CHAPTER 12

Toward Quality Online Problem-Based Learning

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INTRODUCTION

Although problem-based learning (PBL) has its roots in small group facilitation in medical education, it has been used successfully in a number of domains (Walker, Leary, & Lefler, 2015). Facilitating PBL is a demanding practice that requires a repertoire of strategies to guide the learning process and traditionally consists of face-to-face interactions and tutoring. Our recent research demonstrated that technology can be used to support international groups of medical students and tutors in a synchronous PBL to coconstruct an understanding of how to communicate bad news to patients (Lajoie et al., 2014; Lee, Lajoie, Poitras, Nkangu, & Doleck, 2017). In particular, web conferencing software and shared applications were designed with video exemplars to support synchronous interactions with mixed groups of students from Canada and Hong Kong who worked with medical facilitators from each country (Hmelo-Silver et al., 2016). The PBL groups worked together to determine how to best provide patients with bad news by using video examples from their respective countries of physicians giving such news. The PBL was facilitated by tutors, who monitored the thread of discussion in the chat window, and a wizard-of-oz facilitator.

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who prompted tutors to use discourse moves that would lead to productive interactions with their students. Our analysis of the discourse determined that this online PBL supported successful cultural exchanges in which learners and instructors shared multiple viewpoints on common problems that led to better understanding. Interestingly, the culture of medicine emerged as the predominant culture rather than particular cultures of origin.

The value of synchronous online PBL is not in dispute. However, this chapter presents our work on the design of an asynchronous PBL environment, which was motivated by several factors. Our initial technology-based PBL platform reduced the physical distance of international participants and provided tools that supported learning; however, the technology did not address the challenge posed by a 12-hour time difference, so the first reason for developing an asynchronous environment was so that working in different time zones would no longer be an issue. A second reason was that asynchronous PBL allowed tutor expertise to be scaled up to multiple small groups with the proper support tools. Small-group PBL tutoring is costly in terms of human capital in the form of tutors. Normally, a tutor works with one PBL group at a time. Our goal was to create technology tools that would allow tutors to monitor and scaffold multiple PBL groups. This chapter speaks to the design of technology tools for facilitating asynchronous group learning and tutoring.

This chapter describes the design and redesign of HOWARD (Helping Others with Argumentation and Reasoning Dashboard). To our knowledge, this is the first asynchronous online platform specifically designed from the outset to support both students and facilitators in PBL. Therefore features for supporting tutors needed to be created, piloted, and redesigned to ensure that the tools would serve their intended purpose. Accordingly, this chapter provides a description of one approach to developing sound technology tools designed to help PBL facilitators promote high-quality interactions rather than an empirical study on the effectiveness of HOWARD. In particular, we limit the discussion in this chapter to the tools created to support the monitoring and scaffolding of multiple asynchronous PBL groups so that facilitators can recognize when group interactions go awry and make appropriate discourse moves to help guide the groups toward more productive interactions. Such usability studies are a precursor to full-scale evaluations of this type of asynchronous PBL. We discuss the affordances of modern computer-mediated communication, web, and learning analytics technologies and how they can be leveraged
to promote high-quality online discourse. We start with a short synopsis of the PBL approach and how it was used in our work to support medical student learning about how to communicate bad news.

**PROBLEM-BASED LEARNING**

PBL is an instructional framework that is used to support collaborative knowledge construction and in the process helps learners develop skills of critical analysis, problem solving, and content knowledge (Hmelo-Silver, 2004). Learning begins when learners are given a problem to solve on which they work together to identify the problem; identify the facts, including the knowns and unknowns; establish learning objectives; identify learning issues that need to be researched; research the unknowns; analyze and list possible solutions; synthesize results; and discuss, integrate, and summarize solutions (Hmelo-Silver, Kapur, & Hamstra, 2018). Small groups of learners work collaboratively on these cases, and a tutor facilitates the group by guiding the learning process in a manner that helps them at each phase of problem solving. The demands on tutors are high because they must intervene at appropriate times to move the discussions forward (Hmelo-Silver & Barrows, 2006, 2008). Tutors need to be able to adapt their facilitation strategies to help scaffold the group dynamics and encourage students to engage deeply with disciplinary content.

