Use of the Collaboration-Authentic Learning-Technology/Tool Mediation Framework to Address the Theory–Praxis Gap

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Abstract To develop a practical solution to learning with technology a collection of case studies related to the use of education games, a course and a professional development opportunity are discussed. Each case study is presented to explore the use of a collaborative-authentic task–tool (technology)-mediated (CAT) framework. This framework is based on neo-Vygotskian ideas of learning. The case studies on the use of games in education show how collective solving of a game puzzle helped overcome misconceptions held by players. A course on the use of ICTs in teaching and learning, based on the CAT framework, showed that student performance was superior to didactic instruction courses. Academic professional development based on the CAT framework illustrates new ways in which higher education models could be devised. In many of the case studies, the concept of tool mediation is easily misunderstood and therefore requires appropriate scaffolding of the learning activities by the lecturer or teacher. This collection of case studies supports the idea that the use of the CAT framework is a practical way to design teaching and learning with technology.

Keywords Collaboration · Authentic learning · Tool mediation · Learning with technology

1 Introduction

With every new technological innovation comes a promise of a transformed educational practice. But the most practiced form of education is still learning through acquisition (teachers deliver information to students) (Laurillard 2012). This is particularly true in learning designs that use online systems, such as Learning Management Systems (LMSs) (Reeves et al. 2004) and Massive Open Online

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Course (MOOC) systems, which typically replicate traditional classroom instruction practices. These positivist learning designs foreground information, content and technical issues rather than social cognitive development. In addition, the use of technology as the panacea to solve all teaching and learning problems rather that an emphasis on the appropriate pedagogical use of technology in the classroom is a universal problem (Amiel and Reeves 2008). There are other ways that technology could be used in learning task design, for example, through the affordances offered by educational technologies.

Affordance was first coined by Gibson (1977) while developing an "ecological" approach in opposition to cognitive approaches and "refers to the perceived and actual properties of a thing, primarily those functional properties that determine just how the thing could possibly be used" (Pea 1993 p. 51) To create effective and usable computer systems Norman (1988) suggested that a number of affordances could be considered during software design, including visibility, constraints, affordances, natural mappings, and feedback. Conole and Dyke (2004) made use of Pea's definition to explore how the affordances of educational technologies could be articulated into a taxonomy, and how the understanding of such affordances might be used to support learning and teaching. These authors suggested that a taxonomy of educational technological affordances include accessibility, speed of change, diversity, communication, collaboration, reflection, multimodal and nonlinear, risk and uncertainty, immediacy, monopolisation, and surveillance. Also, "affordance descriptors are meant to offer an example as to the fundamental, pragmatic, and functional level at which affordances should be identified in order to be suitable for matching to the affordance requirements of various learning tasks" (Bower 2008, p. 6)

Educators do not universally accept the uses of affordances. Ecological positions need to be considered as cultural context that influence the understanding of the affordances (McGrenere and Ho 2000). Furthermore, the affordance concept has become too ambiguous to be of analytical value and the animal–object relationship over evolutionary scale might have little relevance to moment-to-moment individual interactions unless "we are willing to abandon constructivist values in order to explore 'inherent properties' in a positivistic sense" (Oliver 2005, p. 412). The use of technology may have nothing to do with its design or affordances, but may be due to our individual belief systems, often cognitive and reductionist, of what constitutes teaching and learning (Amory 2007). However, we can re-conceptualise teaching and learning with technology within a social reform model of education, emphasising our social nature of learning within and as part of our communities (Savin-Baden 2000; Stetsenko 2008, 2004). Knowledge should rather originate *out of* social practice that includes cultural tools, *through* social practices of tool exploration and inquiry, and *for* social practice (Stetsenko 2013). The work presented here aligns with the Cultural Historical Activity Theory (CHAT) (Engeström 1987; Leont'ev.1978) predicated on the social constructivist learning theories of (Vygotsky 1978, p. 19). The Collaborative-Authentic Learning-Technology/Tool Mediation (CAT) framework (Amory 2014), which is aligned to Laurillard's conversation model (2012), is presented and then used as a heuristic to evaluate the use of technology in teaching and learning.

