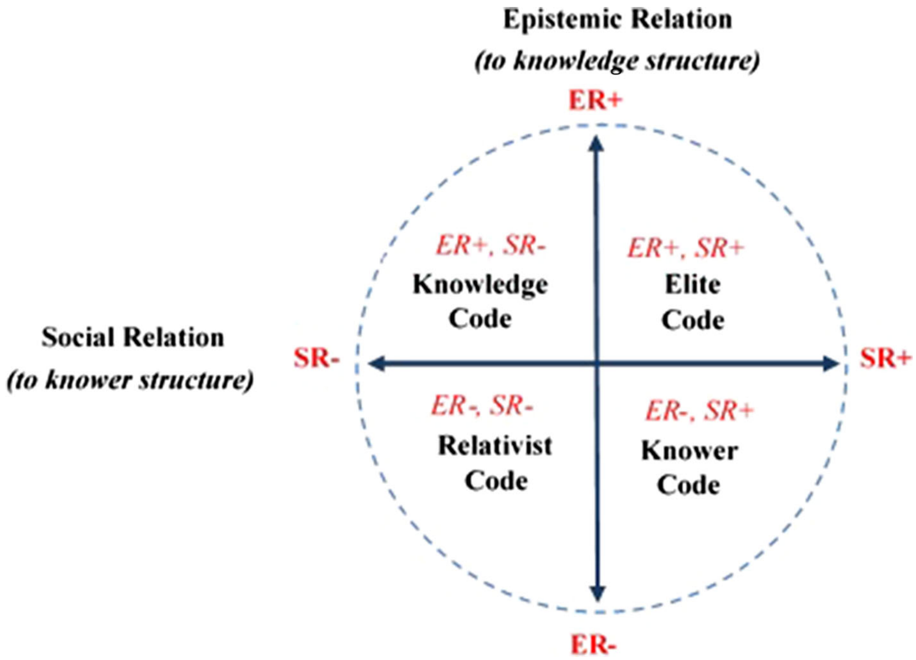


**Fig. 1** Specialisation codes of legitimation (adapted from Maton 2014)

boundaries around and control over not only knowledge (epistemic relations) but also knowers (social relations). As illustrated in Fig. 1, ER and SR can be relatively stronger (+) or weaker (−), and consequently the strengths between the relations generate four principal legitimation codes of specialisation: 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 should 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. The legitimation codes conceptualise the 'rules of the game' (Maton 2014), which is the basis for successfully navigating social contexts.

The next section reports on the qualitative analyses where the framework in Fig. 1 was used to analyse data generated over a 3-year period (2009, 2010 and 2011) through twelve focus groups ($n = 82$), each of which included between 8 and 12 students. Trustworthiness of the qualitative results and inferences were corroborated by a peer examiner during student focus group discussions. The aim is to provide an in-depth theorised account of how the Tooth Morphology board game (TMBG) and Oral Anatomy multimedia game (OAMG) supported the provision of epistemological access. A key aspect of the analysis is the language (words) that the students used to describe what knowledge and procedures (ER) or disposition (SR) is valued in Tooth Morphology and Oral Anatomy, or in Dental Technology, overall. We have, where applicable, used identifiers such as TM and OA to link the quote to the Tooth Morphology board game and Oral Anatomy multimedia game, respectively. All student quotations are given verbatim.

## Qualitative study: specialist knowledge versus agent-centred experiences

Generally, feedback from the focus groups showed more emphasis on epistemic relations and an absence of social relations, which represents a knowledge code (ER−, SR+). Students predominantly reported that the instructional and technical designs of the games promoted epistemological access. Inevitably, this encouraged them to be part of a particular affinity group. By following a predetermined sequence of learning Tooth Morphology and Oral Anatomy through the games, as well as using their notes, the games enabled students' access to legitimate morphological and anatomical knowledge. This is supported by the student responses below:

> …Practical it's also important to remember morphology and anatomy, so I think the games should still be available to us if we want to remember most of the things in morphology – you can go play the game and remember. (TM)
> Important that we know all the muscles that are in the oral cavity so that when we're manufacturing an appliance for a patient we won't go beyond the tissues…. (OA)

In turn, students recognised the value of the discipline-specific content to the professional practice 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 appliances….