Interaction is at the core of PBL, and the quality of the interaction is revealed in the group discourse. Interaction occurs between learners as well as between learners and tutors. The success of the PBL depends on whether such interactions result in learners achieving their learning goals. Many lenses can be selected to examine such interactions. One is to focus on the learners and how their interactions demonstrate effective collective knowledge building. Another is to focus on the tutors and how their facilitation leads to knowledge changes. In either case, theoretical stances can guide the analyses of such group discourse. For example, using a coregulation stance (Hadwin & Oshige, 2011), we have analyzed PBL discourse to investigate whether group members share the metacognitive demands of monitoring, evaluating, and regulating the task processes and how such sharing leads to cognitive changes, as well as whether the types of questions asked by facilitators and students lead to better understanding (Lajoie et al., 2015; Lee et al., 2017).
The quality and type of the learners’ discourse in the group matters, and tutors use such interactions to provide contingent scaffolding—providing the right support based on what is happening in the group at the moment (van de Pol, Volman, Oort, & Beishuizen, 2014). Technology can assist tutors in finding interactional patterns by using data mining techniques to reveal the nature of the group interactions. We describe how these techniques have been used in our project below. We first present the PBL context, followed by the iterative design process used to improve the instructional model. We discuss two phases of the design process. The first phase summarizes our findings from a synchronous online PBL. The second and most recent design phase is centered on an asynchronous online PBL that addresses issues of convenience and scalability associated with online long-distance PBL.

THE PBL CONTEXT: LEARNING HOW TO COMMUNICATE BAD NEWS TO PATIENTS

Research has suggested that effective patient-doctor communication influences patients’ health outcomes (Stewart, 1995). Unfortunately, even experienced physicians struggle in their basic communication skills if they have not had specific training in this area (Aspegren & Lonberg-Madsen, 2005) and lack confidence in their ability to communicate bad news effectively (Sise, Sise, Sack, & Goerhing, 2006). The manner in which a health professional communicates bad news can alter a patient’s course of decisions and actions, potentially affecting his or her relations with the health system, treatment (emotional and mental health), and, importantly, his or her immediate social context (family, workplace, friends) (Pendleton, House, & Parker, 1987). For example, if a physician ineffectively communicates bad news to a patient, that patient may not understand the danger of noncompliance with treatment, which could lead to adverse personal or public health consequences. Given the importance of these communication skills, we created an online PBL to help medical students learn the best ways to deliver bad news. We anticipated that this topic would create lively discourse.

Phase 1: An Online Synchronous PBL
A natural starting point for creating online PBL was communication platforms that allow real-time, face-to-face communication. In the first phase of
our research, we situated an online PBL intervention within a synchronous, video-based communication platform that included a shared whiteboard, with the rationale that this mode of interaction would be familiar to participants and allow them to transfer their face-to-face PBL interactions to a computerized environment. This online PBL provided opportunities for an international exchange of perspectives on how to provide bad news to patients without having to travel across the globe (see Figure 12.1).* In particular, the PBL provided an international cultural exchange of perspectives between medical students and tutors in North America and China on the topic of communicating bad news to patients (Lajoie et al., 2014, 2015; Lee et al., 2017). Students and tutors met synchronously in an online environment created with Adobe Connect. The environment supported individual students in giving bad news to standardized patients using videoconferencing before and after participating in a targeted, small-group PBL on how to communicate bad news effectively. In this way, students were able to practice their skills as well as engage in the required multiple perspective taking that the PBL provided. Tutors interacted with students by listening and watching the “hand-raising” tablet provided in Adobe Connect. However, there were times that the tutor had difficulty listening and observing the technology indicators simultaneously and consequently, a “meta-tutor” or “Wizard-of-Oz” expert facilitator observed and listened

* Full ethical approval to record the tutorials and use sections of the anonymized data (transcripts and still images) in publications was provided by participants and the local authority.
to the PBL interaction in the background and interacted directly with the tutor when needed. The wizard communicated with the tutor through a private chat window, helping the tutor monitor the group exchange and encourage learning strategies that the tutor might not have considered in the heat of the activity. The technology thus supported real-time tutor professional development in a seamless manner that might not have been available in face-to-face settings.

