Author(s): Pöysä-Tarhonen, Johanna; Care, Esther; Awwal, Nafisa; Häkkinen, Päivi; Ahonen, Arto

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Tracking student teachers' technology-enhanced collaborative problem solving: Combining objective assessment data with subjective verbal reporting

Johanna Pöysä-Tarhonen, University of Jyvaskyla, johanna.poysa-tarhonen@jyu.fi
Esther Care, University of Melbourne, e.care@unimelb.edu.au
Nafisa Awwal, University of Melbourne, n.awwal@unimelb.edu.au
Päivi Häkkinen, University of Jyvaskyla, paivi.m.hakkinen@jyu.fi
Arto K. Ahonen, University of Jyvaskyla, arto.k.ahonen@jyu.fi

Abstract: In spite of increasing interest, technology-enhanced formative assessment practices reflecting 21st century skills are not yet much studied, particularly in teacher education context. Also, studies that combine both objective and subjective data around these practices are still rare. This study responds to these challenges in exploration of student teachers' collaborative problem solving (CPS) processes. Relevant events in CPS tasks are tracked through process data acquired via ATC21S™ portal, and complemented with students' interpretations of these processes as cued retrospective reports. The broader aim is to provide student teachers with hands-on experiences of using novel, technology-enhanced formative assessment systems for 21st century skills. It is hypothesised that familiarity with these practices will guide student teachers to be more open toward formative, technology-enhanced assessment culture as they move into professional practice as teachers.

Introduction

Despite recent policy initiatives calling for 21st century skills, such as collaboration, collaborative problem solving, communication and critical thinking, current assessment practices often only focus on students' academic outcomes (Strijbos, 2011). However, to develop 21st century skills assessment strategies should go beyond testing students' factual knowledge and capture the less concrete themes that underlie the key skills defined for 21st century learning (Binkley et al., 2012; Kong et al., 2014).

Formative assessment, as assessment for learning (Black & Wiliam, 2009; Strijbos, 2011), is seen as a key feature of the 21st century learning environments (Redecker & Johannessen, 2013). It is argued that learners need substantial, regular and meaningful feedback during the learning process, enabled by formative assessment, and teachers, in turn, need the feedback to better orchestrate the learning processes according to the evidence provided (Redecker & Johannessen, 2013). However, formative assessment in the context of 21st century skills is a challenging and time-consuming task and may therefore be facilitated with technology and instruments developed to promote such activities as collaboration (Strijbos, 2011; van Aalst, 2013). Technology-enhanced assessment tools and systems that can be used flexibly, will not burden students or teachers, and that will enable constant interchange are therefore seen vital (e.g., Griffin & Care, 2015).

As changing society sets novel demands for schools in terms of learning and assessment, teacher training programs need to reflect these changes. Therefore, to contribute to agency change in this regard, teacher education students play a central role. As teachers-to-be, it is imperative that they recognise the equal importance of academic achievements as well as 21st century skills as learning outcomes (Kong, et al., 2014). Assessment practices tend to have strong influence on the direction of student learning and influence developing pedagogical practices. When teachers-to-be gain familiarity with the novel, innovative, technology-enhanced assessment practices, it is assumed that they will be open to this new learner-centred and formative assessment culture, which they will then bring along when they enter schools as teacher graduates (Binkley et al., 2012; Kong et al., 2014).

Collaborative learning and collaborative problem solving

Even though collaboration is regarded as one of the most crucial skills for learning and is already a part of today's learning environments, the assessment practices for collaborative learning have remained relatively vague (Strijbos, 2011). Assessment practices do not always reflect collaborative learning in a way that takes into account the complexity of cognitive, social and motivational factors as they occur over the collaborative process (Kumar, Gress, Hadwin & Winne, 2010). In addition, a general set of indicators with which to assess the quality

of collaborative activities, or upon which to compare students' collaborative learning activities, is often lacking (Strijbos, 2011).

