SINDH TEACHER EDUCATION DEVELOPMENT AUTHORITY

Exploring the Possibilities and Potential Benefits of Using Blended Learning in Elementary Science Classroom: An Action Research Study in Sindh, Pakistan

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Article History:
Received: 15-03-2025
Revised: 20-03-2025
Accepted: 10-06-2025
Published: 15-07-2025

Keywords:
Blended Learning (BL) Approach, Science teaching, Possibilities of BL, Sindh, Pakistan

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Abstract: This study aimed to explore the possibilities of employing Blended Learning (BL) approach to improve science teaching and learning practices in a public school in Sukkur, Sindh. To achieve this objective, an action research method was used to implement the BL approach in grade 7 involving 30 students. The research was divided into two cycles, each cycle consisting of different actions aiming at improving the situation and guiding the actions for the next cycle. The researcher designed and implemented lessons using the BL approach. Throughout the research process, interviews, observations, and focus groups were used to generate data. Data analysis was an ongoing process where the analysis of data emerging from one cycle guided the next cycle. The research revealed that although the BL approach has the potential to influence the science teaching and learning practices positively in the context of Sindh, challenges like limited availability of IT resources and time management hinder the implementation process. Specifically, the research showed that BL improved students' interest and attitude toward science learning, enriched their understanding of science concepts, and promoted a culture of student-centered learning. The paper investigates the possibilities and potential benefits of using BL approach in the context of Sindh, Pakistan where use of BL is an under-researched area.

INTRODUCTION

Currently, Blended Learning (BL) is being widely adopted by educational institutes and is regarded as the most common and efficient instructional mode because of its apparent usefulness in promoting flexible, continuous, and suitable learning (Rasheed et al., 2020). It is an approach that refers to the blend of face-to-face and technology-facilitated teaching and learning (Wendy, W. Porter, Graham, Spring & Welch, 2014). Soomro et al. (2018) in their study also advocate the use of BL in traditional classrooms. As, it lessens the reliance on printed material and also lowers the load of lecture-based classrooms (Soomro et al., 2018). Thus, the Blended Learning approach which combines the use of videos, lectures, and in-class activities is a more effective strategy as compared to the traditional approaches (Stockwell et al., 2015). Moreover, research suggests adopting BL for three reasons: that is, it can bring effectiveness in learning, it increases accessibility and flexibility, and has better cost-effectiveness (Graham & Dziuban, 2008). Particularly, BL has the potential to improve the teaching and learning practices of science. Like, Mandeville and Stoner (2015) assert that BL can bring constructive and inquiry-based teaching into science classrooms.

Similarly, Longo (2016) states that the blend or combination of inquiry and blended learning facilitates a more persuasive and sound approach to science teaching and learning that is progressively stimulating and easy to approach and justify. Bidarra and Rusman (2017) emphasize that in science education students must show how technical ideas they study relate to their daily lives and they must be engaged in activities that enable them to apply known ideas in different contexts (Bidarra & Rusman, 2017). Therefore, BL provides scope for science teachers to design applicable science activities, pertinent to the modern world, and convertible to real-world scenarios (Bidarra & Rusman, 2017; Stockwell et al., 2015). According to Khokhar and Javiad (2016), science teachers are struggling to integrate separate instruction, tasks, and content as per the demands posed by standardized educational contexts of today. Specifically, In the Pakistani context, science is yet taught as 'an article of faith' which has resulted in a lack of curiosity, interest, and motivation among students about understanding scientific concepts and processes (Iqbal & Mahmood, 2000). However, currently, the use of technology has the potential to renovate the education system throughout the world (Khokhar & Javiad, 2016). Thus, BL is one of the current approaches in education which provides an opportunity for educators to make use of the traditional approach and at the same time use technology in their instructional practices. It also helps practitioners to not take ICT integration as a complex phenomenon but provides them a wider scope to blend their existing face-to-face traditional practices of teaching and learning with suitable ICT tools. As a result, the learners remain actively engaged in the teaching and learning process (Hussain, 2019). Hence, by implementing the BL approach, science teachers can bring equilibrium in their teaching approaches that will not only prepare learners for their higher education but will also portray improved and differentiated instructional practices (Longo, 2016). However, in the context of Sindh, Pakistan, there are no studies found that report the implementation of BL at the elementary level. Nevertheless, Soomro, et al. (2018) in their study cite several key challenges which hinder the implementation of BL in the province of Sindh, Pakistan. Such as limited ICT labs, no official training or orientations for implementation of BL in classrooms, no model of BL to be employed, neither any internationally established framework for adoption of BL nor any course designed to present the advantages of BL (Soomro, et al., 2018). Despite such challenges, there are a few technological advancements in Pakistan like the availability of free MOOC resources, access to various online interactive tools, and the prevailing concept of Distance Education (Soomro et al., 2020). Thus, this evidence indicates the possibility of implementing BL in teaching and learning processes in this context but there are negligible studies available that could report the implementation of BL in this context. Hence, this literature gap necessitates the need to study the possibilities of implementing BL in such a challenging context like Sindh, Pakistan where limited computing infrastructure is available. Thus, the primary purpose of this study was to explore the possibilities of implementing BL in an elementary science classroom and investigate how BL can enhance science education in an elementary classroom in the context of Sindh, Pakistan.