2 The Cat Framework

A number of important themes are part of Vygotsky's (1978) theory of child development. Social development precedes individual development. The child learns everything twice: first on the social (between people—interpsychological) and then on the individual (inside the child—intrapsychological) plane. In addition, Vygotsky defined the zone of proximal development as the distance between the actual and potential developmental levels determined through problem-solving under the guidance of more knowable teachers and peers. Social network analysis research shows that participation in learning communities improves academic performance (Gašević et al. 2013; Rizzuto et al. 2009), persistence (Thomas 2000), retention (Eckles and Stradley 2012), and creativity (Dawson, Tan, and McWilliam, 2011; Perry-Smith and Shalley 2003). Thus, collaboration is the first component of the CAT framework.

For meaningful learning to take place, the object of the activity, the most important component of activity theory (Kaptelinin 2005), needs to be clearly defined, as it is the prime unit of analysis in an activity system (Engeström 2001). In support of (Iverson et al. 2008), Amory (2014) posited that effective learning designs include authentic learning tasks (Brown et al. 1989; Newmann et al. 2001; Reeves et al. 2004; Smeets 2005) and could be viewed as the *object of the activity*. Brown et al. (1989) suggested that situated cognitive apprenticeships included collective problem-solving, displaying multiple roles, confrontation of ineffective strategies and misconceptions, and developing collaborative work skills as part of authentic activities. Means and Olson (1994) argued that within authentic environments technology has the power to support both students and teachers to solve complex problems. Building on the concepts of situated cognition, Herrington and Oliver (2000) posited that instructional designs that include educational technology should make use of authentic learning environments. In addition, Smeets (2005) proposed that for the learning environment to be successful it should include rich contexts, authentic tasks, active, autonomous learning and co-operative learning. Therefore, in the CAT framework, the object of activity is an authentic learning task.

Lastly, a core component of Vygotsky theory is that interaction with the social and physical world is mediated by tools that are either physical (such as pencils and technological artefacts), or psychological *signs* and *symbols* (especially language). Tools are object-orientated to material activity, while signs and symbols are part of social and intrapersonal interaction used to solve problems (that is, part of higher cognitive functions). But depending on the context, a material tool could function as a tool, a sign or both—all artefacts could therefore be seen as both material and conceptual, as parts of our world, modified over historical time, and shaped by human activity (Cole, 1996). In addition, tool mediation can either be explicit (the intentional introduction of a tool, or sign, into an existing activity) or implicit (involves signs, especially language) (Wertsch 2007). In the CAT framework, educational technology should always function as a mediating tool (a learning *with* technology position) and never be the object of the activity (a learning *from* technology position).

Table 1 Collaboration-authentic task—tool mediation (CAT) framework

Collaboration	Authentic learning		Tool/Technological
• We learn from each other • Social media connects us • Together we create new ideas, connections and products • Course facilitators create environments for social change	• Have real-world relevance • Are ill-defined • Are complex • Provide opportunities to examine from different perspectives • Provide opportunity for collaboration	• Provide opportunity for reflection • Are integrated across different subject areas • Are integrated with assessment • Yield polished products • Allow for competing solutions and outcomes	• Information stream • Enabler of communication • Empowering collaboration • Information transformation tool • Professional tool

Therefore the CAT framework includes three components: collaboration to support interpsychological interactions and intrinsic mediation, authentic tasks as the object of the activity, and technological tools to support explicit and implicit mediation (Table 1). The authentic learning tasks are based on the work of Reeves et al. (2004) rather than the more recent conceptualisation by Herrington, Reeves and Oliver (2009), who describe the system using more abstract concepts, thereby making the concept more difficult for inexperienced lecturers.

