Promoting Technology Literacy Skills through Problem-based Learning Integrated with

TPCK Model

Nida Mushtaq Khan

Nida.M.Khan-1@ou.edu

nidamushtaq17@gmail.com

Course Instructor: Dr. Xun Ge

In fulfillment of the Requirement for EIPT 6533 - Development for Learning with Digital

Technologies

Table of Contents

Abstract

This study aims at promoting online literacy skills and Technological Pedagogical Content Knowledge (TPCK) among College Teacher Interns/Interns through Problem-based Learning environment. Two iterations of design-based research were conducted for this research. Six CTIs/Interns from the same college participated in Iteration 1. In the 2nd Iteration, six other participants from the same institution participated in the research except one who is not teaching currently. The data sources were online class meetings, pre- and post-interviews, online discussions, post survey, checklist, participants' artifacts, feedback of the Subject Matter Expert and the Instructor, and recordings of the sessions. Google Classroom as a Learning Management System was used for the instructional platform for this research. The present study suggests that training CTIs/Interns about TPCK and LMS is important to counter online teaching and learning problems. Problem-based Learning is one of the effective ways that, with the support of collaborative technological tools, can help CTIs/Interns design their online instructions effectively.

Key Words: PBL, TPCK, LMS, Google Classroom, Untrained and Inexperienced CTIs/Interns

Introduction

Like most of the institutions all over the world, the educational institutions in Pakistan also went online during COVID-19 pandemic. The pandemic situation requires a well-integrated trained team to detect students' and teachers' needs and provide prompt answers and support with digital tools. We are all surfing the virtual environment, with greater or less difficulty, and we have the firm conviction that education must not stop (Camargo et al., 2020). The biggest problem institutions faced was that teachers were neither ready nor trained for this sudden change. After some research about different groups of teachers at the college where I taught, I realized that the largest group consisted of CTIs and Interns (CTIs are teachers hired by the Government, but Interns are hired by the institutions themselves. Both CTIs and Interns are hired for almost a year. They perform the same duties as regular teachers do but they are paid less and do not have any benefits or allowances like regular teachers). Most students depend on them as they are the largest group of college. So, I selected this group for training purposes. 12 random teachers were selected as participants of the research. Most of the CTIs/Interns were familiar with different learning management systems and online literacy tools but they never got a chance to practice that knowledge and skills in their classrooms. After some online meetings with the Head of Department of Information Technology Department, with the Coordinator of BS Hons program (It is a 4 year Graduate program, considered equal to Masters), pre-survey with 11 students from all disciplines of the college, and a detailed online meeting with the two existing CTIs, it was observed that most of CTIs/Interns were inexperienced, were never trained for online teaching before and their performance remained unsatisfactory.

Ideally, teachers should have well-informed acceptance and be prepared with Technological Pedagogical and Content Knowledge (TPCK) before they take the role of online

instructors (Li, 2022). TPCK refers to the knowledge required by the teacher to integrate

technology in the respective content areas. Teachers with their understanding of the interaction

between the basic components of knowledge of content in the subject area and the knowledge of

pedagogy, use appropriate technologies to deliver the content (Padmavathi, 2017). The initial

data suggests that CTIs/Interns are limited in their repertoire of instructional strategies. By

training them, this gap could be filled. Training is important to develop individual effectiveness.

Organizations can meet their primary goals through training. It enables people to achieve their

personal goals that they set for themselves, and it provides a practicing space where participants

learn and prepare themselves for upcoming challenges, tasks, duties, and unexpected changes.

An effective teacher training system can produce quality teachers who are committed,

pedagogically sound, and concerned about student learning and development (Siddiqui et al.,

2021).

The goal of this study is to enable CTIs/Interns to integrate TPCK in their online

instructions through Problem-based learning. Problem-based Learning environment led towards

a seven-step solution of the given problem and online literacy tools like Google Classroom and

Zoom helped learners integrate technology with their content and pedagogical knowledge.

Problem-based learning is an educational approach whereby the problem is the starting point of

the learning process (Graaff & Kolmos, 2003).