Significantly, and as declared by the students, the lecturer's knowledge in designing the games allowed the discipline-specific content to be arranged and delivered in a highly structured way:

> It shows that this game was designed by a very intelligent person, inciting a very generous idea, it's helpful, it's educational and it's well done. I can say I was so amazed and I was shocked that there could be such games in terms of tooth morphology and muscle…. (TM and OA)

Students maintained that the lecturer's knowledge strongly framed the game such that the selection, sequencing, and pacing of content knowledge were controlled by the lecturer through the design elements of the game. The design of the games also set the pace at which students progressed. For example, in the Tooth Morphology board game, each team had a turn to answer, and the game proceeded in this manner until a team won. Consequently, learning became competitive, fun, and challenging. This is evident by the following student excerpts:

> A fun way of learning…most of us are not English first language … so it not easy to pick up some words, so in the game you can repeat the word, it's easy to understand. (TM)
> …Muscle Mania does give me stages, so while you're playing the game you want to reach the second stage, the fun stage, so it makes it more interesting and more like important for you to like know your work and then go in the further – third stage. (OA)

It can further be gleaned from the aforementioned students' responses that the challenge and competitive elements underlining the concept of fun learning made the students feel they were accessing valued knowledge. The lecturer was considered to be a valuable resource in the facilitation of legitimate knowledge.

Overall, the data indicate that the games represented a knowledge code (ER+, SR−), as specialist knowledge and skills were more valued rather than there being an emphasis on the possession of personal attributes and dispositions. This knowledge code of the games aligns to the knowledge code of the target programme. Indeed, learning through games may have little to do with increasing factual recall or the ability to choose correct answers. Instead, and as exemplified by the students' accounts, games potentially made complex knowledge accessible to all the students, most of whom were English additional-language speakers, and it assisted them to participate in discipline discourses. This will more likely increase their understanding that morphological and anatomical concepts are a precondition to fabricating removable dental appliances.

It is worth noting that the stronger ER and weaker SR of the two games analysed here should emphatically not be the goal of all game design. The games in this study were found to have a knowledge code, and this is aligned to the target discipline knowledge in Dental Technology. This, however, would be entirely inappropriate in a discipline where a particular gaze on the world is what is legitimated in the discipline. Legitimation Code Theory (specialisation) allows us to understand that epistemological access entails access to the knowledge-knower structures of that particular discipline. The aim of any pedagogical intervention is thus to provide access to the code of that discipline, be it a knower code; an elite code; a relativist code; or, as in the case of this study, a knowledge code.

In light of the above, it can be concluded that the games essentially foreground knowledge and background the attributes of the knower (or student). Ultimately, the basis of specialisation for Dental Technology is to have an extensive grasp of morphological and anatomical knowledge that is appropriately presented in professional practice. Hence, and as this study indicated, in order for learning to occur the knowledge and knower structure of the target subject needs to be considered when designing educational games. After all, and as a student aptly described:

> There's this Chinese proverb that I once learned that says 'Teach me and I'll forget, show me and I might remember, involve me and I will understand' so now with these games you are more involved in these games, you get an understanding of what you've learnt. You are not just sitting and reading and answering questions about you, you're applying your knowledge, so that in that way you're understanding what you are doing, all right. (TM and OA)

## Summary

Overall, this paper presented an understanding of how discipline-specific games enriched learning and enabled students' access to, and acquisition of, content knowledge underpinned by morphological and anatomical principles. Consistent with Muller's (2015) think piece, alternative formats such as games can afford students the opportunity to recall and learn complex highly specialised content and its application to laboratory practice. Potentially, this could lead to 'a more robust scenario 3' (p. 415). The future of STEM education looks promising as the recognition and realisation rules of content-specific subjects can be made clearer through discipline-specific games, which are '…better equipped to negotiate the specialising future' (Muller 2015, p. 415).

**Acknowledgments** The financial assistance of the National Research Foundation (DAAD-NRF) towards this research is hereby acknowledged. Opinions expressed and conclusions arrived at are those of the authors and are not necessarily to be attributed to the DAAD-NRF.

## References


Aarseth, E. (2005). Game: Studies: What is it good for? *The International Journal Digital Median and Arts Association Journal, 1*(3), 1–82.

Barnett, M. (2006). Vocational knowledge and vocational pedagogy. In M. Young & J. Gamble (Eds.), *Knowledge, curriculum and qualifications for South African further education* (pp. 143–158). Cape Town: HSRC Press.

Barton, D., Hamilton, M., & Ivanic, R. (Eds.). (2000). *Situated literacies: Theorising reading and writing in context*. London: Routledge.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity: Theory, research, critique* (Revised ed., Vol. 5). Maryland: Rowman & Littlefield Publishers Inc.