The PBL context involved two video-based medical scenarios (one situated in Canada and another in China) of a physician delivering bad news to a patient. These videos served to trigger discussions about communicating bad news. Videos provided the context for collaborative engagement, in which students took responsibility for generating, supporting, and building understanding about these issues using an online whiteboard to externalize their discussion space. The role of the expert facilitator was to guide the discussion toward achieving the goal of the collaborative session. SPIKES (Baile et al., 2000) is a North American medical consensus-based protocol that establishes six steps a physician should take in giving a patient bad news. We used the SPIKES model to facilitate discussion around the appropriate content after viewing the videos. SPIKES stands for establishing the appropriate setting, assessing the patient’s perception of the problem, inviting the patient to ask questions, providing knowledge to the patient, expressing empathy for the patient, and providing a summary or strategies for follow-up when communicating bad news. The PBL group consisted of seven volunteers: four medical students with a mean of 2.5 years’ experience, two from Canada (one male, one female) and two from Hong Kong (two males); two experienced male physician educators (one from each country), and a female expert in PBL facilitation from the United States.

Several analyses were conducted of the online PBL discourse, which revealed rich in-depth discussions similar to what one would find in a face-to-face context (see Lajoie et al. 2014, 2015; Lee et al., 2017). The discourse was coded using the community of inquiry framework developed by Garrison, Anderson, and Archer (2000) to establish the relationship between the facilitators and student interactions and student-student interactions. This framework codes interactions based on evidence of cognitive, social, and teaching presence to determine the nature of the dialogue. Facilitators were found to use appropriate levels of direct instruction and avoided dominating the group dialogue. The students’ discourse revealed
high levels of social cohesion and cognitive presence, revealing high levels of meaning making and multiple perspective taking over a two-hour PBL. They also demonstrated that such conversations could bring discussions of culture to the fore, an important consideration in this medical communication context (Hmelo-Silver et al., 2016). These findings demonstrated that online synchronous PBLs could be effective and revealed multiple episodes of shared understanding and positive group interaction, suggesting that for small-scale instruction, a synchronous video-based platform is an effective medium for delivering online PBL (Lajoie et al., 2015, 2014).

At the same time, the study also made clear that synchronous online PBL has two important limitations. First, connecting instructors and students in distant time zones can be impractical and limits the potential for cross-cultural discussion. Second, synchronous video-based discussion requires a low student-teacher ratio, limiting its scalability to large class sizes. For this reason we redesigned our environment to provide opportunities for scalability.

Phase 2: Asynchronous Online PBL, HOWARD
To address the limitations of synchronous online PBL, the second step in our design process was to create an asynchronous online PBL platform. Asynchronous instruction, by definition, does not require simultaneous participation (Johnson, 2006) and can allow users in different time zones to interact at times that suit their schedules. Distance educators report a number of advantages of using asynchronous communication, including “encouraging in-depth, more thoughtful discussion; communicating with temporally diverse students; holding ongoing discussions where archiving is required; and allowing all students to respond to a topic” (Branon & Essex, 2001, p. 36).

To explore the potential of asynchronous PBL, we developed a collaborative learning platform called HOWARD for online, multiday PBL workshops targeting medical students’ knowledge and skills related to delivering bad news (Hogaboam et al., 2016; Kazemitabar et al., 2016). The PBL groups generally convene over two or more days and are facilitated by one or more PBL experts. A workshop has start and end dates with intermediate milestones, but the individual activities each group member performs can be completed asynchronously. Students work in small groups and log into the system at their convenience to complete coursework collaboratively.
HOWARD provides a platform on which multiple PBL groups can work concurrently and be tutored at a distance. Once again our instruction was situated around realistic case videos depicting physicians delivering bad news to patients. These cases helped to illustrate the complexity of the problem and to stimulate group discussion. HOWARD provides a student interface that supports small-group discussion with a text-based chat space and summarization and synthesis with an integrated collaborative virtual whiteboard, and also includes separate interface for PBL facilitators.