Depending on the objectives of a study, case studies can be divided into three types: intrinsic case studies that investigate the uniqueness of the cases, instrumental case studies that are concerned with advancing theory, and collective case studies that make use of any number of cases as part of an instrumental case (Stake 1995). A collective case study approach is taken here to evaluate the use of the CAT framework in educational technology in learning and teaching. A number of case studies allied to the CAT framework are explored to show that the use of appropriate theoretical approaches to learning design can address issues related to learning from technology (instruction) and overcome the theory–praxis problems often associated with online or e-learning.

3 Case Studies

Case studies reported here include a number of examples of the use of educational games in teaching and learning, an honours course on educational technology for teachers and a professional development workshop for academic faculty staff members.

3.1 Educational Games as Authentic Learning Tasks

Overcoming misconceptions through game play was a primary theme of much of research done by my students and myself into the use of technology in teaching and learning. Adams (1998) used an instrument where each question included three parts: multiple-choice factual question, multiple-choice reason for answer, and confidence level.

After one hour of playing an adventure game (Zadarh) Adams found that there was no improvement in student understanding of misconceptions related to photosynthesis and respiration, and suggested students needed to change their learning strategy for any improvement to be realised. Extending this work, Foko and Amory (2004) worked with small groups of students in northern KwaZulu-Natal who played on their own (as was the case with the work done by Adams), played in groups with discussion between the players and facilitator for 8–10 h and then took either a written or oral test (Table 2).

Students who played with a partner overcame many of the misconceptions the game was designed to address (increase in the number of correct answers) and more so with the support to improve their understanding of the instrument item. These results clearly indicate the game puzzles, acting as the authentic tasks, support student understanding of photosynthesis and respiration when they played together. Social dialogue and solving puzzle mediated knowledge construction.

A second study investigated how young Sowetans (14–18 years old) played a game on the biology of important diseases including HIV/AIDS and tuberculosis (Amory 2010). As in the previous example, the adventure game narrative was driven by authentic puzzle-solving activities. The young Sowetans played in groups of three or four participants that included both sexes with facilitator support for 10 h over a number of days. All participants completed the game except one group who insisted on playing on their own.

During game play, participants kept a personal reflective journal and after game play they answered an instrument designed to determine the misconceptions related to the diseases and participated in a round-robin discussion. Statistical analysis of their questionnaire answers showed that these young school students performed in a similar manner to first-year university biology students and better the first-year non-biology university students (Table 3). Analysis of their journals and group discussion illustrated that they understood that solving the game puzzles mediated

Table 2 Playing Zadarh to overcome misconceptions related to photosynthesis and respiration (from Foko and Amory 2004)

Treatment	Correct answer (%)	Correct reason (%)
Individual play—written evaluation	57.9	28.4
Group play—written evaluation	75.0	42.5
Group play—oral evaluation	90.5	50.0

Table 3 Performance by teenagers measuring their understanding of the biology of a number of diseases after game play compared to first-year university students (from Amory 2010)

Group	Mean score ± SD (%)		
Teenage participants	57.1	±	8.9[a]
First-year biology students	61.4	±	10.2
First-year non-biology students	37.6	±	8.1[a]

[a]Significant difference, t test = −7.982, DF = 116, $p < 0.001$

their learning, allowed them to identify the object of the activity (learning about diseases) and suggested ways in which they might help their community.

In a third example, third-year B.Ed. students (n = 184) were introduced to the theories related to authentic learning and an object-tool-social framework (a simplified versions of the CAT framework) (Amory 2011). They played the same game (biology of important diseases) in pairs as one of the course's authentic tasks. The students were told to find four cards and four keys to solve the final game puzzle, to think about the motives related to the playing of the game (identification of the object of the activity) and to analyse their actions using the object-tool-social framework. Students submitted a portfolio for their final examination assessment and were asked to select three of the 11 course authentic tasks to demonstrate what they had learnt in the course. Their performance in a number of the authentic tasks, and the relationship between their performances in these tasks and the tasks they selected for their portfolio were quantitatively analysed (Table 4). Their written submissions on the game play task and their examination portfolio submissions were quantitatively analysed deductively against the object-tool-social framework to gain insights into what they learned through their game play.