THEORETICAL SUPPORT

Definitions of Blended Learning

According to Hrastinski (2019), BL has become an umbrella expression. In literature, all the definitions, conceptualizations, and models consider all types of education that combine face-to-face learning and online learning as BL (Hrastinski, 2019). In other words, most of the studies describe an amalgam of traditional classroom instruction and virtual learning as Blended Learning. However, there is no distinct definition of BL in the literature due to the myriad conceptualizations and meanings of BL as per different modes, technologies, and strategies used. As, Means et al. (2013) in their study state that 'blended learning' and 'hybrid learning' are interchangeable terms without a widely accepted specific definition. Although the term 'Blended Learning' (BL) is difficult to define because of its extensive use, researchers and practitioners have proposed different interpretations and terminologies (Hockly, 2018). Similarly, Hrastinski (2019) also acknowledges the ambiguousness in the definition of BL. Generally, Blended learning refers to the blend of face-to-face and technology-facilitated teaching and learning (Wendy W. Porter, Graham, Spring & Welch, 2014). Traditional face-to-face learning refers to a teacher-directed environment with person-to-person interaction whereas distributed learning system focuses on self-paced learning and asynchronous learning-material interactions (Wang et al., 2004). Almasaeid (2014) in his study presented a different definition of BL. Syahrawati et al. (2022) in their study consider an online learning environment that specifically uses educational technology as the significant feature of BL. Cronje (2020) in his study proposed a mediated definition of BL which combines context, theory, method, and technology. He defined BL as the suitable use of a combination of theories, methods, and technologies to improve learning in a given context (Cronje, 2020). Considering the above conceptualizations by different researchers, BL comprehensively can be defined as an interactive teaching approach that involves a thoughtful incorporation of offline and online classroom activities.

Models used in Blended Learning

Considering the flexible nature of BL, different researchers have proposed a multitude of BL models. Valiathan (2002) developed three BL models. That is, i) the Skill-driven model which combines self-paced learning with continuous support from the facilitator to develop particular knowledge and skills ii) the Attitude-driven model which aims at developing attitudes and behavior by blending traditional classroom with collaborative learning activities iii) the Competency-driven model which facilitates learners by transferring implicit knowledge through observing job experts. In the same way, Graham et al. (2013) presented a few important models. Specifically, he classified these models as a) the Model of Higher education b) the Model of K-12 education, and c) the Model of corporate training. Hui (2016) conscripted the following six profiles of emerging BL models (Horn & Staker, 2014) in her study which were initiated at secondary level education. Concisely, these models are:

1. F2F Traditional Model: The teacher in this model instructs in a traditional classroom setting while using online learning for improvement or reinforcement.
2. Rotation Model: In this model, the students move back and forth between traditional and online learning environments.
3. Flex Model: The course content is delivered through an online approach while teachers scaffold the instructional process using the f2f approach.
4. Online Lab Model: The online course is delivered in a physical classroom or computer lab setting.
5. Self-blend Model: This model allows students to choose online courses on their own supplementary to the courses offered by their school.
6. Online Driver Model: The courses offered in this model are mainly online and physical facilities are only used for extracurricular activities or check-ins.
Apart from these models, Cottrell and Robison (2003) suggest other three types of blends, that is; 'enabling blends', 'enhancing blends', and 'transforming blends' based on their different purpose and foci.