Purpose

The purpose of this research is to determine the effectiveness of Problem-based learning

design in helping CTIs/Interns learn the integration of technological pedagogical content

knowledge in their online instructions. Training is defined as a process that uses a broad range of

instructional techniques to change attitudes, skills, or actions to achieve efficient output in a

particular task or collection of tasks (Collin et al., 2013). The initial data collected in the form of interviews, online meetings and pre-survey affirmed the need for an effective training intervention. Participants of this research knew the importance of Technological, Pedagogical, Content Knowledge, they were familiar with different online literacy tools also, but they had never been trained to bring all the important components of online instruction together at one platform. As a result, they faced a lot of mismanagement, disorganization, and haphazardness in their online classes resulting in frustrating them and the students also. Training the CTIs/Interns regarding the incorporation of Technological Pedagogical Content Knowledge in online instructions was a viable solution to address the online teaching and learning problems of CTIs/Interns. TPCK is a full-fledged knowledge framework for thinking about the type of knowledge that teachers should have to integrate technology into the teaching-learning process and ways of developing this knowledge (Vijayan & Joshith, 2018). This training would help them keep the Learning Management Systems organized and effective by following the TPCK framework. They would also learn how to scaffold their instructional methods with the help of relevant content material, media, and tools for their online classes.

The purpose of this design-based research consists of two main points. First, to train the CTIs/Interns about online literacy skills through online Problem-based learning. Second, to determine the effectiveness of Problem-based Learning by integrating Technological Pedagogical Content Knowledge in CTIs/Interns' online teaching. Problem-based learning (PBL) is an instructional method in which students learn through facilitated problem solving. In PBL, student learning centers on a complex problem that does not have a single correct answer (Silver & Cindy, 2004). Problem-based learning helps students develop self-directed learning skills and the instructor acts as a facilitator in the learning processes. When planning problem-based

learning, attention must be given to the resources that will be needed by students in between tutorials to answer the questions they have set themselves (Towle & Cottrell, 1996).

The design of this research consisted of a seven-step PBL approach. The learners were presented with an authentic complex problem that they tried to solve by following those seven steps. These steps include encountering the problem, identifying the problem, defining the problem, researching the problem, finding a suitable solution, implementing the solution, and integrating that solution in the real-world settings.

Following questions guided this research design.

1. In what ways does PBL help teachers integrate technology with content knowledge?

2. In what ways does PBL help teachers integrate technology with pedagogical knowledge?

3. In what ways does PBL help teachers integrate content knowledge with pedagogical knowledge?

4. In what ways does PBL help teachers integrate technology with content and pedagogical knowledge?

Problem-based Learning Environment

The overarching goal of this training intervention was to enable CTIs/Interns to learn online literacy skills through Problem-based Learning environment. PBL is an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2015). However, the purpose of this research is to determine the effectiveness of Problem-based learning design in helping CTIs/Interns learn the integration of technological pedagogical content knowledge in their online instructions. After some research, Merrill's First Principles seemed to be an accurate model to design this problem-based learning environment.

Merrill's First Principles describe the fundamental principles of effective instruction and provide a unifying view of different instructional perspectives (Frick et al., 2011). As a design heuristic it was intended to be used in conjunction with any learning theory to create good instruction (Cropper & Bentley, 2006).

First principles of instruction are design oriented or prescriptive rather than learning oriented or descriptive. They relate to creating learning environments and products rather than describing how learners acquire knowledge and skill from these environments or products (Merrill, 2002). Although First Principles are more instructor-centered and PBL is more learner-centered, when brought together, they emerge as an effective product to facilitate both the instructors and the learners. Merrill's First Principles of Instruction provide a set of five interconnected principles that are compatible with Problem-based learning. These principles include Problem-centric task, Activation, Demonstration, Application, and Integration. By using these principles, challenging and problem-based environments are constituted which enforce learners to be more critical, creative, and encourage them to think more and in different ways that all help to raise the creativity (Jalilehvand, 2016). For this online PBL design, four key aspects of pedagogy described by Ge & Huang (2022) were considered mainly. These aspects are preparation and planning, design and development, Implementation and facilitation, and assessment. Problem-based learning is an educational approach whereby the problem is the starting point of the learning process (Graaff & Kolmos, 2003). The training was divided into four modules by following Merrill's First Principles of Instruction starting from Problem-Centered Task. In the Activation phase, the learners were given a hypothetical problem that they encountered in the beginning. Keeping in view that problem, the learners identified and defined the problem. Demonstration step included researching the problem and finding the solutions. For

the Implementation part, the learners implemented the solutions and Integration let the learners practice PBL as a homework assignment.

The learners practiced all seven steps of PBL through different learning activities designed for them. These activities were designed and presented with the support of Google Classroom's Learning Management System and Zoom. Like other learning environments, technology plays a vital role to enhance innovative teaching and learning skills in Problem-based learning environments also. To solve the traditional PBL difficulties, we need support from technology as the students in this era are actively using the technology (Hussin et al., 2018). Problem-based learning as a student-centered approach develops learners' critical thinking, higher order thinking, self-directed learning, collaborative learning, researching, inquiry-based learning, cognitive and metacognitive skills. The role of the instructor is more of a facilitator to scaffold the activities in the problem-solving process. For all activities, proper instructions and timely feedback were provided to keep learners at ease and be motivated. The successful guidance of PBL is largely dependent on the availability and skills of instructors who can scaffold students' problem-solving activities with strategies such as providing hints and cues, asking questions to direct students' attention, eliciting their causal explanations, and elaborating their thinking (Brown, Collins, & Duguid, 1989).

