Interdisciplinary Journal of Problem-Based Learning

Volume 9 | Issue 2 Article 1

Published online: 10-6-2014

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IJPBL is Published in Open Access Format through the Generous Support of the Teaching Academy at Purdue University, the School of Education at Indiana University, and the Jeannine Rainbolt College of Education at the University of Oklahoma.

THE INTERDISCIPLINARY JOURNAL OF PROBLEM-BASED LEARNING

VOICES FROM THE FIELD

Using PBL to Prepare Educators and Emergency Managers to Plan for Severe Weather

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Within the past 10 years severe weather has been responsible for an annual average of 278 fatalities in the United States (National Weather Service, 2013). During severe weather special populations are populations of high concentrations of people that cannot respond quickly. Schools show both of these characteristics. The average lead time for tornadoes is only 11 minutes (Simmons & Sutter, 2008), so decisions must be made decisively and leaders must be prepared in advance. This paper describes how an instructional design process was used to develop an interdisciplinary problem based learning training for both school personnel and emergency managers. In this real world based activity, participants simulated difficult decisions that must be made during severe weather to develop a better understanding of each others' roles and responsibilities.

Keywords: PBL, K–12 education, weather, emergency management, training

Introduction and Background

Severe weather is a very important topic throughout the United States. Over the past 10 years, severe weather has been responsible for an average of 278 fatalities annually in the United States (National Weather Service, 2013). In Oklahoma, severe weather and tornadoes can occur any time of year but are most prominent during the spring and early summer months (Storm Prediction Center, 2013). In the past five years, there have been 252 tornadoes reported just in the months of March, April, May, and June alone (Storm Prediction Center, 2013).

Because severe weather is prominent in Oklahoma and regularly occurs during the school year, school administrators have to make severe weather decisions regularly and with limited lead time. Schools are just one of the vulnerable populations during severe weather, others include hospitals, nursing homes, and large business districts. All of these vulnerable populations, as well as the regular population, are served by emergency managers. Emergency managers are specially trained individuals that generally work for the city (or volunteers in rural areas) and are responsible for understanding weather information, sounding alarms, and dealing with the aftermath of a storm. Because of this, the communication and information dissemination process is complicated with many different levels of receiving information, personalizing the information, and then making decisions (Mileti & Sorensen, 1990; Schumacher et al., 2010; Sorensen, 2000). Emergency managers depend on leaders who work with these special populations to understand severe weather procedures and work with them to keep people safe and make decisions proactively and in a timely manner. The average lead time for tornado warnings is 11 minutes (Simmons & Sutter, 2008). Therefore, when planning a response for a tornado, this is the maximum amount of time school decision makers have to get all of their students and staff to safety.

So then, how do you prepare school officials to work with emergency managers and make life-and-death decisions during a tornado warning? We engaged in an instructional design process to develop a problem-based learning training program for school decision makers that would increase their knowledge of other stakeholders' responsibilities during severe weather, as well as train them on the importance of proactive decision making during severe weather. We set out to see if both school personnel and the emergency managers could develop a better idea of the constraints and responsibilities that each group dealt with during a severe weather event. This paper chronicles the process and design decisions that we made during the research and design process for these learning activities.

http://dx.doi.org/10.7771/1541-5015.1441

Description of Practice

In order to better explain our design process, we will present our process using the organizational framework of the general instructional design framework ADDIE which stands for Analyze, Design, Develop, Implement, and Evaluate (Morrison, Ross, Kalman, & Kemp, 2011). Following this design process resulted in a study that consisted of three phases. The first two phases consisted of needs analyses where we sought to discover what information needs the participants had related to weather preparedness. Phase one consisted of a statewide survey investigating school decision makers' information needs and how school personnel and emergency managers communicated during tornadic events. Phase two consisted of a focus group with different stakeholders within the severe weather decision making process to further investigate the information needs, decisions, and actions during a weather event. Both of these phases led to phase three, in which we designed, implemented, and evaluated a PBL activity to help stakeholders think about their decisions and the actions of others during severe weather.