Enabling blends

Enabling blends focus on accessibility and convenience which aim at providing flexibility to learners to choose the learning mode that suits them best as per their cost and time limitations (Lindquist, 2006).

Enhancing blends

Enhancing blends is based on the notion of enhancing the course experience by integrating technology such as the implementation of learning management systems (LMS) and technology-integrated classrooms (Cottrell & Robison, 2003).

Transforming blends

At last, transforming blends as their name suggests aim at completely transforming the pedagogy by using technologies like visualizations, simulations, and mobile devices that allow them to interact dynamically and actively construct knowledge (Cottrell & Robison, 2003).

Blended Learning in Science Education

Many researchers have emphasized science teachers to implement the BL approach in their teaching practices to support teaching and learning practices in public schools to maximize the productive education and outcomes of teaching (Brenner & Brill, 2016; Elmendorf & Song, 2015; Pittman & Gaines, 2015; Ritzhaupt et al., 2017). The research suggests several blended learning strategies being used in science courses such as recordings of lectures, 2-D and 3-D images, computer-supported programs, animated models, and radiographic images (Nicholson et al., 2006). Chen (2017) in his study proposed a BL approach based on Augmented Reality (AR) in which a learning activity based on mobile augmented reality was combined into BL to teach a science course. The results of his experimental study revealed that BL complemented with AR increased students' interest in the course, and they enjoyed the learning process. Simpson and Anderson (2009) also conducted an experimental study on students of grade nine in the context of Germany to investigate the

effect of the blended learning approach on their knowledge and motivation towards Science. The findings indicated that the Blended Learning approach improved the learning outcomes of the experimental group, particularly in the area of cognitive processes showing higher levels. Krishnan (2015) also conducted an experimental study on students of secondary grade to examine the effect of the Blended learning strategy on their science achievement and science process skills. The study showed that BL is more effective than the traditional method in increasing science achievement and science process skills among secondary school students. The research revealed that using the Blended learning strategy led to improvement in the achievement skills and attitudes of students as compared to students who were taught through traditional teaching methods.

Theoretical Roots of the Study

Although there is a limited amount of research regarding the development and use of theory in the realm of BL (Drysdale et al., 2013), currently a broad theoretical framework stated as technological pedagogical content knowledge (TPACK) presented by Mishra and Koehler (2006) serves as a theoretical root for integration of technology in education. Technological Pedagogical Content Knowledge (TPACK), developed by Mishra and Koehler (2006), is a combining structure designed to blend components of content, pedagogy, and technology in a way that enables teachers to deliver effective technology-infused lessons (Hilton, 2016). Hilton (2016) in his study defines TPACK as a framework that consists of seven areas and is illustrated as circular. The framework involves technological, pedagogical, and content knowledge as three knowledge domains. That is, TK, PK, and CK. The framework depicts three intersections, connecting pedagogical and content knowledge, technological and pedagogical knowledge, and technological and content knowledge. Namely, PCK, TPK, and TCK. The intersection at the center constitutes the crux of this framework which intersects all three domains and forms a Technological Pedagogical Content Knowledge (TPACK).

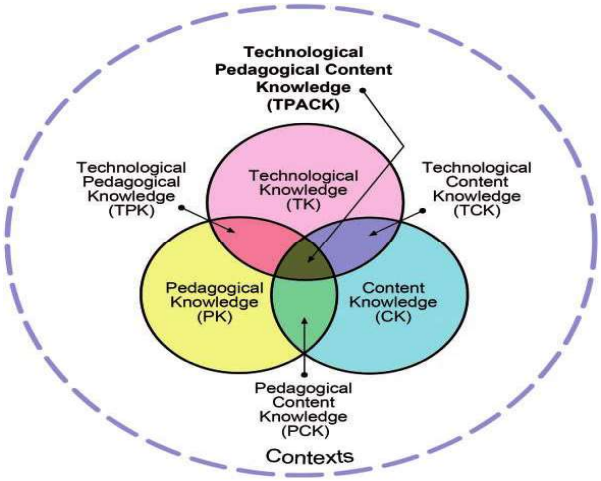

Figure 1. TPACK Framework

Similarly, for this action research study, The Science Learning Activities Model (SLAM) proposed by Bidarra and Rusman (2017) is adopted. Although the SLAM model has its theoretical roots in the TPACK framework reflecting the pedagogical, technological, and contextual dimensions, this design framework is based on three dimensions: context, technology, and pedagogy. It is specifically used for the integration of science learning into formal as well as informal contexts through the BL approach via using flexible, interactive, and immersive technologies of today such as augmented reality, mobile, and virtual reality (Bidarra & Rusman, 2017). It is based on three significant dimensions which are explained as follows:

Context

In this model, Bidarra and Rusman (2017) have entailed three types of contexts. Firstly, it refers to formal and non-formal learning which involve features like specifying topics and types of science activities and how they will fit together in a learning situation like field trips, lab, science center, etc. Secondly, they define context as individual and collaborative learning which includes characteristics like specifying science study modes and related resources. Finally, they describe context as an open and closed learning environment in which free and restricted learning environments and resources are combined such as massive open online courses (MOOC) and small private online courses (SPOC).

Technology

Bidarra and Rusman (2017) in their SLAM model define technology to be used in three ways. Firstly, it is described as synchronous and asynchronous learning which includes technology-facilitated science learning interaction modes. Secondly, they define technology as virtual and physical interaction which involves technology used for blended learning interaction. Lastly, it refers to single platform and multi-platform which involves integration of online learning platforms as needed such as Moodle, Moodle Mobile, Blackboard, and Edmodo.

Pedagogy

Bidarra and Rusman (2017) describe their SLAM model-related pedagogy in four ways. Firstly, it involves Theoretical and hands-on activities such as a mixture of student-centered science activities as per a blended learning curriculum such as activities based on personal learning environments (PLEs) and social networks. Secondly, it includes Restricted and open learning design which involves activities like multiple-choice tests, teacher-marked assignments, games, portfolios, open discussions, and simulations. Next, they included open and centralized assessment which involves peer-assessment, self-assessment, formative, and summative assessments. Finally, the pedagogical dimension of SLAM includes modes of supporting the learning process and tutored activities such as peer assistance and tutorials.

Table 1. Science Learning Activities Model (SLAM)

	Seamless dualities	Typical features
Context	Formal and non-formal learning	Specification of topics and types of science activities and how they fit together in learning scenarios (e.g. lab, science center, field trip, etc.)
	Individual and collaborative learning	Specification of science study modes and related resources
	Open and closed learning environment	Combination of free and restricted access learning environments and resources
Technology	Synchronous and asynchronous learning	Technology supporting science learning interaction modes
	Virtual and physical interaction	Technology for blended learning interaction
	Single-platform and multi-platform	Online learning platform integration as needed (e.g. Moodle, Moodle Mobile, Elgg, Blackboard, Edmodo)
Pedagogy	Theoretical and hands-on activities	A mix of learner-centered science activities set in a blended learning curriculum
	Restricted and open learning design	Design of structured activities for restricted outcomes (e.g. multiple-choice tests and tutor-marked assignments), and design of open activities (e.g. games, simulations, portfolios, and open discussions)
	Centralized and open assessment	Modes of learner assessment components in a learning scenario with many activities (e.g. formative and summative assessment, peer assessment, self-assessment)
	Pre-structured and open guidance	Modes of scaffolding the learning process and tutoring of activities (e.g. tutorials and peer guidance)

METHOD

Research Design

Concerning the research method of this study, the qualitative research method was employed to explore the possibilities of implementing BL in an elementary science classroom. Since this study was focused on BL experiences of elementary students in science classrooms, the qualitative research method was best suited to explore them. Specifically, the action research design was used in this study, as the aim of this study was to implement BL in an elementary classroom to improve science instructional practices in science. Particularly, the action research spiral model proposed by Kemmis and McTaggart (2000) was used in this study. The spiral model stresses the cyclical process of action research that surpasses the early plan for change and based on the initial cycle of research, it also suggests revisiting and revising the initial plan (Clark et al., 2020). The SLAM model of BL proposed by Bidarra and Rusman (2017) guided the actions in each cycle as the model combines context, technology, and pedagogy. Hence, all the BL activities were carried out as per features in the SLAM model for integrating BL into science teaching and learning.