Educational Design-based Research

In many ways, design-based research is intrinsically linked to, and its development nourished by, multiple design and research methodologies (Wang & Hannafin, 2005). Educational design research is a genre of research in which the iterative development of solutions to practical and complex educational problems provides the setting for scientific inquiry. The solutions can be educational products, processes, programs, or policies (Mckenney

& Reeves, 2014). The characteristics of EDR are described in the article, *Design-based research: An emerging paradigm for educational inquiry* in five points. First, the main goals of designing learning environments and developing learning theories are interconnected. Second, development and research result from non-stop cycles of design, presentation, evaluation, and redesign. Third, research should direct towards relevant theories that may help the designers and practitioners provide relevant implications. Fourth, research should consist of designs that are developed for authentic settings and those designs should help the readers understand the learning issues. Fifth, the research design must consist of methods that may lead towards outcomes of interest.

Both iterations for this EDR paper were conducted through Zoom and Google Classroom was used as a Learning Management System. Both the tools helped in data collection also. The learners participated in individual tasks and group work activities. Six female teachers participated in the first iteration and most of them belonged to the English department. Overall, there were 6 activities designed for the learners, 5 of them to be performed in the learning environment and 1 was assigned for homework. All activities were designed to let learners explore the 7 steps of PBL with the help of multiple technological tools and by staying in a sequence. At the end of the training, the participants had to complete a post-survey and a checklist. Data collected from post-survey was used for the evaluation of the training and the checklist was designed for the self-assessment of the participants.

After analyzing the first iteration, some areas needed more focus for the second iteration. For example, time duration, one module per session, development of the research questions, change and development of instructions for some steps in Activity 3 and Activity 5, and addition of pre-interview. Participants were changed for the second iteration. Six female teachers

participated again. They belonged to different departments. Five of them have just joined the service and one is not currently teaching. The above-mentioned changes were made for this iteration and through the data collected, an evident improvement was seen in the participants regarding their responses, understanding, attitude, motivation, navigation skills, research skills, communication skills, and teamwork.

Iteration 1: Design-based Research

Design and Implementation

Pre-implementation data justified the need for this training intervention. Zoom and Google classroom were used for instruction, content material, communication, and practice to use technological tools. Before the intervention, brief instructions were provided about the purpose of the training. Module 1 consisted of two individual activities. Activity One consisted of the first half of an authentic problem scenario. It was presented to the learners as Problem Scenario (Part 1) so that they encounter the problem. The learners were asked some questions about the problem scenario which they answered through 'Learners' Space 1', created through Google Docs. Activity two consisted of answering questions on 'Learners' Space 2' via Google Docs sheet so that the learners identify and define the problem.

Module 2 consisted of Activity three and four. Activity three was a group activity and learners were supposed to research about the problem through the web resources of their own choice and they were provided access to Google Drive so that they could read one of the two articles related to LMS. For Activity four, learners worked individually. They were asked to think about the possible solutions, write them down and read the next half of Problem Scenario (Part 2) (Continued from Part 1).

Module 3 consisted of a hands-on activity and learners worked in groups. They were supposed to implement the solutions and Google Classroom was used for practice. A [YouTube Tutorial Video](#) was used. The instructor created a classroom herself for procedural scaffolding and guided the learners in navigation, uploading documents, and creating instructions whenever they needed it.

Module 4 consisted of integrating the newly learned knowledge and skills in the real-world settings. A small demonstration about the importance of LMS was also given via a [PowerPoint presentation](#). After this, an overall discussion about the importance of PBL and LMS took place. The learners were now supposed to answer some [interview](#) questions about PBL and LMS. The questions were prepared via Google Forms. The learners were given a problem scenario for homework and they were supposed to find the solutions via PBL as they did in the learning environment [Problem Scenario for Homework](#). Detailed instructions were provided to the participants to work on problem-solving solutions as homework collectively. This was also a group task.

For all the activities, the instructor scaffolded the content knowledge with technology. The instructor also helped the learners perform different tasks through detailed instructions and by guiding the learners about accessing the documents, performing different steps, giving responses, using different tools, and submission procedures. All the activities and discussions helped the learners in brainstorming, work independently and in groups, think critically, collaborate with each other, use web tools with more ease, explore the problem, find solutions, and implement them. Learners were encouraged and feedback was provided.

At the end, the learners were asked to complete a Checklist for self-assessment and a Post-survey that was used later for evaluation of the training. Please refer to 'Design and Research Document: Iteration 1'.