**The Student Interface.** The student interface (see Figure 12.2) is composed of four components: (1) a navigation bar, (2) videos that are reviewed and annotated by students, (3) a discussion board on which students work together to discuss the PBL, and (4) an interactive whiteboard on which students report on the PBL. The navigation bar allows students to access the platform’s different functions (i.e., guide, today’s tasks, reflections, etc.). Students are first directed to the Guide, which introduces them to the goals of the workshop and frequently asked questions about how to interact in the workshop. Subsequently, students are directed to the Today’s Tasks page, where they review their to-do lists for each day of the workshop. Students then navigate through their tasks by working on their assignments, be they reviewing the video, interacting with others in the discussion space, or posting comments on the whiteboard. Once they complete their tasks for the day, students are prompted to mark the items they have completed on their task sheets before logging out of the system.

As in phase 1, the videos served as the context for the PBL; students reviewed, reflected on, and discussed video vignettes with their group. Unlike phase 1, students could play the videos and annotate them with comments and reflections about how the physician was communicating bad news to patients. These annotations could then be shared with the group. In an effort to support asynchronous dialogue within the groups, the discussion board provided an area for sharing thoughts and perspectives and negotiating and resolving conflicts when they appeared, and it could be used by the instructor as an assessment tool for choosing if, how, and when to intervene in the group discussion. Students would be notified when new messages were available as well as when emerging edits appeared in the whiteboard.

The collaborative whiteboard was located to the right of the discussion area and could be used to document the problem, summarize, and record
Figure 12.2 Components in the student user interface: (1) navigation bar, (2) videos, (3) discussion space, and (4) collaborative whiteboard. New messages appear in blue (5); discussion space posts can reference text in the whiteboard, which students can locate via a “Look up” link (6).
important points from the discussions. Background color was used to attribute regions of text to their authors, with each learner having a unique color within a group. For ease of navigation learners could link their posts in the discussion area to a whiteboard entry. For other students reading these linked posts, locating the target text was accomplished by clicking a look-up button on the top-right corner of the post. The discussion space appeared as a threaded chat, in which each student’s entry appeared. Since students entered the discussion space at different times, the system updated their discussion space by illustrating the old messages in white and new ones in blue.

Finally, students completed two private reflective writing activities on whiteboards shared only with their instructor. The system notified learners when their assignment had been reviewed; feedback on the assignments, as well as other general messages from instructors, could be accessed via the “Instructor Input” menu item. Thus, the system provided for individual accountability and feedback as well as group accountability, consistent with best practices for collaborative learning (Blumenfeld, Marx, Soloway, & Krajcik, 1996).

The instructor interface for HOWARD was created to assist the tutors in their observation and decision making regarding the effectiveness of small-group interactions. Tools were created that would provide the instructor with indicators of how each group was functioning in terms of amount and quality of interaction, frequency of interaction by individual students in the group, and group cohesion. Tutors need such interaction indicators to make decisions about when and how to intervene in the asynchronous PBL—thus providing contingent scaffolding. In an effort to support the instructors in their tutoring decisions, we created a learning analytics dashboard.

**Learning Analytics Dashboards for Online PBL.** To address challenges with employing PBL on a large scale, we have drawn on developments in the emerging field of learning analytics (LA). LA has emerged from the broader area of educational data mining (EDM). EDM analyses are data driven, aimed at extracting value from big datasets (Ferguson, 2012), namely mining online class data to investigate the relationship between students’ participation and learning outcomes. LA also analyzes educational data, but does so for “purposes of understanding and optimising learning and the environments in which it occurs” (Ferguson, 2012, p. 305). Where EDM is passive, observing patterns in educational data,
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LA is active, putting this information to use to transform instruction and learning processes (Long & Siemens, 2011).