Consequently, collaborative problem solving (CPS), a specific type of collaboration, which conjoins critical thinking, problem solving, communication and collaboration (Griffin & Care, 2015; Griffin, McGaw, & Care, 2012), has received increasing interest as one of the central 21st century skills suitable for formative assessment. In short, CPS is defined as a joint activity between dyads or small groups to transform a current problem state into a desired goal state (Hesse, Care, Buder, Sassenberg & Griffin, 2015). Typically, CPS is organized through the use of directly observable verbal and nonverbal signals. That is, to work successfully, participants need to communicate, exchange, and share in the process of identifying the parts of the problem; interpret the connections between the parts and relationships between action and effect (i.e. rules); and propose generalisations in search for a shared solution (Hesse et al., 2015). This "side effect" of externalization makes CPS a visible and measurable activity, which, in contrast to individual problem solving, may make CPS a more teachable skill (Hesse et al., 2015).

Measurable CPS competency may be seen as the capacity of an individual learner to engage effectively in the joint and shared activity of problem solving. CPS skills can be divided into a set of sub-skills that comprise five broad social and cognitive capacities. These capacities may overlap between different stages of a CPS activity (Hesse et al., 2015) and include: social skills (participation, perspective-taking and social regulation), which are about managing participants (including oneself), and which refer to the "collaborative" aspect of CPS; and cognitive skills (task regulation and knowledge building), which are about managing the tasks at hand, and refer to the "problem-solving" aspect of CPS. These measurable skills are considered essential for successful CPS activity.

The assessment portal developed in the ATC21S™ project (Griffin & Care, 2015; Griffin et al., 2012) is one recent example of a technology-enhanced formative assessment approach that focuses on assessing more generic and transversal skills. The project explored new, technology-enhanced ways of assessing CPS skills and linked them to teaching interventions designed to deepen learning and move students to higher skill levels (Griffin & Care, 2015; Csapo, Ainley, Bennett, Latour, & Law, 2012). The ATC21S™ project built on the ideas of the developmental model of learning (Vygotsky, 1978); thus, its primary goal was to maximise the developmental progression of individuals' skills, such as those in CPS (Griffin et al., 2012). During the ATC21S™ project, a web-based, formative assessment portal for assessing CPS skills was developed at the Assessment Research Centre at the University of Melbourne.

In spite of increasing interest, technology-enhanced formative assessment practices reflecting 21st century skills are not yet much studied, particularly in teacher education context. Also, studies that compare methods based on objective and subjective data in this context, are still rare. This study responds to these challenges. Focus not only on the outcomes of CPS activity, but also the (collective) route to these outcomes from the learner perspective is important. Current technologies are typically inadequate to the task of analysing the contents of communication during the chat, and so the focus has been on placement (and occurrence) of chat actions in the CPS process (Care, Griffin, Scoular, Awwal, & Zoanetti, 2015). To acquire a deeper understanding of students' collaborative efforts in the course of CPS, a process-tracing method (van Gog, Paas, van Merrienboer & Witte, 2005) is proposed as a complementary method. Process-tracing methods produce data such as verbal reports, that can be applied for obtaining information that enables drawing inferences about the cognitive processes that underlie problem solving performance (Cooke, 1994; van Gog, Paas, van Merrienboer & Witte, 2005). In this study, the method is extended to cover not only the cognitive but also the social processes related to CPS.

Accordingly, the aim of this study is: (1) to compare process data acquired through the ATC21S™ portal to individual students' verbal reports on the process; and (2) to examine whether congruence between process and verbal data varies according to person and task characteristics.

Methods

Participants

The sub-study is part of a four-year research project that aims to promote student teachers' CPS and socially-shared regulation of learning (SSRL) skills and competencies as well as attitudes towards the use of ICT in teaching and learning. The research described here is an ongoing study, conducted during Autumn 2015. The participants are students (n = 20) in their second year of the four-year master-level teacher education program at a Finnish university.