Data Analysis/Results

After 5 activities, I analyzed the performance of the learners and created a chart based on their understanding of the content, attitude, motivation level, interaction level, and navigation skills. I used a Line Chart containing 40 scores to assess the performance of learners in above mentioned areas.

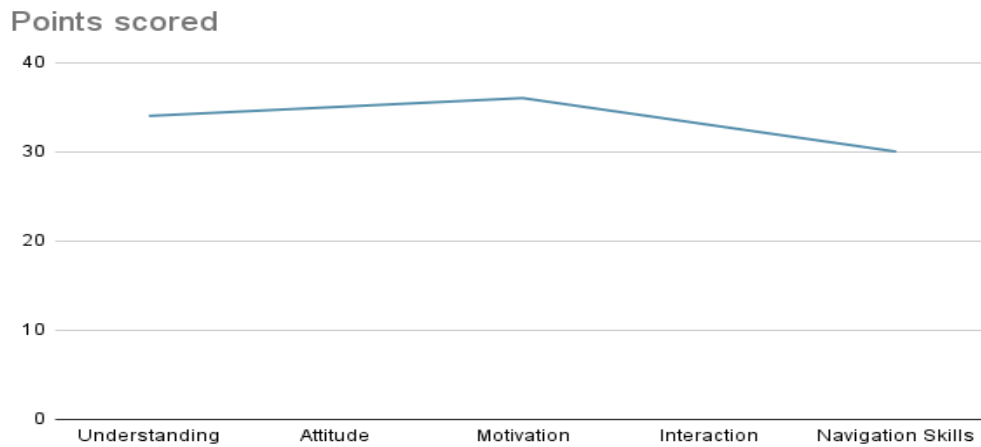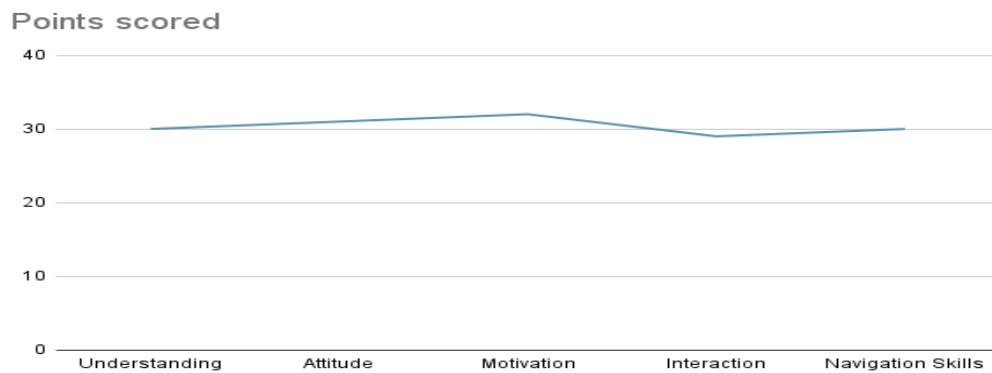Figure 1: Points scored by Group A (Iteration 1)

Figure 2: Points scored by Group B (Iteration 1)

After looking at Figure 1 and Figure 2, I realized that both groups were good in their attitudes, understanding and interaction but Group A seemed to be more efficient in executing their motivation and navigation skills. As far as Group B's performance is concerned, first, they got overwhelmed by the LMS articles and YouTube Video tutorial. Khadija believed that it would be better if the articles were related to their subjects and that it was impossible to navigate through all options and learn about them in one sitting. They felt that it was a lot of stuff to do, and they immediately jumped to the conclusion that they would not be able to do that. Second problem they faced was dragging files, media, or attachments from their devices. Third, when we worked on the posting part of the assignment, they were able to post random content from their computers that did not seem relevant, and I observed that they were running away from posting instructions with the content. Once they tried to provide instructions about the assignments, they were neither clear nor detailed. It seemed that they were more focused on using different tools but they did not pay much attention on how to scaffold those tools and content through effective pedagogical skills. Group A seemed to be more efficient as they navigated the classroom options a little easily. They had good communication with each other. I saw Zahida and Sadaf helping Asima regarding the grading options and selecting due dates for students. They also let her know about the option of sharing the assignments to specific people and how they could also add their colleagues in their classrooms for second opinions. They were a little better in selecting the relevant content, choosing relevant tools for their content, and providing facilitation but still a lot of effort was required to create effective online learning environments. It seemed to be impossible in two tiring training sessions. Both groups explored maximum options. We did not get much time to explore the general settings of the classroom in detail. I really wanted more time to explain how these settings could help them customize different options like selecting

specific students for feedback, allowing, or not allowing students to edit an assignment, allowing or not allowing students to respond on an assignment, showing or not showing the grades of students openly.