Dashboards are tools that have materialized out of LA research with the potential to transform learning processes. A dashboard can generally be defined as “a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance” (Few, 2006, p. 34). It is a set of visualizations that provide a multifaceted, synthesized look at the status and activities of a system. Historically, dashboards have their roots in business analytics, which are concerned with leveraging corporate data and presenting them in visualizations to enable business decisions (Few, 2006). In an educational context, however, logs of learner and group activities drive dashboards “that provide graphical representations of the current and historical state of a learner or a course to enable flexible decision making. Most of these dashboards are deployed to support teachers to gain a better overview of course activity . . . , to reflect on their teaching practice . . . , and to find students at risk or isolated students” (Verbert, Duval, Klerkx, Govaerts, & Santos, 2013, p. 3).

By synthesizing detailed log files and showing the data to instructors or students in condensed form, dashboards have strong potential to help instructors monitor learning-related interactions, particularly those in which intervention may be required. This functionality seems especially applicable to asynchronous instruction, in which many discussions and activities may have taken place since the last time a teacher logged in, and an efficient method is needed for bringing the teacher up to speed on the activities of the groups and for triaging the groups to focus the teacher’s attention on those that need it most.

We have applied LA techniques to the design of the learning analytics dashboard (see Figures 12.3 and 12.4) in HOWARD. The dashboard was created to meet the needs of PBL facilitators and help them manage multiple groups. LA is used to extract value from the datasets produced in online collaborative PBL activity. In our case these datasets are the group dialogues and individual activities that are mined to present visualizations for the instructor to make decisions. The visualizations were designed to help instructors understand the type, frequency, and quality of students’ participation; the type of interaction with fellow members; and generally whether or not the group was on track in engaging in productive collaborative activity. The LA dashboard presents a graphical arrangement of
Figure 12.3 The initial HOWARD learning analytics dashboard.
Figure 12.4 The redesigned HOWARD learning analytics dashboard.
a set of data visualizations that allow instructors to more quickly grasp
group dynamics, help identify difficulties, and signal when intervention
is needed. Trace data obtained from logs of student and facilitator inter-
actions during a HOWARD workshop feed into an analysis module that
processes the data and drives the visualizations.

Our initial dashboard design (shown in Figure 12.3; see also
Kazemitabar et al., 2016) included four information displays: (1) partic-
ipation in group discussion and progress on workshop tasks by means of
pie and bar charts, (2) student and instructor activities through a news feed
display updated in real time, (3) group member interaction patterns via a
social network analysis graph, and (4) frequently discussed topics shown
with a word cloud. A pilot test of this initial design revealed that it effec-
tively signaled student participation and interaction patterns but did not
provide enough support for helping instructors to quickly understand the
contents of students’ discussions (Hogaboam et al., 2016). Consequently,
we redesigned the dashboard (see Figure 12.4) to provide more nuanced
LA tools that include more context for each interaction.

More specifically, the second iteration of the LA dashboard replaced
the static pie and bar charts with dynamic versions, removed the activity
news feed, enhanced the functionality of the social network analysis graph,
and replaced the word cloud with an interactive conversation explorer. We
elaborate on these changes below.

The conversation explorer presents the overall participation level of
individual students in terms of when and where they contributed text
outputs in their discussions. More specifically, it presents an interactive
diagram that visualizes each conversation from the threaded discussion
space as a graph: nodes in a graph represent group members’ posts, and
links between the nodes indicate the boundaries of a conversation as well
as turn taking. At a glance, instructors can examine how many people are
talking and look for interactional patterns. Importantly, they can click on
the nodes to (a) read the contents of conversation threads that were occur-
ring at any point in time and (b) access a Key-Word-In-Context search
tool (Luhn, 1960), which provides a list of frequently occurring words
together with their sentential contexts. In this manner, the visualization
provides a deeper way for the instructor to see the conversational context
and content of the PBL.