Based on the post hoc test, which did not assume equal variance, the means were clustered into two general groups, the chapter review exercise belonged to both

Table 4 Performance by third-year students in course work authentic tasks and examination portfolio tasks. Column 1 lists authentic task, column 2 lists the per cent of group a choosing specific task as relevant for their learning, column 3 lists the average percentage obtained by the group for the task, column 4 the standard error, column 5 the statistical similarity in performance of the different tasks (ANOVA $F = 22.61$, $p < 0.001$; Levene = 13.71, $p < 0.001$; Post hoc test = Tamhane; from Amory 2011)

Authentic task	%	Mean	SE	Group
Test	4.0	72.0	1.7	1
Computer LAN	16.4	69.2	1.2	1
Education game	8.2	65.3	1.2	1
Interactive whiteboard	19.2	64.9	1.2	1
Chapter review	7.8	63.1	1.9	1, 2
Authentic learning	13.6	56.0	1.4	2
SA classroom design	10.8	55.3	1.4	2
Classroom design mind map	14.2	49.0	1.1	2
Other	6.0			2

groups. Students who understood the theories associated with authentic learning and object-tool-social concepts scored higher for these tasks (group 1) and were more likely to select these tasks for their portfolio (for example the educational game task). Content analyses revealed that students were able to identify the object of the activity, but also made reference to tool mediation, collaborative learning and authentic tasks. However, a single student realized that the primary object of the activity was to "evaluate [the] game for learning". Pre-service teachers demonstrated that they understood the importance of social interactions is undertaking authentic tasks and solving game puzzles. In addition, they understand tool mediation. For them, an interaction with game puzzles led to knowledge construction.

The construction of education games that include authentic story lines and puzzles allows collaborative tool-mediated knowledge construction. This is especially true when the game puzzles are designed to address specific misconceptions or conceptually challenging content areas. These examples illustrate that the design of educational games that include authentic activities (game puzzles) mediated learning in small and large groups of students. However, what is important in these situations is the role of the teacher, or facilitator, who scaffolds and supports students in their collaborative explorations. More specifically, discussions between game players intrinsically mediated their understanding; the games, puzzles and game artefacts supported knowledge production as they function as mediating artefacts and not as the object of the activity; and the introduction of games puzzles into a learning activity acted as the extrinsic mediator. Likewise, a CAT framework designed course that includes a number of related activities supports collaborative tool-mediated knowledge construction.

3.2 Course Design

Amory (2014) used an educational design approach (McKenney and Reeves 2012) to develop a course on the use of Information Technology and Communication in teaching for Bachelor of Education (Honours) students. The course included ten 2-h contact sessions and required the students (district officials and teachers) to spend at least an additional 180 h on assignments. The course included five authentic tasks:

- Evaluation of the school's e-maturity-output: a Google document;
- Use of tools available to support the development of e-maturity-output: a Google presentation;
- Exploration of the knowledge, skills and attitude of current learners-output: a MindMap diagram);
- Use of Open Source, Open access and Open resources in teaching and learning-output: a Weebly web site; and
- Plan for a future education system-output: a StoryBoard document.

Tools used to create assignment outputs ranged from the familiar (Google documents) to the unfamiliar (StoryBoard). Each task required a group submission followed by a class discussion. The final summative portfolio required each student to provide a brief introduction on what they thought they had learnt, a selection of three of two or three assignments that they could improve to take into peer and lecturer comments, and provide a critical review of the course. Results reported included student opinions on the course, an assessment of the course using the authentic learning principles and an analysis of their performance.

Students liked finding relevant information, thought that it was important to work in groups but wanted to select who was part of the group, and thought they learnt more at the end of the course than they expected (Table 5). But, in contradiction, they also wanted additional lectures and more reading materials to be provided.

Except for reflection, all the components of authentic learning were rated highly by the participants (Fig. 1). Students did not seem to appreciate that the discussion of each topic in class and the detailed comments made by the lecturer were part of reflective activity. In addition, they thought that there was insufficient emphasis placed on the production of the polished product. However, they appear not to understand that the portfolio was the primary instrument for reflection and an opportunity to produce improved work.