Phase One: Survey

Phase one of the study fell within the analysis part of the ADDIE framework. Phase one consisted of a statewide survey of Oklahoma school building personnel (teachers, principals), school district personnel (superintendents), and emergency managers. The survey had four constructs: preparedness, weather information, communication, and past experiences. These constructs were defined from a review of literature on risk perception and decision making (Kano & Bourque, 2012; Mishra & Suar 2007; Leclerc, Schmitt, & Dube, 1995; Keller, 1985; Weber & Bottom, 1989; Weber & Milliman, 1997).

We found that teachers and school personnel felt well prepared and confident in making severe weather decisions, but we realized that this was self-reported data. In response to an open ended item about their decision influences, participants mentioned they recall their past experiences to help them make decisions during a current storm. In their responses, we found there were inconsistencies about the information they used to make critical severe weather decisions. For example, 50% of school building personnel and 80% of districts said they used a NOAA weather radio (a programmed radio that only receives weather alerts and sounds alarms during severe weather), but 47% of school building personnel and 38% of districts said they did not know if they had a weather radio at their school or not. These kinds of inconsistencies informed us that we needed more information, beyond the survey, in order to better understand our audience. The survey also showed that there is a need for schools and districts to have a better understanding of the severe weather warning process and techniques for proactive decision-making. We decided to add phase two of the study, a focus group, in order gain a deeper understanding of the needs that we were seeing.

Phase Two: Focus Group

Phase two of the study consisted of a focus group. The focus group was considered the second part of the analysis phase of the ADDIE framework. By having a focus group where we could have several stakeholders interact, we hoped to gain insight on the relationships and how information was needed and used by the different groups. Because phase one showed a need for school decision makers to better understand the warning process, we designed the focus group to mimic a severe weather event in chronological order. The focus group was moderated by one of the researchers. Since the format of the the focus group mimicked a severe weather event, we were able to analyze the problem in further depth than the survey and allow the participants to talk freely and interact with one another. This focus group also allowed us to be able to triangulate the results with the survey to improve the reliability of the phase one results (Creswell, 2012b; Spector 1994).

Phase two had stakeholders from the National Weather Service, emergency management, and school administration to further investigate their information needs, decisions, and actions during severe weather. Because the focus group was designed in a manner that mimicked a severe weather scenario in chronological order, the National Weather Service representative and emergency managers were encouraged to describe what they do during each stage of severe weather development. In addition, the statewide survey showed that there was a disconnect in what information was used to make severe weather decisions in schools; schools often used unofficial sources such as community member reports to make decisions. The focus group scenarios allowed school decision makers to discuss the information they use to make their decisions as well as the constraints they face during a severe weather event. The entire focus group was voice recorded, transcribed, and coded for common themes and patterns by the researchers.

From this focus group, we learned several things. Participants mentioned the importance of having a source of weather information that was reliable. They were often confused by conflicting reports between radio, TV stations, and community member reports. The focus group also explored the many different stakeholders (parents, students, community members, pets, etc.) and how their influences make the decisions of school officials and emergency managers complex. For example, when schools are locking down their facilities, parents often come to pick up children or to seek shelter themselves and often bring their pets with them. One participant shared, "Parents arriving saying, 'I want my kid' and we are not going to release them and then citizens arriving saying 'I'm here for shelter.'" Participants of the focus group also mentioned that a

main source of weather-related communication is e-mail. E-mail can be difficult to depend on during an emergency because email is often not functional or the people they would email would be in the field and unavailable. Many participants talked about communication, and the process that was in place at each school or building, for example one exchange was, "Well we begin with notifying each school principal, and then the superintendent notifies transportation."

Results from phase one and phase two were both used in the design process of the PBL activity (phase three) of this intervention. Because we used two different techniques during the analysis phase of the ADDIE instructional design framework, we were able to gain in-depth information about how decisions are made within the emergency management and school systems along with the complexities that occur for each stakeholder during a severe weather event. Through phases one and two, we found that participants consistently had misconceptions about weather decision processes and other stakeholders roles within the decision making process, they relied on their past experiences, they were unaware of policies and procedures that were in place, and expressed a need for increased communication during tornadic events. These concerns became our objectives when we began designing our intervention activity. This allowed us to design a PBL activity, which was phase three of the study, specifically for school decision makers incorporating all of these aspects in the scenarios and activities.