Findings to Research Question 1

Research question 1 asked, "In what ways PBL helps teachers integrate technology in their online teaching?". Data collected to answer this question was in the form of observations of learners' overall performance in the learning environment. After some initial difficulties in accessing the documents, typing on the spaces provided, and using the recommended space for communication, the participants got comfortable with the flow of the training.

Through the findings of Research Question 1, I realized that the question was not answered completely. PBL proved to be a good support for teachers to use different tools in their online learning environment, but the participants did not utilize PBL fully. They learned to access certain documents, use Google Docs, pull up documents from Google Drive and their computers, utilize the chat box, create Google classroom, and navigate different options there. However, they could not practice much about creating instructions, scaffolding instructions with the supporting material/tools, selecting relevant content or supporting tools, and their pedagogical skills could not be seen much. They also felt overwhelmed during Activity 3 and Activity 5, especially Group B as they complained that there was much information load, and they needed more time to consume this information and practice accordingly. That's why the integration of content knowledge and pedagogical knowledge remained a little neglected. The original plan was to see the effectiveness of PBL in integrating not only technology but content and pedagogical knowledge also in online teaching which could not be seen much.

Findings to Research Question 2

Research question 2 asked, "In what ways can PBL help learners transfer their online literacy skills? Data collected to answer this question was in the form of homework assignments of the learners which were evaluated by the feedback of the SME. The feedback of the SME suggested that the teachers were not specific about using the tools, devices, activities, resources, and pedagogical methods. They learned to transfer technological skills but did not transfer the content knowledge and pedagogical skills much. Their designs for homework assignments were quite general in nature. Both the groups did not mention the ways they were planning to scaffold their instruction and she could barely see the instructions to reach the documents and ways to perform the activities. Both the groups mentioned that they were using some links, videos, and other resources to conduct different activities in the classroom, but they did not provide links to those resources. So, it was not possible for the SME to analyze the content material to see whether it was accurate and relevant or not. SME liked Group B's homework more as they had kept in mind the time limit, chose the learners from their own classes, and came out with a more authentic plan. After going through the artifacts of the learners, the SME felt that it was not the right time to expect flawless results from the learners but being the practitioners of implementing PBL for the first time, teachers' job was not bad. This training session was also not sufficient to analyze the transfer skills of the learners. I also realized that transfer was a crucial part of PBL already so there was no need for this question. The transfer skills of the learners could also be analyzed through the first question as the integration part could be assessed through the first question with some modifications.

Iteration 2: Design-based Research

Design and Implementation

Overall, the design and implementation were the same for iteration 2 but I made some changes keeping in view the reasons for failure to answer question 1 completely. The changes I made are as follows. First, I felt that more time should be provided to the learners and one module should be implemented in one session only. Second, it was very important to provide PDFs of subject specific articles to the learners for Activity 3 instead of general articles related to LMS. In the first iteration, the learners failed to relate the information to their subjects, and they felt overwhelmed. So I selected 10 articles instead of 2 about LMS that could help learners in their relevant fields. Third, for Activity 5, the YouTube video for Google Classroom tutorial that I used in the first iteration was not a good idea as it was too long, and participants started feeling annoyed before even having the hands-on experience. So, I decided to skip that video for the second iteration and let the learners utilize that time in having more hands-on experience. Fourth, the data collected from the post-interview in the first iteration did not help much as there was no data to compare the present knowledge and skills of the learners with their existing knowledge and skills. So, I decided to conduct a pre-interview before the training starts. Fifth, I decided to skip research question 2 as PBL is incomplete without the integration or transfer step. Question 1 talked about PBL, so this question was not needed separately. All I felt is that question 1 should be modified so I divided it into 4 parts to see how PBL helps the learners integrate technology, content, pedagogy, and technological pedagogical content knowledge in their online instructions. The purpose of modifying research question 1 was to analyze the performance of the learners about integration of each component separately.

Lastly, I decided to elaborate my instructions more about the integration of relevant content material, tools, and pedagogical methods for online instructions. That's why I made changes in the Line chart to evaluate the performance of the learners in the following categories. Understanding, Navigation Skills, Announcements, Tools, Interaction, and Motivation. This time, the Line Chart contained 100 scores to assess the performance of learners in above mentioned areas. Please refer to 'Design and Research Document: Iteration 2'.

Data Analysis/Results

I changed the Line Chart a little bit for Iteration 2 as I felt that last time, I did not include the Announcements category and I did not have a parameter to assess how the participants posted their assignments and how well their pedagogical methods were about their assignments. This time I skipped the 'Attitude' category as I could assess that through 'Interaction' and 'Motivation' categories. I increased the total score from 40 to 100 and wrote the exact % age below each category just to make sure that readers get the exact percentage. I didn't do it in the previous iteration.