The social network analysis (SNA) reveals different types of data about
the group dynamic. In Figure 12.4 the SNA is illustrated in the lower left
of the dashboard. The display is realized as a set of nodes and linking lines, in which one color-coded node represents one student user. The larger the node is, the more output the student has produced. In the example shown in Figure 12.4, Matthew is the least interactive. Each line connecting two nodes represents the interaction between two users. A thicker line indicates more communication, compared with a thinner connecting line. Information about communication flow is depicted with arrowheads at the end of each line and can be useful for identifying unbalanced interaction patterns, such as that between Paige and John. By examining the SNA visualization, the instructor can make quick observations about the group dynamic in terms of equal or unequal participation or problematic groups that are not functioning as a collaborative unit. The task progression view allows the instructor to see how each individual is progressing throughout the workshop on the assigned tasks. The activity view presents a temporal view of when and how each group member participated during the workshop. In other words, it presents a snapshot of word counts and chat turns at different points in the workshop.

EVALUATING TECHNOLOGICAL TOOLS FOR ONLINE ASYNCHRONOUS PBL: A SIMULATED-DATA APPROACH

Our goal in creating the LA dashboard was to provide instructors with a quick and observable way to examine group dynamics and make decisions about when and where to intervene. The data analyzed in our earlier pilot (Hogaboam et al., 2016) provided methodological insights regarding the challenge of evaluating the effectiveness of the dashboard design for tutors at the same time as evaluating the effectiveness of the platform for students. In essence, it was difficult to evaluate the true effectiveness of the LA tools without large numbers of students to populate the visualization dashboards, and we were not prepared to run large samples without ensuring that these tools were usable by instructors to facilitate large numbers of students. Consequently, our approach was to select an alternate strategy to test the usability of the new dashboard for tutors to increase the speed of the design-test feedback cycles. Our strategy was to use a simulated data approach to evaluate HOWARD by creating a mock dataset of simulated learners to maximize the power of the learning analytics tools to provide visualizations for tutors. Our research question was a simple one:
Can instructors differentiate between specific group dynamics using the HOWARD visualizations?

Methods

Participants
The LA dashboard was tested with 10 PBL instructors who individually participated in a two-hour online data collection simulating a two-day workshop.

Materials
In this study the materials consisted of creating PBL groups of simulated students: These materials were created by consulting PBL experts and surveying the literature to identify specific group dynamics frequently observed in PBL sessions. Based on this review, we created a dataset of fictional groups with well-defined dynamics described in the PBL literature (e.g., Hendry, 2009). More specifically, we created five types of groups (well functioning, dominant group member, dysfunctional, social loafing, and parallel play) that would require different types of tutoring intervention (see Table 12.1 below for descriptions). We created a scripted scenario for each of the five groups that would allow us to examine the types of observations instructors would make given these different group dynamics.

In creating each simulated group, the research team took a collaborative approach to scriptwriting that approximated the interactional behavior expected from real students in the workshops. We started by constructing a well-functioning group script, with the rationale that once we had created this script, it could be used as a starting point for developing scripts for the less functional groups. This script assumed that the well-functioning group would reflect equal involvement of all participants in discussion and negotiation, leading to successful collaboration (Hendry, Ryan, & Harris, 2003; Skinner, Braunack-Mayer, & Winning, 2016).