A 1 x 3 repeated-measure analysis of variance (RM-ANOVA) was applied to test for significant differences between the final examination results of three different courses (educational ICT, research methodology, and education theory) (Table 6). The educational ICT and research methodology courses were similar in design and made use of authentic tasks while the education theory was a didactic lecture course. Amory (2014) found from a pairwise comparison that the education ICT and research methodology courses were significantly different to the education

Table 5 Analyses of students (n = 27) to a number of statements on the design and delivery of the ICT course (from Amory 2014)

Item	Rating
Finding information for myself is a good way to learn[a]	5.36 ± 0.18
Working in groups supported my learning	5.05 ± 0.32
Working in groups is effective	5.00 ± 0.27
By the end of the module, I learnt more than I expected[a]	4.82 ± 0.28
I also learnt from information that other students found	4.77 ± 0.25
I did not like the way the module was presented in the beginning, but I am now comfortable with it[a]	4.27 ± 0.35
I would prefer to be given all my learning materials[a]	3.95 ± 0.35
I think the lecturer should have taught more[a]	3.86 ± 0.35
I would have preferred that the classes were more structured	3.41 ± 0.35
The lecturer should decide who are in groups[a]	1.91 ± 0.27

[a]Wilcoxon significance <0.005 (compared to results from a 2007 group)

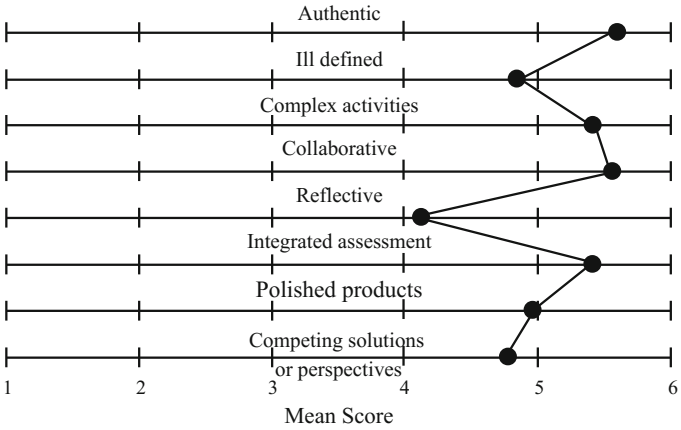

Fig. 1 Student assessment of the authentic task design principles (redrawn from Amory 2014)

Table 6 Descriptive analysis of different honours courses (mean ± standard deviation; from Amory 2014)

Course	Final mark
Educational ICT	60.73 ± 10.66
Research methodology	56.07 ± 16.48
Education theory	50.07 ± 11.33

theory course ($p < 0.0001$ and $p = 0.006$, respectively) and that the educational ICT and research methodology courses were similar ($p = 0.25$).

This case study illustrates that collaboration allied to authentic tasks and technological tools mediated new understandings. The introduction of authentic learning was challenging for students who are used to the didactic lecture but with time they come to prefer the approach. More importantly, courses that include components of authentic learning lead to improved performance and student attitudes to learning. The last case study explores how academic staff members responded to a professional development opportunity based on the CAT framework.

3.3 Academic Professional Development

This case study is concerned with the professional development of academic members from a South African University in the use of technology in their teaching, learning and assessment practices (Amory 2013). In this institution, learning was conceptualised as: becoming a practitioner of a knowledge and professional domain; that information-oriented (recitation of information) approaches limit optimal learning; and ICT should extend contact teaching in innovative and digitally rich ways (Amory et al. 2008). However, prior to 2012, professional

development in the use of ICT in teaching, learning and assessment was limited to training (a learning *from* technology approach). The use of the CAT framework to support professional development fostered a new approach (a learning *with* technology approach). The workshop included two authentic tasks. Participants acted as students (authentic task 1) and then as learning designers (authentic task 2). During the workshop the participants created a number of artefacts, including the use of a CAT framework instrument to review a number of papers on the pedagogy associated with the use of games in teaching and learning, the design of a learning task, and an evaluation of the workshop. Participants also used the data from the games evaluation exercise to create graphs and a mind map as part of the first activity. Their learning designs were analysed by Amory (2013) deductively using the CAT framework.