Tasks

Pairs of students completed one bundle of assessment tasks of ATC21S™ portal. The bundle comprised four tasks in the science and math domains, related both to curriculum content and to generic skills. The assessment tasks are complex game-like tasks, constructed to have the characteristics of problems that require true collaboration and are related to everyday teaching and learning (Care et al., 2015). Some of the tasks are content-dependent, while others are content-free and, the tasks also vary from symmetric to asymmetric (Care et al., 2015). Specifically, the tasks are designed for a student pair (Students A and B), who are expected to communicate only through an online chat interface. In this sub-study the bundle comprised following tasks: "Laughing Clowns" and "Olive Oil", which are content-free tasks, and "Plant growth" and "Small pyramids" which are content-dependent. Laughing Clowns is a symmetric task whereas the other three were designed asymmetric. Symmetric refers to the characteristic that both students within a collaborative pair are presented with the same stimulus content and actionable artefacts within the online task space; with asymmetric referring to the characteristic that each student within a pair is presented with different information and different actionable artefacts. To complete the bundle lasted approximately 60-90 minutes.

Objective assessment data

Students' work in the ATC21S™ portal was assessed individually, with the scoring based on their actions which included movement of artefacts, and the occurrence of chat to collaborate. Students also completed a brief reflective questionnaire as part of the online process. Students' completion of the assessment tasks generated log file data. The data generated were captured in a process data file, and patterns in these data were then automatically coded as indicators of the CPS elements (i.e. social and cognitive), producing reports ("Learning readiness profiles") on students' social and cognitive skill levels (Adams et al., 2015; Hesse et al., 2015). In addition, CamStudio™ software (see http://camstudio.org) was used for the recording of all the screen activity during the CPS sessions on the ATC21S™ portal.

Process-tracing data

To obtain a subjective account on the CPS processes, the process-tracing method as cued retrospective reporting (CRR) (e.g., van Gog et al., 2005; Jarodzka, Scheiter, Gerjets, & van Gog, 2010) was used. In short, CRR is defined as a verbal reporting procedure, in which study participants are invited to verbalise their thought processes during the task performance retrospectively, based on a cue or cues of their performance (see e.g., Jarodzka et al., 2010). With verbal reporting the aim is to make explicit the CPS process in terms of students' self-monitoring of *why* and *how* they took the actions, especially as a student pair. In this study, CRR interview was cued with the activity data (i.e. mouse operations, chat discussion) recorded during the ATC21S™ portal session. The CRR sessions were videotaped. The sessions took approximately one hour.

Analysis and expected outcomes

CRR resulted in qualitative accounts as retrospective reports concerning the cognitive and social processes of CPS from the perspective of an individual student. In-depth content and process analysis under the proposed CPS framework by Hesse and colleagues (2015) is being applied to the CRR data in studying the students' interpretations of their collaborative efforts during the problem solving activity. The aim is to compare the process data obtained via the ATC21S™ portal to individual students' verbal reports on the process and analyse for congruence. Congruence findings are being interrogated with regard to CPS success of the pair and characteristics of the task. To track and make visible the shared routes of successful CPS processes and their relevant events route maps of objective assessment data acquired via the ATC21S™ portal will be notated by the subjective verbal data. It is hypothesised that there will be relatively small skill level differences across student pairs due to the strict selection procedure of the teacher education students in Finland. At the conference, final results will be presented through route maps enriched with data examples.

Conclusions and implications

As previously mentioned, the recent international trend to modify curriculum and instruction to more adequately reflect 21st century learning poses new challenges in terms of assessment. For example, instead of considering collaboration merely as a learning method, it should be seen as general human competence to be assessed in its own right (van Aalst, 2013). Together with studying the underlying processes pertaining to (successful) CPS activities of student teachers, the ongoing sub-study is expected to provide student teachers with hands-on experiences of utilizing novel technology-enhanced assessment systems for 21st century skills. From a broader perspective, it is expected that these experiences may activate teacher education students' awareness of 21st century skills and most crucially, of novel assessment practices reflecting these encounters. Since teachers in

Finland are considered pedagogical experts with significant decision-making authority in the application of core curriculum and assessment (see also Darling-Hammond, 2012), this might be a critical next step. Based on this relatively small sample sub-study, later stages in the project are being designed to accumulate data with repeated and enriched objective and subjective methods with comparable, but larger, groups of teacher education students.

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