EXPLORATION OF A TECHNOLOGY-ALIGNED FRAMEWORK TO SUPPORT 21ST CENTURY TEACHING AND LEARNING

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ABSTRACT
The work presented here develops a framework that integrates cultural-historical activity theory (C), authentic learning (A), and six potential roles of technology (T) in teaching and learning. Five individual case studies on the use of technology in teaching and learning are reviewed against the CAT framework. In adventure games, the embedded puzzles and core content acted as the extrinsic mediator and the discussions between players intrinsically mediated their knowledge construction. Artefacts of mass media, such as games, software and other media, supported knowledge production when they functioned as the tools and not as the object of the activity. The Vygotskian concept of social tool-mediated dialogical knowledge construction is therefore an appropriate framework for the use of games/media in teaching and learning.

KEYWORDS
cultural-historical activity theory; authentic learning; educational technology; mediation; knowledge construction

INTRODUCTION
The main objective of this paper is to highlight and discuss the use of a theoretical framework to support the use of technology and contemporary media in teaching and learning. Both residential and distance education systems today make extensive use of learning management systems (LMS). However, the design of LMS may, in part, constrain innovative, collaborative and interactive learning (Reeves, Herrington & Oliver, 2004).

In many instances the design of LMS foregrounds content (Finger & Jamieson-Proctor, 2009), focuses on technical issues (Dutton, Cheong, & Park, 2004), makes use of commodified learning content (Amory, 2010a), concentrates on information (content) rather than the learning process (Paulsen, 2003) and replicates traditional instructional practices (Blin & Munro, 2008; Browne, Jenkins, & Walker, 2006; Dutton et al., 2004; Yueh & Hsu, 2008). Amiel and Reeves (2008) argue that the technology should never be a unit of learning, but should rather form an integral part of a learning process. However, the design of an LMS is not the only problem faced by teachers. During both formal instruction (Reid, Dawson & Forster, 2006) and teaching practice (Larose, Grenon, Morin & Hasni, 2009) teachers found it difficult to integrate technology and media into their teaching practices. For example, when pre-service teachers designed text-based web quests and PowerPoint presentations, they focused on lower-order thinking skills and failed to understand the ideological dimensions that are inherently part of all media (Reid et al., 2006).

All media are created using symbols and signs that are not politically neutral, objective or illustrative of a balanced position, and that are often used to maintain and reproduce dominant cultural values (Torres & Mercado, 2006). Mitchell (2008), in discussing McLuhan's “the medium is the message”, suggests that contemporary media theory is driven by an obsession with war machines, coercion, aggression, surveillance and propaganda. Gibson (2008), however, argues that the ways in which we use media, and therefore all content, determine their meaning or message.

This paper investigates how media (content), educational technology and interactive learning environments can be integrated into learning designs that support the current dominant pedagogical paradigm – learning as a sociocultural dialogic activity.
Vygotsky (1933/1978). Furthermore, the paper briefly describes the framework referred to above and then reviews examples to highlight important aspects.

THE FRAMEWORK
The framework makes use of cultural-historical activity theory (C), authentic learning (A) and potential roles of educational technology (T) in teaching and learning.

Vygotsky (1933/1978) argues that learning is never direct, but is instead always mediated by cultural and psychological tools. Through tool-mediation, we learn about our world and thereby learn to master ourselves and the world around us. This Vygotskian subject-object-tool triad was expanded by Engeström (1987) to include rules, the community, and division of labour to better understand human activity and work as explained below (Figure 1). Core concepts associated with socio-cultural dialogic activity include the object of activity, social interactions and mediation.

![Figure 1. Activity system diagram (redrawn from Engeström, 2008)](image)

The object and associated actions are central to activity theory (Engeström, 2008). However, as Kaptelinin (2005) observes, different meanings are associated with the object: the term objekt refers to material things that exist independently of the mind (that is, something to be realised), and predmet is a thought or an action (that is, the object of desire). The motive behind the activity is not the object, and when we instantiate an object, we formulate it and realise an object when we reach an outcome (Nardi, 2008).
Socio-cultural interactions are fundamental to cognitive development, and every function in a child's cultural development appears twice: first between people (inter-psychological) and second inside the child (intra-psychological) (Vygotsky, 1933/1978).