Phase Three: PBL Activity

When we sought to design phase three, we were left with the question, how can we best prepare teachers, administrators, and emergency managers to work together to solve problems during a tornadic event? With an average lead time of 11 minutes (Simmons & Sutter, 2008), having learners learn during a real event is not feasible or safe. We referred to the literature and looked for examples where people were trained to solve problems in an emergency. We found that problem-based learning (PBL) was a method that has been used for this goal, and given the information we had already collected from a statewide survey and focus group, it matched our design concerns and information needs that we had identified.

PBL is a learner centered approach that has three principles: problems must be open-ended and ill-structured, problems must be complex and challenge to motivate and engage participants to their interests while adapting to their prior knowledge of the subject, and problems must contextualize to the participants' current or future workplaces (Jonassen, 2011; Jonassen & Hung, 2008; Savery, 2006). Jonassen (2011) also states that a PBL environment must allow participants to engage with problems, make mistakes, and make an argument for what they believe is the best solution.

PBL has been used for many years, successfully, across many disciplines and it continues to grow as an instructional approach (Savery, 2006). PBL was first developed in the medical field, and it is still used widely (Lee & Kwan, 1997; Savery, 2006). PBL paired with simulations allows medical students to learn how to address complex problems without putting real patients at risk (Halm, Lee, & Franke, 2010).

There are two studies that related directly to meteorology and emergency management in the literature. One study looks at the possible feasibility while teaching meteorology students at the undergraduate and masters level within UK Universities (Charlton-Perez, 2013). Although PBL has not been widely used within the meteorological subject matter, it has been used within other cross-discipline emergency preparedness training. Streichert et al. (2005) use PBL in an interdisciplinary way in conjunction with officials from fire, EMS, law enforcement, emergency management, public health, and hospitals. The authors noted that members of these professions are typically 'imperfectly' aware of working styles, assets, strengths, and limitations of partner disciplines. In order to improve role awareness and collaboration skills, facilitators and education consultants wrote three cases: a radiological attack of water supply, a ricin poisoning incident that involved two state jurisdictions, and a broadcast anthrax release in an urban setting. They found these cases to be effective in training these diverse groups to work together.

Given the examples from the literature and our information needs, phase three of the study consisted of the PBL activity with the following objectives

Given a scenario and real life weather data in a structured PBL environment, stakeholders (emergency managers and school personnel) of the hazardous weather decision making process:

- will be able to describe concerns, complexities, and informational needs of other stakeholders within the decision making process.
- will apply past experiences to the decision making processes.
- will compare policies and procedures with other stakeholders in the decision making process.
- will communicate with other stakeholders in the decision making process.

The design of the activities used the needs analysis results from phase one and two and a pilot test of one activity to fully develop the PBL activity. A total of three activities were then designed using real severe weather case data available from the National Weather Service including alerts that were given, convective outlooks (technical weather information for emergency managers) and damage reports, which had happened previously in different parts of the country. This allowed for real and authentic problems (Jonassen & Hung, 2008). How-

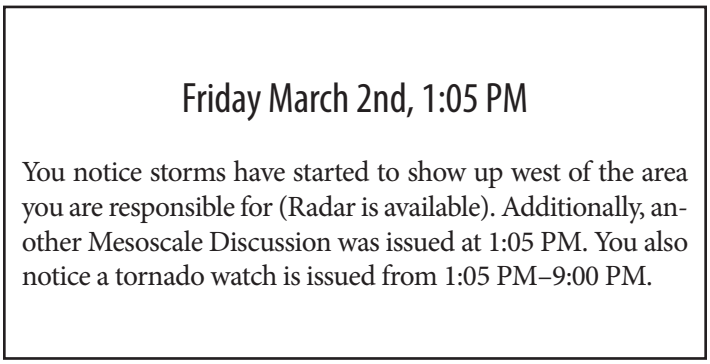


Figure 1. Example Critical Time Stamp Card for Emergency Managers

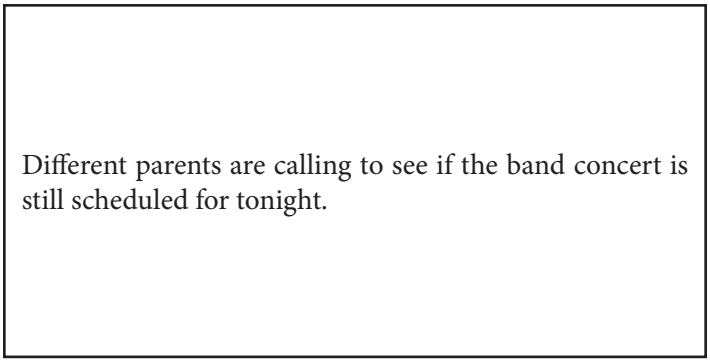


Figure 2. Example Happenings Card for School Decision Makers

ever, we used storms from different regions so participants did not have personal experience with the exact scenarios.