The participants were able to use the CAT framework instrument (tool mediation) to identify pedagogical practices, plan learning activities and evaluate the workshop. However, explicit and implicit mediation involving either tool or sign were not fully appreciated. The use of ICT as tool mediator was mostly limited or superficial. Participants found the workshop challenging but of the 29 comments received, while two were negative and two dealt with administrative issues, the rest were positive, for example:

> An insightful workshop that helps us understand how simple changes to thought and application can help in getting students to learn something old in a new way.

> I loved the workshop! I so much appreciate the departure point of authentic learning, focused on skills and perspective, rather than content. I enjoyed the engagement, and the discussions at the end. Maybe mid-way through the workshop a discussion session would be useful.

4 Discussion

The case studies selected for this chapter explored the effective use of the CAT framework as a heuristic to understand the use of games to overcome misconceptions, to design and present a fourth-year course to education students, and to design a professional development for academic staff members. The primary aim was to show how collaborative engagement with authentic tasks mediated by educational technologies can support learning and overcome the theory–praxis divide. In addition, the examples highlight how the use of ICTs can enrich teaching in innovative and digitally rich ways. These collective case students support declarative and procedural design principles based on the work of Amory (2014). The declarative principles include, knowing that:

- Cultural Historical Activity Theory supports course design and evaluation;
- Authentic learning tasks promote effective learning; and
- Educational technology (as tools) mediates knowledge construction.

The following procedural principles apply:

- Use the CAT framework as a heuristic to conceptualise game puzzle, course and workshop design and evaluation;
- Implement authentic learning tasks as the object;
- Incorporate educational technologies as tools to facilitate knowledge construction (a learning *with* technology position);
- Reject course designs when education technology functions as the object (a learning *from* technology position); and
- Use the CAT framework as a device to evaluate learning activity or course design.

The question that these collective case studies attempt to answer is that based on appropriate theoretical foundations a practical framework can support the creative use of technology to support collaborative learning rather than supporting recitation of information as a means of knowing.

Herrington and Parker (2013) suggest that complex authentic tasks can be designed but require a substantial amount of effort by collaborating students. Also, emerging technologies should be included in authentic tasks as a social cognitive tool, in other words to support tool-mediated knowledge construction. They also point out that for such an approach to succeed it requires a commitment from lecturers and teachers to provide scaffolding and support, which is a significant task.

Likewise, the use of authentic learning allied with profession development requires considerable effort to transform teaching from a didactic information distribution paradigm to one that makes use of authentic tasks (Teras and Herrington, 2014).

The use of technology to mediate (as a cognitive tool) collaborate problem-solving (authentic) tasks, the CAT framework, provides a practical approach to addressing the theory–praxis divide.

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Author Biography

Alan Amory is currently employed by Saide and is a Visiting Professor at the University of the Witwatersrand. He joined the Centre for Academic Technologies, University of Johannesburg, in 2012, after working in the Faculty of Education from November 2007. Before that, he spent a brief sojourn as acting Chief Director for Education Support Services at the Gauteng Department of Education, Johannesburg, South Africa. Previously Alan worked in the Biology Department of the University of Natal for 15 years before he was employed as the Director of the Centre for Information Technology in Higher Education at the University of KwaZulu-Natal, Durban, South Africa, where he and a small team supported the academic community in the use of educational technology. Alan is the principal author of the open learning system (OLS) developed at and used by the University of KwaZulu-Natal that in 2005 obtained the Technology Top 100 Qualifier Award for the University, the first University in South Africa to be identified as a technologically innovative company. Alan was the recipient for of the prestigious South African Government's Innovation Fund Award to investigate the use of computer video games in learning, which has been recognised as pioneering work in the field.