Boughey, C. (2010). *Analysing teaching and learning at the Universities of Technology: A tribute to Terry Volbrecht.* Paper presented at the RITAL conference, Cape Peninsula University of Technology.

Brandt, D., & Clinton, K. (2002). Limits of the local: Expanding perspectives on literacy as a social practice. *Journal of Literacy Research, 34*(3), 337–356.

Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (Eds.). (2008). *Handbook of research on new literacies*. New York: Routledge, Taylor & Francis Group.

Cope, B., & Kalantzis, M. (Eds.). (2000). *Multiliteracies: Literacy learning and the design of social futures (Literacies)*. London: Routledge.

Council on Higher Education. (2006). *KAGISANO: Universities of Technology*. Pretoria: CHE Press.

Dental Sciences Department. (2013). *Dental technology: 1st year study guide*. Durban: Durban University of Technology.

du Pré, R. (2006). The philosophy of a University of Technology in South Africa: An introduction. In Council on Higher Education (Ed.), *Kagisano Issue No 5* (pp. 1–23). Pretoria: Vaal University Press.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave MacMillan.

Gee, J. P. (2007). *Good video games + good learning: Collected essays on video games, learning and literacy*. New York: Peter Lang Publishing Inc.

Gee, J. P. (2008a). Being a lion and being a soldier: Learning and games. In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of research on new literacies* (pp. 1023–1036). New York: Routledge, Taylor & Francis Group.

Gee, J. P. (2008b). Learning ecologies. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 21–40). Cambridge: MIT Press.

Gee, J. P. (2010). *New digital media and learning as an emerging area and "Worked Examples" as one way forward*. London: MIT Press.

Gillard, E. (2004). *Considerations on the designation and nomenclature of higher education institutions*. Pretoria: CHE Press.

Jenkins, H., Purushotma, R., Weigel, M., Clinton, K., & Robieson, A. J. (2009). *Confronting the challenges of participatory culture: Media education for the 21st century* (p. 146). Cambridge, Massachusetts: MIT Press.

Maton, K. (2014). *Knowledge and knowers: Towards a realist sociology of education*. London: Routledge.

Mills, K. A. (2010). A review of the "Digital Turn" in the new literacy studies. *Review of Educational Research, 80*(2), 246–271. doi:10.3102/0034654310364401.

Muller, J. (2015). The future of knowledge and skills in science and technology higher education. *Journal of Higher Education, 70*(3), 409–416.

Paideya, V., & Sookrajh, R. (2014). Student engagement in chemistry supplemental instruction: Representations of learning spaces. *South African Journal of Higher Education, 28*(4), 1344–1357.

Shaffer, D. W. (2005). Epistemic games. *Innovate, 1*(6).

Shaffer, D. W., & 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*, 1–18

South African Dental Technicians Council. (2011). Designing an education for life after university. http://www.sadtc.org.za. Accessed 30 March 2011

Squire, K. (2005). *"Game-Based Learning": An x-learn perspective paper*. Wisconsin-Madison: Masie Center e-Learning Consortium.

Squire, K. D. (2008). Video-game literacy: A literacy of expertise. In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of research on new literacies* (pp. 635–669). New York: Routledge, Taylor & Francis Group.

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). Electromagnetism supercharged! Learning physics with digital simulation games. In Y. B. Kafai, W. A. Sandoval, N. Enyedy, A. S. Nixon, & F. Herrera (Eds.), *The sixth international conference of the learning sciences: Embracing diversity in the learning sciences Mahwah*. New York: Lawrence Erlbaum Associates.

Squire, K., & Giovanetto, L. (2008). The higher education of gaming. *E-Learning, 5*(1), 2–28.
Street, B. (2003). What's "new" in new literacy studies? Critical approaches to literacy in theory and practice. *Current Issues in Comparative Education, 5*(2), 77–91.
Technology Programme Accreditation Committee. (2013). Policy for the accreditation of Engineering Technology programmes. In ECSA (Ed.): ECSA.
The New London Group. (2000). A pedagogy of multiliteracies: Designing social futures. In B. Cope & M. Kalantzis (Eds.), *Multiliteracies: Literacy learning and the design of social futures* (pp. 9–37). London and New York: Routledge.
Wheelahan, L. (2007). How competency-based training locks the working class out of powerful knowledge: A modified Bernsteinian analysis. *British Journal of Sociology of Education, 28*(5), 637–651. doi:10.1080/01425690701505540.
Winberg, C. (2005). Continuities and discontinuities in the journey from technikon to university of technology. *South African Journal of Higher Education, 19*(2), 189–200.