

A Digital Formative Assessment Intervention for Cultivating Teamwork Skills

Elizabeth Koh, Yi-Huan Tee, Dhivya Suresh, and Imelda Caleon

elizabeth.koh@nie.edu.sg, yihuan.tee@nie.edu.sg, dhivya.suresh@nie.edu.sg, imelda.caleon@nie.edu.sg

National Institute of Education, Nanyang Technological University, Singapore

Abstract: Many studies have focused on problem-solving and collaborative learning, leaving out the collaboration process, which is important on its own right, especially for younger students preparing for the working world. A digital formative assessment approach, which moves away from traditional assessment approaches to emphasize visual analytics, awareness, reflection and target-setting, was developed for blended learning environments. The visual analytics were based on self and peer ratings of a domain-general, four-dimensional teamwork competency measure. To evaluate the intervention, a quasi-experiment using embedded mixed methods design was carried out with 452 Grade 8 students and 26 teachers. Findings suggest that the design principles enacted were instrumental for helping students learn and reflect more about their teamwork competency. It also improved their team behaviors in a targeted manner. This intervention has challenged the boundaries of conventional schooling and traversed domains, providing a set of effective design principles for teamwork skill development.

Introduction

Many studies have focused on problem-solving and collaborative learning, leaving out the collaboration process, which is important on its own right, especially for younger students preparing for the world of work (National Research Council, 2012). In this research, we focus on teamwork competency, conceived, as four dimensions relating to social process skills as compared to task skills (such as argumentation) required in group collaboration. A domain-general teamwork competency measure was created in terms of:

- coordination (COD) – organizing team activities to complete a task on time
- mutual performance monitoring (MPM) – tracking the performance of team members
- constructive conflict (CCF) – dealing with differences in interpretation between team members through discussion and clarification
- team emotional support (TES) – supporting team members emotionally and psychologically

Besides making clear what teamwork aspects are examined, in order to nurture teamwork skills in students, a digital formative assessment approach was developed for blended learning environments. In addition, this approach and measure were incorporated in an intervention program and carried out with 452 Grade 8 students and 26 teachers. To evaluate the digital formative assessment intervention for cultivating teamwork skills, this paper asks, “to what extent and in what ways is the digital formative assessment intervention effective in developing students’ teamwork competency?”

Digital formative assessment approach for nurturing teamwork

There has been consensus in the literature of the need to move away from traditional summative assessment towards formative assessment or assessment for learning (National Research Council, 2012; Wise, 2014). Formative assessment makes rubrics visible, provides learners timely feedback for their learning, and builds a profile of learner’s characteristics through a multi-method approach as opposed to a singular score approach that is applied in summative assessment.

While ICT tools afford real-time and rapid calculations, some summative and standardized 21st century competencies assessment tools have been used to test individuals’ collaboration with computer agents (OECD, 2017). Other studies have attempted to measure teamwork within naturalistic computer-supported settings using formative assessment tools designed with more implicit guidance. Soller et al. (2005) leveraged on the affordances of ICT to design principles for developing mirroring and metacognitive tools and guiding systems that support collaborative learning. In a study that focused on teams’ socio-cognitive and socio-emotional monitoring processes, Näykki et al. (2017) used a macro script with prompting questions during collaborative learning. In other studies that aimed to help increase awareness of collaborative behaviors, students were presented with visual analytics of peer assessment during the process of working in groups (Phielix et al., 2011).

Additionally, while group awareness of learning process is important, studies show that this awareness must be converted to other productive engagements (Järvelä et al., 2016; Phielix et al., 2011; Wise, 2014). Phielix

et al. (2011) found that peer feedback and reflection tools in a computer-supported collaborative learning environment enhanced group-process satisfaction and social performance of groups who collaborated on a writing task. Wise (2014) emphasized that pedagogical learning analytics intervention design needs to integrate the entwined four principles (Integration, Agency, Reference Frame and Dialogue) and three processes (Grounding, Goal-Setting and Reflection) to support productive learning. Self-set goals can guide learners in their learning processes and elicit self-monitoring of progress on goals. Goal-setting and monitoring go hand in hand with reflection; an essential part of constructing one's understanding to support learning. Likewise, other than gaining awareness of the learning process, Järvelä et al. (2016) suggested two other design principles for socially shared regulation of learning tools - externalizing shared learning processes and goals explicitly.