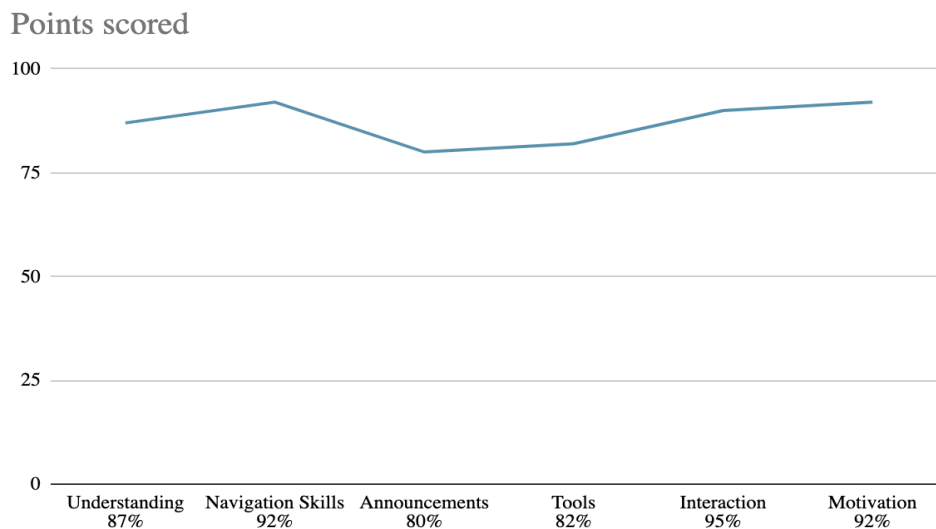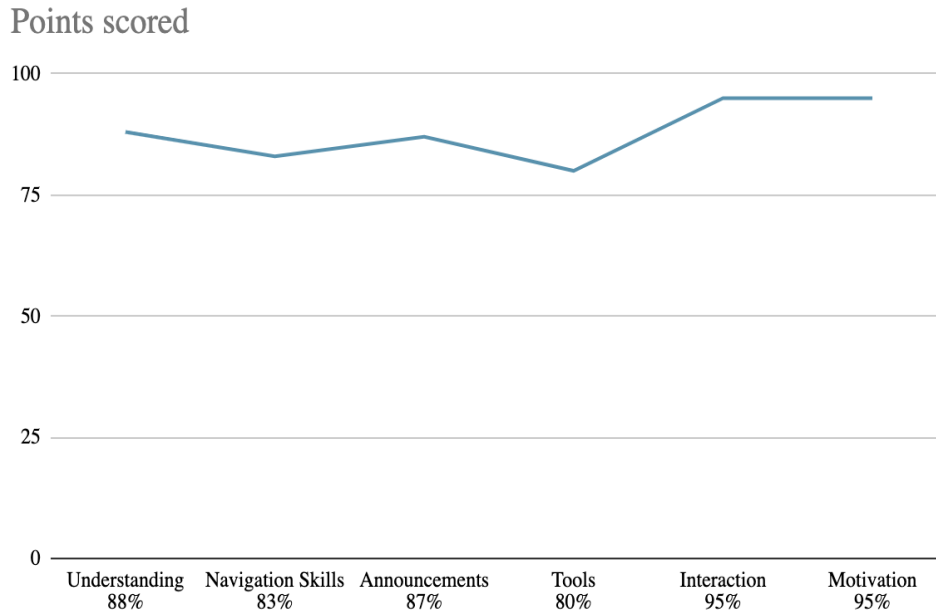Figure 3: Points scored by Group A (Iteration 2)

Figure 4: Points scored by Group B (Iteration 2)

Points scored

| | Understanding 88% | Navigation Skills 83% | Announcements 87% | Tools 80% | Interaction 95% | Motivation 95% |

I could see a marked difference in the learners' performance this time than the previous iteration. After looking at Figure 3 and Figure 4, it seems that both the groups had done a good job. Group A's understanding level was very good. They were better in their navigation skills and the usage of relevant tools to support their content, but they were a little weak in creating instructions and providing details about the assignments. When I looked at the examples of their postings, I realized that they had uploaded the relevant content but provided insufficient detail about how to complete the assignment. They had tried one posting per person. The topics they chose to create assignments were Cognitive Computing (Maheen), Cryptography (Asra), and Special Relativity (Asifa). The content uploaded seemed to be relevant, but instructions provided with the content were not sufficient. If they post their assignments like this, it might create difficulty for their students to understand the content or the requirements of the assignments. They used Google Docs, Web links and Excel Spreadsheet for making rubrics. Students were not

given details about how to make use of each tool and content posted in Google Docs sheet and Excel Spreadsheet was not much clear.