The PBL activities were designed to place participants in two teams. One team consisted of emergency managers and the other team of school decision makers. The participants were guided through these authentic severe weather cases by a facilitator using the actual storm timeline and critical decision points. Each case was arranged by times that occurred during the real event, referred to as critical time stamps (Figure 1). This information resembled the type of information that they would receive on a typical weather day. For example, emergency managers were given the real data from the National Weather Service (e.g. convective outlooks and mesoscale discussions archived online) from the day and school officials were given simulated daily schedules including conflicts such as meetings occurring throughout the day in different buildings. In addition to the critical events, each team received 'happenings' cards (Figure 2). These cards presented things that can happen during a severe weather day (e.g. Parents are calling asking if the baseball games are cancelled tonight because of the weather). These happenings were developed from the discussion topics during the phase two focus group discussions and issues that both school personnel and emergency managers said they faced on a severe weather day.

Each activity ran like a timed board game. Each "round" started with a critical event card (and sometimes also happening cards) with the participants having five minutes to discuss what had happened, what they would do, and record their thoughts on the back of each time stamp card by answering the following questions:

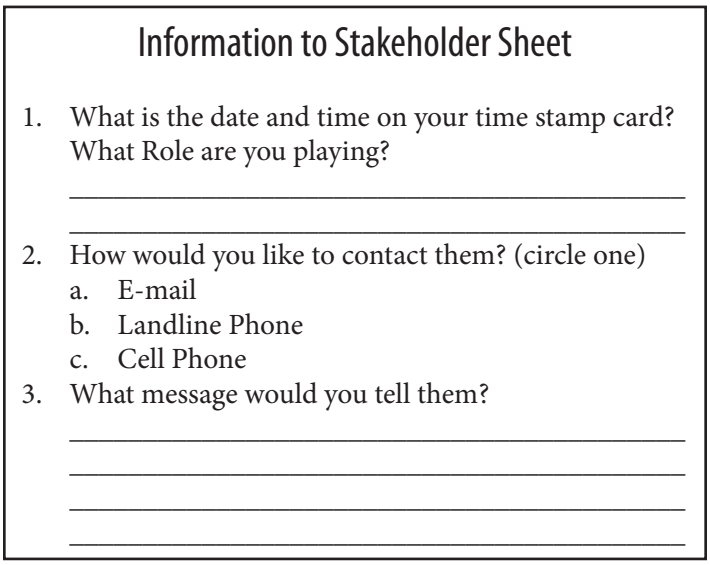
1. What actions do you take?
2. Why do you choose to take those actions?
3. On a scale from 1–10, how concerned are you? (1 = not concerned at all and 10 = completely concerned)
4. What information do you want and need at this point?
5. On a scale from 1–10, how confused are you? (1 = not confused and 10 = completely confused) What is confusing you?

These cards were collected at the end of each activity to see what participants decided to do. As each table deliberated, their discussions were recorded and after each activity the participants debriefed the activity as a group.

Pilot Test

An important step in the development of this PBL activity was pilot testing the activity structure with the target audience. After the case to be used in Activity A and B was fully developed, a group of volunteers whose backgrounds mirrored the target audience (three school decision makers and two weather professionals) were asked to use the prototype in a pilot study of the activity. They performed Activity A, where emergency managers took the roles of school personnel and school personnel took the roles of emergency managers. The participants consented to being recorded and were asked to think aloud (Morrison et al., 2011) and share any confusion or frustration during the activity. The recordings were listened to after the pilot test and additional observations were made. These observations and notes were used to refine the activity for the full implementation. Debrief questions were developed during the activity and asked to better understand participant experience and plan for future debrief questions. These debrief questions proved to be useful and they lead to formal debrief questions being developed for the actual implementation.