Building on these works as well as drawing from key tenets in experiential learning and collaborative learning, a digital formative assessment approach to nurture teamwork was conceived. The approach incorporates the design principles of:

1. engaging students in naturalistic computer-supported team collaboration
2. making teamwork assessment visible real-time through a visual analytic
3. encouraging social group awareness
4. providing a safe and guided space for student reflection
5. supporting student agency in teamwork target-setting and monitoring

An ICT tool was developed to support these design principles. Notably, Figure 1 displays the visual analytic of the teamwork assessment (showing self ratings, and the average of ratings from their team members) in a radar chart. This is placed beside the guided reflection space, allowing students to more easily reflect on the visual analytic. Figure 2 shows the teamwork target-setting where students could think about how to improve their behaviors, and set up to four steps for their teamwork improvement, as well as the monitoring space.

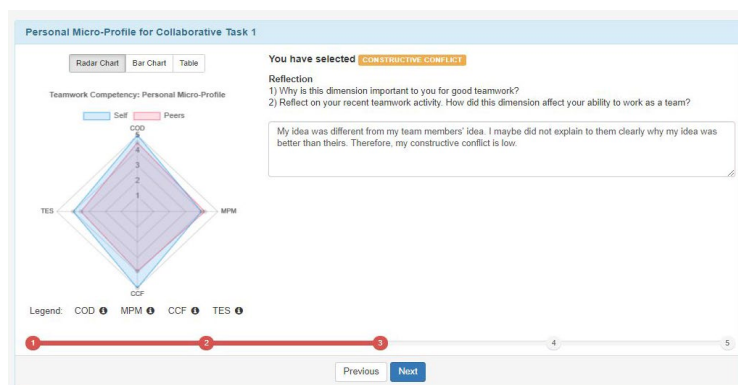


Figure 1. System screenshot of personal teamwork competency visual analytic and guided reflection space.

Figure 2. *Left.* Target-setting is represented as steps that students can type and set on the system, to a maximum of four steps, for them to have the choice to plan and carry out. *Top.* Students can provide an update of the status of their steps, to monitor their teamwork target progress.

Evaluation of the teamwork intervention

The above-mentioned approach was incorporated in an intervention program and implemented as part of the post-examination curriculum in three schools. In order to address the research question, a quasi-experiment with an embedded mixed methods design was planned (Creswell & Clark, 2017). An intervention group (Format 1) and a lagged control group (Format 2) were designed. The intervention group followed the sequence of design principles mentioned above for a team task (students were given about twenty minutes to solve an open-ended dilemma task), followed by the same design principle sequence for a second task. For the lagged group, design principles 1 to 3 were first enacted for task 1 and then task 2. After teams had completed the two tasks, principles 4 and 5 were carried out. The visual analytic was created from self and peer ratings of the four-dimensional teamwork competency measure where students rated their recent collaboration activity from 1 to 5 (strongly agree). Students were randomly allocated into 144 mixed-gender teams of three to four students within a class.

Teachers participated in a professional development (PD) workshop and implemented one of the two formats. To check if the implementation adhered to the design, the fidelity of the intervention was scored with four conditions: adherence to activity, adherence to rationales, quality of lesson (whether it was a good lesson), and student responsiveness (how engaged students were with the lesson). The teachers who conducted the session as well as the researcher who observed the session scored these fidelity conditions. For each condition, a “yes” or “no” response corresponded to “1” or “0”. These binary responses were collated and aggregated scores calculated.