The procedure we took to create the script involved participating in the workshop in a way similar to how real students would participate. The scriptwriters watched a video and then composed the script in Google Docs collaboratively, in real time. Each group member wrote an initial and overall reaction to the video. For example, some commented on the style of physician communication, the method of communication, and the importance of specific things that were said. Members then posed
questions concerning the initial posts, such as “I wonder if the physician did X because of Y?” or “What might happen as a result of this method of bad news delivery?” Following question creation, members responded to posts of others as they saw fit. For each post that was created through this process, a general discussion ensued as to whether the responses reflected the intended target group dynamics. Scripts for the dysfunctional groups were created by modifying the healthy group script. For example, to create the dominant-member group, posts from one of the well-functioning group members were modified to disproportionately increase the participation of this member and create instances in which the dominant member exhibited signs of confidence and controlling others. We also increasingly shortened or removed responses from other members as the workshop progressed to create the effect of participation withdrawal as a result of the dominant personality. Table 12.1 provides additional information on the key features of the other scripts for all groups. Finally, to simulate a two-day workshop and study how instructors observed group activities over time, we divided the scripts into two sections and developed a software tool that could upload these scripts to populate the HOWARD database incrementally, mimicking the asynchronous nature of the online PBL.

**Procedure**

Instructors participated in the two-day workshop and were asked to think aloud and verbalize their thoughts as they examined different visualizations on the dashboard and made observations about the group dynamics relating to the quality of the group work. Screen capture technology was used to record videos of the instructors’ actions while using HOWARD, along with the audio of their think-alouds.

**Results**

For the purposes of this chapter we report preliminary findings on only four instructors in depth: two advanced PBL instructors (with 10 or more years’ experience) and two novice instructors (zero to five years’ experience) because we are in still in the process of a full analysis (Chen et al., n.d.). Preliminary analysis of the protocol data revealed that all instructors were able to use the LA dashboard to identify three types of groups, the well-functioning group, the dominant group, and the social loafing group. This finding is reassuring because identifying these patterns is a first step to identifying successful interventions when needed.
TABLE 12.1 Group Dynamics Selected for Implementation as Mock Script Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>Key features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well functioning</td>
<td>A high-functioning yet realistic group serves as a reference for a “healthy” PBL group.</td>
<td>Conversations with high involvement and reciprocity, reflection on the problem, consideration of the connections between the current and previous problems, self-evaluation of performance and of peers, reflection on effectiveness of collaborative learning</td>
</tr>
<tr>
<td>Dominant member</td>
<td>The dominant member “talks a lot, tries to control the direction of discussion, and prevents others from contributing.” (Hendry, 2009, p. 611)</td>
<td>Dominant personality that exhibits little open-ended thinking; is controlling and self-confident; and argues against the ideas of group members, shuts them down, and orders fellow members; dominant personality that becomes increasingly the main and only voice; and the source of most of the ideas; increasingly fewer exchanges between members</td>
</tr>
<tr>
<td>Social loafing</td>
<td>“Social loafing occurs when there is a reduction of individual contributions . . . and this can result in individuals’ free loading off the group. This can be either because they do not think their contributions are valued or, more commonly, because they know that they will still benefit from the group’s efforts regardless of their own input.” (Seymour, 2010, p. 73)</td>
<td>Members slow to react or become engaged; high dropout rate; limited responses of shorter length; lack of members taking the initiative; reliance on others; lack of building on each other’s contributions; similar amounts of text output from members; reports of more effort than actually expended</td>
</tr>
<tr>
<td>Parallel play*</td>
<td>Members complete their work in a shared space, but do so independently, moving “through the activity on parallel paths without meaningfully interacting with one another.” (Hmelo-Silver, 2004, p. 197)</td>
<td>Longer and fewer comments and replies; lack of acknowledgment of others’ contributions, ideas, etc.; unanswered questions; inactive group leader and summarizer</td>
</tr>
<tr>
<td>Off-topic</td>
<td>Members frequently engage in discussions that wander away from the main subject or dwell on minor points (Gilkinson, 2003), such as fixating on diagnosis or on the technicalities of treatment.</td>
<td>Active participation, alternating between on- and off-topic discussions (a completely off-topic group would be unlikely)</td>
</tr>
</tbody>
</table>