Group B was also as vigilant as Group A. If we make a comparison, they were better in the 'Announcements' area as they uploaded the content with detailed instructions and relevant supporting tools. Their understanding was as good as Group A's. Their organization in posting the content, creating instructions, and using relevant tools seemed a little better than Group A. Their navigation skills were a little less than Group A and it was understandable because Group A had two members from the IT department and Group B had diverse participants. One from Zoology, one from English and one from Psychology. Each of them tried creating the assignment according to their subjects as Group A had done. Faiza chose 'Reconstruction of the Phylogeny of Invertebrates', Sidra chose 'Critical Analysis of Jinnah's Letters' and Maria selected 'Racism and its Effects on Minority Groups' to use for their assignments. They uploaded the assignments with a detailed account of the requirements. The instructions were clearer as compared to Group A. They had also used the tools from the given options in Google Classroom. They used Images from different Web resources and uploaded them in the Classwork with the assignments. They also used a video for Maria's content material whereas Sidra had used a Google Docs sheet to present the speech only. There was no additional tool for her content. Also, like Group A, they had not scaffolded the tools as well as they could. But at this level, whatever they came up with was totally unexpected.

Findings to Updated Research Question

The updated research question was divided into four parts like this.

    a) In what ways does PBL help teachers integrate technology with content knowledge?

    b) In what ways does PBL help teachers integrate technology with pedagogical knowledge?

c) In what ways does PBL help teachers integrate content knowledge with pedagogical knowledge?

d) In what ways does PBL help teachers integrate technology with content and pedagogical knowledge?

The data collected to answer each part was in the form of overall performance of the learners especially in Activity 5 and the homework artifacts. From Activity 5, homework assignments and the feedback of the SME, I assumed that both the groups were clear about their ideas and their participation for each activity proved that they had learned a lot about online PBL. For homework, they made their own worksheets that they used as their resources, they had made good lesson plans, they provided links to the resources that they were using which showed that nothing was done in general, but they used very specific material, they used content related to their own subjects and tools they used supported their pedagogical methods and content. The SME said that she would not say that their homework assignments were perfect as some more effort was required to focus on the pedagogical methods but for the beginners, it was a brilliant job.

The pre-interview and post-interview helped me compare the knowledge and skills of the participants. This time training went well, and the results were far better than the previous iteration. I realized that 4 of the participants already had much clarity about PBL and two of them had practiced it also in their classes. The changes I made proved fruitful this time. I cannot say that the question was completely answered as teachers still need time to work on their pedagogical skills. As far as the integration of content material and technology in online instructions is concerned, I was satisfied with the learners' performance. For a detailed view of the results and responses, the data collected can be seen from the appendix list for both iterations.

Discussion and Implications

Data collected from iteration 1 was insufficient to answer the research questions but data collected from iteration two was quite sufficient to answer two parts of the question. PBL helped learners incorporate technology and content knowledge well in their online instructions, but they remained a little behind in integrating pedagogical skills with technology and content knowledge. Results suggest that teachers who participated in the first iteration were less familiar with the advanced tools and PBL. They faced more difficulties because of their minimal background knowledge and because the design was not well planned for them in Activity 3 and Activity 5. The design seemed to be lacking sufficient instructions also due to which they could not perform well in Activity 3, Activity 5 and for their homework assignments. For Iteration 2, the design was improved, and instructions were updated. Iteration 2 proved better because of the improved design, updated research questions, background knowledge and technological skills of the participants. Finally, literature review suggests that PBL is one of the effective ways to design online instructions with the help of TPCK framework and this intervention, especially the data collected from iteration 2 aligns with that. The training intervention, responses and attitudes of the participants suggest that PBL should be adopted as an effective means to design learning environments, but more time and research is required for that.

This EDR paper contributes to the instructional design and technology as instructional designers can use this design to plan research-based solutions for complex problems. Problem-based learning environments designed this way can let the instructional designers explore more possibilities of using technology to support and design the content and pedagogical knowledge. The iterative pattern adopted in EDR can help designers walk through the plan, find out the weakness, review them, make changes, and come up with a better plan for the next time.

Although the research question was not completely answered even after the second iteration, it still contributes to the existing research by highlighting the importance of online PBL as an effective method for training purposes and for new teachers to practice PBL for their online classes. This EDR paper also contributes to the research that emphasizes the value of background knowledge to learn a new concept. The findings of this research also suggested that this type of training design can be more effective for the learners who have a strong background knowledge of PBL and online literacy skills. Another contribution is this training design itself. This type of training can be used in an educational setup like my college in Pakistan where these training sessions are not common and new teachers suffer because of insufficient training and advanced teaching methods.