From this pilot test, the activity was refined in the following ways. The format and information on critical time stamp cards was changed to reduce confusion for day of the week, and events going on at the school. Additionally, during the debrief, participants who played the role of emergency managers stated that some of their actions would to be to contact the school they were serving. To make the activity realistic, pilot test participants suggested having a way to send messages to the other group. (See figure 3) During the implementation, a facilitator sat at each table and delivered messages between groups when requested. The informal debrief



Information to Stakeholder Sheet

1. What is the date and time on your time stamp card? What Role are you playing?

   _____

   _____

2. How would you like to contact them? (circle one)
   a. E-mail
   b. Landline Phone
   c. Cell Phone
3. What message would you tell them?

   _____

   _____

   _____

   _____

Figure 3. Communication Tool for PBL Activity.

questions were formalized for the full implementation and a pre/post survey was designed to be able to capture learner characteristics of the participants the day of the implementation, this enhanced our evaluation of the activity.

During the pilot test, some of the design decisions that had been made were able to be tested. For example, the pilot test allowed us to test how the cards were distributed. The facilitator distributed the cards one at a time instead of leaving the cards for the entire activity at each table, a decision that defined the sequence of instruction and also controlled the pace of the game. Participants were only given five minutes to make decisions because average lead time is 11 minutes (Simmons & Sutter, 2008) but that time would include being able to move people to shelters, lock doors, and so on, so decisions had to be made quickly. We were able to see how this kept the game moving during the pilot test and added time pressure to decisions. Additionally, Morrison, Ross, Kalman, and Kemp (2011) stress that learning is enhanced with the use of pictures and graphics. Participants had access to weather data from the actual event in the form of weather maps and radar. These maps and multimedia content helped to lessen cognitive load throughout the activities and allow participants to use the skills they had developed through previous weather experiences as discussed in both the statewide survey and focus groups. The pilot test helped us to test this data, and see that users needed prompts to use them. So we added prompts on the time stamps cards to know that new radar was available, and more happening cards for emergency managers during the event. Our observations and recordings of the pilot test proved useful, so we also had an observer and tape recorder present at each table. Each discussion was reviewed by the researchers and compared to each team's written responses to gain insight to the process and rationale for weather decisions.

To exploit a participant's cognitive dissonance (Ormrod, 2012), the three activities comprised of only two past severe weather cases. The first two activities used the same weather event (Henryville 1 and Henryville 2), but asked participants to play each other's roles to build empathy. For the first case, Henryville 1, participants switched roles with other stakeholders, that is, the school officials were given the information and tasks of emergency managers and vice versa. This allowed them to gain an understanding of the other stakeholder's roles and what they do during severe weather. For the second case, Henryville 2, they were then moved back to their native roles and participated in the same case as while working with people who were not from their home districts. Finally they participated in the final activity, Greensburg, which was a new past severe weather case in which they solved the problem by working with their coworkers to find a solution.

Participants had an opportunity to discuss with other districts and hear other points of view and past experiences

Table 1. Descriptions of the three cases used during full PBL implementation.

PBL Activities	Scenario	Roles
Henryville 1:	This was the pilot tested case, where the case chosen was March 2nd, 2012 with a tornado that occurred in Henryville, IN.	The emergency manager table played the role of school decision makers, and the school personnel tables played the role of emergency manager. The school district personnel were also inter-mixed with other districts at their tables.
Henryville 2:	This was also the pilot tested case of March 2nd, 2012 Henryville, IN.	The school decision maker table played their native roles of school decision makers and emergency managers played their native role of emergency managers but school district personnel were still inter-mixed at each table.
Greensburg:	This was a second tornado case that occurred in Greensburg Kansas on May 4th, 2007	Participants again played their native roles but this time the school personnel sat at a table with others in their same district. This was to simulate a situation where they would talk with those they typically collaborate with.

from others outside of their district and open up communication avenues for the future. This networking during the activity provided another resource participants could consult during future severe weather events. An overview of the cases used for each activity is shown below. After the changes were made to the design of the PBL activities, full implementation occurred with school decision makers and emergency managers. Table 1 shows the three cases were used during the full implementation.