Psychological and cultural tools play an important part in the mediation of knowledge construction. According to Wertsch (2007), mediation includes two formulations: explicit, that is, the intentional introduction of a stimulus into an ongoing stream of activity – this is obvious and non-transitory; and implicit, making use of signs, especially language, the primary function of which is communication.

Therefore, within the activity framework we need to consider two components more carefully. First, the design of a learning activity needs to consider an easy-to-use approach to the design of the object of the activity (the design of the learning actions). Second, the role of technology and media/content in the system needs clarification. Amory (2012) suggests that authentic learning could help in the description of the object of the learning activity, and proposes a number of ways in which technology could be used in such a system.

According to Reeves et al. (2004), learning environments should include authentic tasks that:

- have real-world relevance;
- are ill-defined and include a number of subtasks;
- are complex and require students to undertake complex investigations;
- provide opportunities for students to investigate the tasks from different perspectives;
- provide collaborative and reflective opportunities;
- integrate across different subject areas;
- include integrated assessment;
- yield possible products that include more than one iteration; and
- allow competing answers or solutions.

Technology can play different roles within the system and includes:
• as information stream: the delivery of learning resources and other necessary information pertinent to learning, research, and administration (for example, medical images needed for a case study).
• as enabler of communication: the use of both synchronous (real-time) and asynchronous (any-time) communication modes.
• as enabler of collaboration: the use of collaborative authoring and other online services to support co-authorship and co-construction (for example, Google Docs allows several authors to write and edit documents synchronously).
• as information transformation tool: information transformed from one, or many, information streams to alternative streams (for example, the development of a storyboard from a written novel).
• as professionalisation tool: the use of technological tools associated directly with a profession (for example, the use of computer-aided design software by architecture students).

MATERIAL AND METHODS
Case studies, depending on the aim of a study, can be divided into three types: intrinsic studies, which investigate the uniqueness of the cases; instrumental studies, which are concerned with advancing theory; and collective studies, which make use of any number of cases as part of an instrumental case (Stake, 1988). The study reported on made use of a collective case study approach to evaluate the use of the object-tool-social framework in the use of video games in learning and teaching. The unit of analysis for the individual cases was pre-service teachers’ understanding of the use of video games in the classroom. The unit of analysis of the collective case was to build theory on how to use video games in teaching and learning. A review of five individual case studies (Creswell, 1998) was used in this study. These cases entailed:
• students from a rural school playing a game to overcome misconceptions related to photosynthesis and respiration (Case 1);
• orphans from Soweto playing an interactive game to learn about diseases (Case 2);
• third-year BEd students playing a game to design a learning intervention (Case 3);
postgraduate certificate in education (PGCE) students playing a game to overcome misconceptions related to Mendelian genetics (Case 4); and education students at honours level undertaking a number of authentic tasks in learning how to use technology in the classroom (Case 5).

RESULTS AND DISCUSSION

Case 1

Table 1. Performance of grade 11 students in overcoming misconceptions related to photosynthesis and respiration

<table>
<thead>
<tr>
<th></th>
<th>Individual play (n=19)</th>
<th>Playing in pairs (n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Answer</td>
<td>Reason</td>
</tr>
<tr>
<td></td>
<td>57.9%</td>
<td>31.9%</td>
</tr>
</tbody>
</table>

Two groups of grade 11 students from Qhakaza High School played an adventure game that attempted to rectify misconceptions related to photosynthesis and respiration (Table 1) (Foko & Amory, 2008). After playing on their own (individual play), participants understood only 31.9% of the concepts. During gameplay it was noticed that those participants who could not solve the game puzzles learnt the answers by rote from those who were able to solve the puzzles. In addition, some participants had difficulty understanding the English test instrument. The second group then played in pairs, and a subgroup could ask for clarification of the language. Playing together and asking for language clarification led to improved test scores (50%).
Case 2

**Table 2.** Performance of teenagers in understanding the biology of a number of diseases after gameplay compared with first-year university students