The limitations of this research include less time, few training sessions and insufficient scaffolding techniques especially for the first iteration. Another limitation is that my participants belonged to another country. I could not get more of their time and their participation also suffered because of everyone's different schedules, weak internet connections, electricity shortage, and different time zones. Lastly, being a researcher and trainer for the first time, I could not implement the design as skillfully or expertly as an expert would have done.

For future research, I would improve the assessment and analysis methods by including tools like rubrics, scales, graphs, or other parameters to analyze the data. I would plan to have participants from nearby locations so that I can meet them in person. Lastly, I would increase the training sessions and each step of PBL would be implemented in one session only with detailed instructions, better facilitation and improved pedagogical and technical skills.

References

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational researcher*, *18*(1), 32-42.

Camargo, C. P., Tempski, P. Z., Busnardo, F. F., Martins, M. D. A., & Gemperli, R. (2020). Online learning and COVID-19: a meta-synthesis analysis. *Clinics*, *75*.

Collin, S., Karsenti, T., & Komis, V. (2013). Reflective practice in initial teacher training: Critiques and perspectives. *Reflective practice*, *14*(1), 104-117.

Cropper, M., & Bentley, J. P. (2006, June). In Search of Empirical Support for Merrill's First Principles of Instruction for Online Instruction. In *EdMedia+ Innovate Learning* (pp. 1792-1795). Association for the Advancement of Computing in Education (AACE).

De Graaff, E., & Kolmos, A. (2003). Characteristics of problem-based learning. *International journal of engineering education*, *19*(5), 657-662.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational researcher*, *32*(1), 5-8.

Frick, T., Koh, J., & Chadha, R. (2011). Designing effective online courses with first principles of instruction. *Education technology in changing society*, 22-47.

Ge, X., & Huang, K. (2022). Designing Online Learning Environments to Support Problem-Based Learning. In Handbook of Open, Distance and Digital Education (pp. 1-18). Singapore: Springer Nature Singapore.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational psychology review*, *16*(3), 235-266.

Hussin, W. N. T. W., Harun, J., & Shukor, N. A. (2018). Problem based learning to enhance students critical thinking skill via online tools. *Asian Social Science*, *15*(1), 14.

Jalilehvand, M. (2016). Study the impact of Merrill's first principles of instruction on students' creativity. *Mediterranean Journal of Social Sciences*, *7*(2), 313.

Li, B. (2022). Ready for online? Exploring EFL teachers' ICT acceptance and ICT literacy during COVID-19 in mainland China. *Journal of Educational Computing Research*, *60*(1), 196-219.

McKenney, S., & Reeves, T. C. (2014). Educational design research. In *Handbook of research on educational communications and technology* (pp. 131-140). Springer, New York, NY.

Merrill, M. D. (2002). First principles of instruction. *Educational technology research and development*, *50*(3), 43-59.

Padmavathi, M. (2017). Preparing Teachers for Technology Based Teaching-Learning Using TPACK. *Journal on School Educational Technology*, *12*(3), 1-9.

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows*, *9*(2), 5-15.

Siddiqui, K. A., Mughal, S. H., Soomro, I. A., & Dool, M. A. (2021). Teacher Training in Pakistan: Overview of Challenges and their Suggested Solutions. *IJORER: International Journal of Recent Educational Research*, *2*(2), 215-223.

Towle, A., & Cottrell, D. (1996). Self-directed learning. *Archives of disease in childhood*, *74*(4), 357-359.

Vijayan, V. R. I. N. D. A., & Joshith, V. P. (2018). Technological pedagogical content knowledge: A framework for 21st century teacher cognition. *International Journal of Research and Analytical Reviews*, *5*(3), 325-329.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning

environments. *Educational technology research and development*, *53*(4), 5-23.

Appendixes

Instructional Plan: Iteration 1

Updated Instructional Plan: Iteration 2

Implementation, Data Collection and Analysis: Iteration 1

Implementation, Data Collection and Analysis: Iteration 2

Pre-Survey

Iteration 1

Learners' Space 1

Learners' Space 2

Post Interview Responses

Artifacts of Learners' homework: Group A: Response **, Group B:** Response

Feedback of SME for Homework

Overall Feedback of SME

Checklist

Post-Survey

Iteration 2

Pre-Interview

Learners' Space 1

Learners' Space 2

Post-Interview

Artifacts of Learners' homework: Group A: Response**, Group B:** Response

Feedback of SME for Homework

Overall Feedback of SME

Checklist

Post-Survey