Interpretation of the PBL Activity

The systematic process of using the instructional design framework ADDIE facilitated using the information from the needs analysis survey and focus group data to meaningfully develop a PBL learning activity. Jonassen and Hung (2008) explained that PBL problems must be open ended, ill-structured, complex so as to motivate and engage participants and their interest, authentic, and encourage the use of prior subject matter knowledge (Jonassen & Hung, 2008). While the events did actually occur, there is never really a "right" answer about how to respond to severe weather. From the survey results (phase 1), the majority of school building personnel and district personnel stated they would feel confident in making severe weather decisions for their schools if the decision was left to them. This indicates that as an audience, they were suitable for a PBL activity because they felt they had knowledge in the subject matter.

Our evaluation was based on our learning objectives, and our learners were able to achieve our learning objectives through the PBL activity. This study demonstrated that PBL effectively engaged the participants in exploring their weather related decisions, they learned the responsibilities of other stakeholders in the weather decision process, and they gained relationships to other stakeholders. Participants were clearly engaged as shown by laughter, sharing of stories of past experiences, and their struggle to understand the information presented to them. This study also showed that participants did apply their past experiences to their decision making by telling stories to their other team members, which allowed other participants to learn from one another. For example, a school decision maker described a past experience "The year before, we didn't have a situation, we were not as well prepared . . ." Participants also mentioned they were learning throughout this PBL activity by both making comments during the activity and also during the debrief sections. For example, while playing the role of emergency manager, a school decision maker remarked, "Well, what I am learning from this is there is a whole lot about the emergency management system, how they operate, and what information they have access to and what they have to do…" In addition, participants not only stated that they were learning more about how difficult decision making was during severe weather, the importance about proactive and timely decisions, but also that they learned a lot more about the other stakeholders and their responsibilities during severe weather. A different school decision maker acknowledged the difficulties of the emergency manager profession, "I don't know how many spotters to know whether or how they communicate, you know what I mean? Do they communicate by e-mail or cell phone call?" From the post questionnaires, many participants mentioned that one of the most valuable things about participating in the activity was networking with people from other districts and other stakeholders. One participant wrote, "Being able to connect with other districts to talk about their plans during severe weather was extremely beneficial." This shows that designing the PBL to have multiple districts' personnel intermixed with each other for two of the activities allowed for fostering communication and relationships. Given our stated objectives and our evaluation measures, the PBL activity was successful in preparing our participants to collaborate and to make weather decisions during a tornado event.

Next Steps

Part of the ADDIE instructional design framework is constant review and revision. For future administrations of this activity there would be several changes made. First, it is possible the participants did not have enough time to write their answers on the time stamp cards. For example, one table wrote "Weather Information" in response to what types of information they needed but in the recordings from the same group, participants listed some specific information needs. So perhaps in the future, giving the users choices on the responses or other questions may be more useful. Recording the table conversation was very important as well and should remain part of our procedure when possible. Next, because Henryville 1 and 2 were the same scenario, participants may have remembered information from their first activity to make decisions in Henryville 2. To address this, three separate cases will be used in the future. The new case will also not conclude with a tornado touching down, in order to demonstrate a different real life outcome, that often you have to prepare for a tornado and it may not hit the school. This will reinforce the fundamental characteristic of PBL that the cases are open-ended and there are no "right" answers (Hmelo-Silver, 2004; Jonnasen & Hung, 2008; Savery, 2006).

The development of this PBL activity will also benefit from more evaluation. We will follow up with the participants after the next severe weather season. Unfortunately, the immediate season was "quiet" and severe weather planning was not a top priority but further follow up continues as the PBL activity is used again and refined. This will allow us to know whether going through the PBL activity fostered long-

term sustainable learning. This will also allow us to fully explore the evaluation part of the ADDIE instructional design framework. In addition, we also plan to conduct this activity in another geographic area to compare responses and design a different type of regional severe weather PBL activity, possibly winter storms or hurricanes.

These simple revisions to the design of the PBL activity will aid in the development of a sustainable training program to help school decision makers making hazardous weather decisions proactively and work more effectively with emergency managers. Given the time stamps and linear nature of the activity, this activity could be administered online to allow greater dissemination to a larger national audience.

Severe weather is a major issue that affects schools each year, and in our experience, PBL was an effective way to prepare school officials and emergency managers to face real life challenges in a severe weather situation together. Following an instructional design process to design this learning activity created a robust, user-focused, and responsive design that allowed learners to plan for their decisions in dangerous situations in a safe environment. Using systematically planned additional PBL applications would be beneficial to all stakeholders of the decision making process as it relates to hazardous situations.

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