Assessing collaborative problem solving in the context of a game-based learning environment

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Abstract: Game-based learning environments provide students with the opportunity to collaborate with peers and solve ill-defined problems that align to a problem-based learning (PBL) inquiry cycle. However, game-based assessments must not only be psychometrically valid, but also fun. Drawing on problem-based learning (Hmelo-Silver, 2004) and a collaborative problem-solving framework (Liu et al, 2016), we present a conceptual piece detailing the design of collaborative work products and PBL assessments in the context of our game-based learning environment, CRYSTAL ISLAND: ECOJOURNEYS.

Keywords: collaboration, assessment, problem-based, game-based

Problem-Based Learning (PBL) refers to an instructional method that presents an ill-defined problem for students solve collaboratively with the aid of scaffolds (Hmelo-Silver, 2004). Although PBL has often been used in the classrooms, game-based learning environments can provide a rich context to situate problems. Shifting to a game-based learning environment means that generating a validated assessment can be challenging since it requires accounting for assessment design, psychometrics and the element of fun. To address this challenge, we utilize Liu et al.'s (2016) evidence-centered design (ECD) framework of collaborative problem solving (CPS). We aim to explore the relationship between scaffolds and the impact it has on group collaboration and learning outcomes. In this conceptual paper, we highlight how CPS framework aligns with steps in the PBL process and the design of collaborative work products in the context of a game-based learning environment[1]. It is hoped that by making these aspects visible in our work, we can facilitate discussions about how to design game-based PBL assessment in collaborative settings.

Evidence-Centered Design (ECD) approach to game-based assessments

Evidence-centered design (ECD) is an approach towards designing assessments by attending to evidentiary arguments, wherein claims about what students know can be reasoned from what they do (Mislevy et al., 2014). There are multiple layers that need to be addressed in the design of assessments; domain analysis, domain modeling, conceptual assessment framework, assessment implementation and delivery (Mislevy et al., 2014). The ECD framework has been widely utilized in game-based assessments, allowing researchers to examine constructs such as emotional engagement (Kim & Shute, 2015). Given the centrality of collaboration in PBL, we utilize the collaborative problem solving (CPS) model designed by Liu et al. (2016) who outline four categories of skills (table 1), that were crucial to successful collaborative problem solving. In their work, the authors found that individuals who were able to share ideas with others performed significantly better at understanding seismic events (i.e., their outcome of interest) than those working on their own. In table 1, we present an alignment between CPS, the PBL cycle and activities in CRYSTAL ISLAND: ECOJOURNEYS. In the game, students work in groups of four and have to solve an aquatic problem. As students engage in the game, they use a whiteboard tool, hypothesis board and chat to share their ideas and solve the problem.

Table 1. Mapping of the CPS model, PBL cycle and activities in CRYSTAL ISLAND: ECOJOURNEYS

CPS skills	**Problem-solving in PBL**	**Activities in the game**
1.CPS Sharing ideas 2.CPS Negotiating ideas	1.PBL Identifying facts 2.PBL Generating hypothesis 3.PBL Understanding gaps in knowledge 4.PBL Presenting solutions to the problem	**Whiteboard & Hypothesis board:** A shared environment where students identify facts and share information after meeting assigned stakeholders and gathering data. Students evaluate evidence to generate hypothesis and solutions to solve the problem
3.CPS Regulating problem solving activities 4.CPS Maintaining communication	5.PBL Engaging in self-directed learning	**Chat environment:** Use chat to discuss ideas, resolve conflicts and identify knowledge deficiencies; regulate group process and return to the game to look for more information **To-do list:** Helps regulate problem solving

In our work, the student model is an integration of the CPS model and the problem-solving processes in the PBL cycle. Based on both the CPS and problem-solving processes in the PBL cycle, we identify two dimensions of interest: collaboration skills as it relates to sharing and negotiating ideas and process management skills. Based on this alignment, it is reasonable to assume that there is a strong relationship among process management skills, problem-solving skills, and content learning. To unpack the relationship between the student model and the task model (i.e., student activities), we provide an outline of work products (Mislevy et al., 2014) in the game that and that help elicit evidence of desired student competencies (i.e., CPS skills).

Table 2. Work products from students' game play in CRYSTAL ISLAND: ECOJOURNEYS

Pre-defined	**Contingent**	**Log file data**
Whiteboard. Students identify relevant facts (1.PBL) and share evidence that support hypothesis provided. (1.CPS & 2.CPS) *To-do list and notebook.* Structure problem-solving and self-directed learning (3.CPS and 5.PBL)	*Whiteboard*. Students evaluate peer claims and evidence. Students decide which hypothesis to keep based on evidence (2.CPS, 3.CPS & 3.PBL) *Chat*. Students use chat to discuss & negotiate (all four CPS and five PBL skills)	Data mined from students' written interactions in chat and trace interactions at the whiteboard. Students' talk in chat highlight how they discuss ideas, resolve conflicts and identify knowledge deficiencies; regulate group process and return to the game to look for more information.

These work products are associated with designed scaffolds in the game, such as the whiteboard, a hypothesis board and prompts provided in the chat space to students. Based on when and how scaffolds were delivered to students, we will leverage a time-series analysis to understand the relationship between the scaffolds provided and collaborative problem skills at both individual and group level.

References

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