* The term originates from Parten’s (1932) study of social participation patterns in preschool children’s group play.
Furthermore, the think-alouds revealed effective use of specific visualizations to determine directionality and patterns of interactions. One instructor explicitly referred to comparing the size of nodes in the SNA to determine who was most dominant and described how the activity changed over time by checking the SNA. She also shared how she would respond as a tutor by intervening to “encourage others to increase their participation, so that they benefit from activity without being steamrolled.” Another instructor referred to using the conversation explorer to examine group dynamics in more depth. For example, he verbalized: “Ok, so that sounds like it is building a very good um to prepare the groups, it sounds like a very good dynamics. Oops go back. . . . Now, here is a new member, his name is Trixie Tran and he, she is also, I think she is female, she is very excited to be on board. to meet everyone and she is a sophomore from Hong Kong.” This example captured the instructor’s thoughts as she used the tools to inform her decisions concerning group dynamics and participation. Another instructor who read a different set of posts determined “this group has a lot of work yet ahead of them . . . working a way towards possible and variable solutions.”

**CONCLUSION AND FUTURE DIRECTIONS**

This chapter has demonstrated how technology can support PBL interactions in innovative ways that support both learners and tutors. In particular, we have presented new directions that might make it easier to sustain PBL interactions at a distance and on a larger scale. This chapter has documented our journey in exploring ways to use technology to create online PBL environments that would increase access to students and tutors. In particular, we discussed different online designs that we have created to support both learners and tutors in engaging in high-quality collaborative discourse.

Phase 1 of our work replicated the strengths of face-to-face PBLs in an online synchronous PBL and extended the resources in a manner that could be used by students and tutors internationally. Results from this phase demonstrated strong group cohesion, productive discourse, and strong learning outcomes in terms of meaning making and learning how to communicate bad news to patients. Furthermore, we found that the “Wizard-of-Oz” approach to having an online expert facilitator tutor the other tutors in managing the PBL was a real strength of this approach. This
research demonstrated the value of sharing PBLs cross-culturally to encourage multiple perspective taking on these difficult constructs (Hmelo-Silver et al., 2016; Lajoie et al., 2014). However, the research also demonstrated that this approach did not address the practical issues of scalability of the PBL model, especially when working with individuals in different time zones.

In phase 2 we have been tackling the scalability issue more directly by creating an asynchronous online PBL platform, HOWARD. This platform allows students and instructors to participate on their own schedule but still have access to an evolving small-group discourse about the PBL content. A unique dashboard was created for the instructors, using LA techniques to mine group data and present visualizations that let the instructor see overall group interaction patterns, the depth of discussions, the frequency of discussions, who is and is not talking with whom, who is making progress on the task assignments, and so on. Preliminary data demonstrate that the dashboard is being used by instructors to make appropriate decisions about group dynamics that will ultimately lead to specific tutorial interventions. The detailed think-aloud data and screen recordings document the reasoning processes used by instructors as they interpret the visualizations, as well as help identify group dynamics of interest. This methodology of using think-alouds with simulated groups provides an important window into tutors’ cognition as they attempt to understand different interactional data and use these for instructional decision making. These simulated group scripts may find further value for providing professional development for new PBL tutors to help them learn to support high-quality interactions in tutorial groups.

By combining simulated student data with real instructor data, we have been able to make decisions about the effectiveness of technology tools in a relatively short period of time. This design-and-test scenario will make testing these tools on a large scale more effective. The next step in our research will be to complete the analysis of the think-aloud data from phase 2 to examine the types of instructional decisions that are made based on identifying group dynamic differences. These data can help reveal the types of tutorial scripts that might help others in facilitating PBL and promoting more uniformly productive discourse related to emotionally charged topics in medical communication, such as breaking bad news. Engaging students in cross-cultural discourse is particularly important in the area of medical communications, where learning to have these
discussions will be important for future medical professionals. We will also further examine the expert/novice instructor data to find out if there are expertise-related differences in self-regulation that may be associated with tutoring strategies. Finally, we will examine these data to determine any other usability issues and then make design changes accordingly. Future research will involve testing the refined dashboard in a large-scale study with real students and instructors to learn how they use HOWARD and to better understand the prospects and challenges for using technology to support PBL on a large scale.

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