For the quantitative analysis, RANOVAs were performed to examine the format, fidelity scores, and students’ peer-rated teamwork competency dimensions. In general, intervention fidelity (summed average of fidelity conditions as scored by teachers and researchers) did not interact with format on peer-rated teamwork competencies. A possible reason could be that fidelity was interpreted in different ways between teachers and researchers, as teachers generally report higher fidelity scores than researchers. The second condition of fidelity, adherence to rationales, is one of the key elements of the intervention. Researchers were also more objective in scoring the fidelity conditions. Thus, we decided to focus on the fidelity score from only the researchers and the condition, adherence to rationales. Using this narrower fidelity score, intervention fidelity interacted with format on peer-rated teamwork competencies. When intervention fidelity was high, Format 1 students significantly improved in both peer-rated COD, $F(1,430)=5.00$, $p=.026$, partial $\eta^2=.011$, and CCF, $F(1,430)=8.42$, $p=.004$, partial $\eta^2=.019$. Also, regardless of format, high intervention fidelity resulted in higher peer-rated TES, $F(1,430)=4.94$, $p=.027$, partial $\eta^2=.011$, as compared to low fidelity. There were no statistically significant results for the other relationships. This result suggests that the intervention mechanisms, when enacted in accordance to the rationales, were at play in building the peer-rated teamwork competency of students, especially the reflection and target-setting principles. For TES, it indicates that when the rationales were implemented as designed, the sessions went on more smoothly; there was fewer distractions and interruptions in the classroom. This could have helped teams from both formats work together more easily.

For the qualitative analysis, focus group discussions (FGDs) were conducted with 44 students (drawn from a convenience sample with some maximum sampling variation). FGDs followed a protocol and were audio-recorded and transcribed. Two researchers performed thematic open coding analysis of the transcripts and six themes emerged. Due to space constraints, two key themes are highlighted briefly here. Firstly, *reflecting on feedback from their peers via the visual analytic helped students to understand more about their teamwork competency*. As revealed by student B2, “**Reflections give you a third person’s view of yourself...** It helps you to know... the things that you need to improve on, or ... the things that you are already good at”.

Secondly, the intervention also helped some students *gain a broader notion of teamwork where the process matters just as much as the outcome*. Student Sha’s sharing illustrates this point:

At the start [of the intervention], we didn’t really work that well, but then **in a short period, suddenly we could work better**. That’s so weird because usually during group work in school, we tend to not get along well even after a few weeks... Because maybe in normal school days, where we require teamwork, **our main objective is to get the work done, it’s not really to work as a team**. However, yesterday’s session was more about teamwork, and not just getting the work done.

Together, both the quantitative and qualitative findings suggest that the design principles enacted in the intervention were instrumental for helping students learn and reflect more about their teamwork competency and as a result, improve their team behaviors in a targeted manner.

Discussion, implications, and conclusion

A digital formative assessment approach, which moves away from traditional assessment approaches to emphasize visual analytics, awareness, reflection and target-setting, was developed for blended learning

environments. This was alongside a visual analytic that was based on self and peer ratings of a domain-general, four-dimensional teamwork competency measure. Towards interdisciplinarity in the Learning Sciences, this approach holds much potential as it is not discipline dependent, and can be carried out in multiple domains and/or interdisciplinary curriculum. The design goes beyond triggering social awareness of learners of their collaboration processes in various tasks, but provides a pedagogical balance of structure and autonomy through guided reflection and agentic target-setting and monitoring. Besides the contribution to the learning design of teamwork interventions, this has been demonstrated to be effective and practically possible in current school systems.

Nevertheless, as with all interventions, there were challenges to the fidelity of the program. As found, enactments that adhered to the rationales of the intervention, were the most successful. We acknowledge the inevitable difficulties in facilitating these design principles as we forge towards an assessment for learning culture. Furthermore, there are limitations to the study. A practical concern was that the current intervention was a one-time approach. While this allowed the project to meet certain learning objectives, for greater teamwork transformation and shifts, we believe that a longer-term undertaking may be needed. Students (and teachers) need more time to enculturate themselves to this new approach to draw fuller value from it. Next, having two researchers score the intervention fidelity would have been ideal but this was not achieved due to constraints in human resources and scheduling conflicts. However, we believe researchers were consistent in scoring fidelity, as they are more knowledgeable about the design principles.

This intervention with its innovative digital formative assessment approach has challenged the boundaries of conventional schooling. It focuses on what is often ignored or taken for granted, the process of collaboration, and traverses domains, providing a set of effective design principles for teamwork skill development. It contributes to the theoretical literature of teamwork and pedagogies for nurturing 21st century competencies. Practically, it has developed design principles that are implementable across various school contexts. This work continues to be explored and investigated in terms of the methodology of the visual analytic, as well as a co-design with teachers interested in applying the design principles to Geographical Investigations.

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