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Score ± SD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teenage participants</td>
<td>57.1 ± 8.9**</td>
</tr>
<tr>
<td>First-year biology students</td>
<td>61.4 ± 10.2</td>
</tr>
<tr>
<td>First-year nonbiology students</td>
<td>37.6 ± 8.1**</td>
</tr>
</tbody>
</table>

** significantly different, $t_{test}=7.982$, DF=116, $p < 0.001$

Participants (orphans from Soweto ranging in age from 14 to 18 years, $n = 12$) played an adventure game related to the biology of diseases, including HIV/AIDS and tuberculosis. They were divided into groups of 3 members, and played the game for 10 hours (Table 2) (Amory, 2010b). Knowledge gained was determined after gameplay and compared with the performance of first-year biology and non-biology students. One group preferred not to work together, and was the only group not to complete the game. Results indicated that participants' scores were similar to those of the first-year biology students.

Case 3

Third-year BEd students ($n = 184$) played an adventure game to explore an object-social Vygotsky framework (Table 3) (Amory, 2011). Participants played in pairs. For the examination, participants were required to submit three of the semester tasks they found most useful in their own personal development.

**Table 3.** Performance by third-year students in course work, authentic tasks and examination portfolio tasks
An analysis of participant portfolio results (Table 3) indicated that some found playing the educational game to be of value. In the analysis of the reasons for this choice they argued that they learnt better when they played together, and some were able to identify the primary object of the activity as being to “evaluate [the] game for learning”.

**Case 4**

**Table 4.** Evaluation of misconception related to genetics held by PGCE students before and after gameplay

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean Score ± SD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>29.8 ± 4.7**</td>
</tr>
<tr>
<td>Post-test</td>
<td>44.4 ± 6.5**</td>
</tr>
</tbody>
</table>

** significantly different, t-test=-3.69, p < 0.001

Life science PGCE students (n = 11) divided into pairs played an adventure game designed to rectify misconceptions related to Mendelian genetics (Table 4) (Amory, 2011). A pre- and post-test investigation showed that after gameplay their understanding of difficult Mendelian genetic concepts had nearly doubled. In addition, the participants understood that the game puzzles acted as a device (tool) to facilitate discussion between the members of the team, and in that way mediated learning.

**Case 5**

While all the previous examples made use of complex adventure games as tools to mediate knowledge construction, this case made use of a number of authentic tasks,
core readings and software tools as part of an education course at honours level. The authentic tasks included:

- the evaluation of e-maturity at a school (report written using Google Docs);
- presentation to the school board on software tools to support e-maturity (Google presentation);
- a mind map on the knowledge, skills and attitudes of current students (FreeMind);
- a website on the use of open source, open access and open content materials in schools (Weebly); and
- a film script on the design of a future educational system (storyboard).

At the end of the semester, participants were asked to rate the authenticity of the course (Amory, 2012). In addition, their performance was reported in comparison to similarly (research methodology) and dissimilarly (education theory) designed courses.

![Figure 2. Student assessment of the authentic task design principles](image)

Participants rated all the authentic attributes of the course, with the exception of reflections, highly.

**Table 5. Descriptive statistics for different courses**
A 1 x 6 x 3 repeated measure analysis of variance tested for significant differences between three different courses (educational ICT, research methodology, and education theory). The pairwise comparisons indicated that the education ICT and research methodology courses differed significantly from the education theory course (p = 0.0001 and p = 0.006 respectively) and that the educational ICT and research methodology courses were similar (p = 0.25).

CONCLUSIONS
Three conclusions can be drawn from the research reviewed here:

- The introduction of game puzzles, core reading and appropriate software into a learning activity acted as the extrinsic mediator, while the discussions between players intrinsically mediated their understanding.
- Artefacts, such as games, media, and software, supported knowledge production when they functioned as the tools and not as the object of the activity.
- The Vygotskian concept of social tool-mediated dialogical knowledge construction is an appropriate framework for the use of games and media in teaching and learning.

These findings support the design of learning objects as part of an activity for delivery in both residential and distance education systems.

REFERENCES