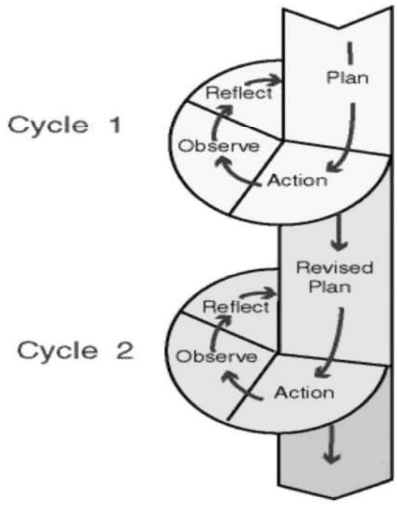

Figure 2. Kemmis and McTaggart Action Research Model (2000)

Research Setting and Participants

The research was conducted in one of the public schools of Sukkur, Sindh. The primary reason to select the particular school was that it provided a favorable infrastructure and setting with regard to provision of technology which was required for implementing BL as compared to other public schools of Sukkur. The convenient sampling was used to select the class sample of this study. The research was conducted on grade 7 students at a public school in Sukkur, Sindh. The participants for this research were thirty students including girls and boys. Although all students of the class took part in the study, to collect manageable data, one-third of them were selected through random sampling. As, Noor et al. (2022) in their study state that random sampling assists the researchers in randomly selecting an impartial, representative, and equal prospect of the population for their study.

Therefore, the researcher employed a random sampling technique to ensure that all students of the class sample had equal opportunity to take part in the research.
To ensure the validity and reliability of data collected in this action research, triangulation was employed. Hence, in this study, interviews, observations, and focus group discussions were utilized as complimentary foundations of information. By utilizing multiple data collection techniques, the findings of this study were validated across different sources, thus enhancing the dependability and credibility of the outcomes of this study.

Research Instrumentation

A variety of tools were used to collect data throughout the three phases of the study, that is, reconnaissance, intervention, and post-intervention. The observation checklist, interviews, focus groups, and field notes were used. To know the current science teaching and learning practices, a classroom observation tool was used. The observation checklist was based on the three dimensions of the SLAM model designed by Bidarra and Rusman (2017), that is Context, Technology, and Pedagogy. Each dimension of which is further split into seamless dualities, specifying typical features of a BL Classroom. The science teacher was also interviewed in the pre-intervention stage to explore her existing science teaching and learning practices regarding the integration of technology into her science lessons. The interview protocol was also grounded upon the three dimensions of BL proposed by Bidarra and Rusman (2017) in the SLAM model and Technology Integration Protocol TIP developed by Li and Dawley (2019). To know students' current and post-intervention experiences of learning science, they were involved in two focus group discussions which were then audio-recorded and transcribed. The Focus group discussion tool which was used in the reconnaissance stage involved a few components of BL mentioned in the SLAM model while the Focus group discussion carried out after intervention involved general questions encompassing the BL activities done in the intervention stage.

RESULT AND DISCUSSION

Situational Analysis

Before implementing BL in science classrooms, a situational analysis was carried out to understand the existing situation regarding science teaching and learning practices. After obtaining informed consent from the principal of the school, the science classroom of grade 7 was observed, the field notes were taken, an interview was conducted with the science teacher and the students were also involved in a focus group discussion to learn about the use of BL in their existing science instructional practices.

The observation aimed at identifying the teaching and learning practices of science teachers with an emphasis on the use of BL in the science classroom. For this purpose, the science classroom of grade 7 was observed a couple of times. The observations were recorded using a checklist while the researcher also took field notes throughout the reconnaissance stage. The data emerging from the observations revealed that the science

teacher occasionally integrates ICT into her lessons like she used virtual images as a starter activity which helped her to stimulate students' thinking. However, whole class discussions, and group tasks without any use of technology were dominant teaching and learning practices in her science lessons.

To learn about students' current experience of learning science, they were involved in a focus group discussion. The results of the session revealed that they were involved in group discussions, reading activities, and lecture sessions in their science classroom. Sometimes, they also went to science labs to practically understand some of the concepts. As far as the use of digital resources was concerned, the students mentioned that they had never learnt science through digital games, quizzes, or animations or images to learn science which also aligned with the results of observations conducted by the researcher.

First Cycle

As per the research framework of this study, the SLAM model proposed by Bidarra and Rusman (2017) guided the steps for action research cycles. To plan the lessons, the National Curriculum of Science (2016) was considered to pick students' learning outcomes such as 'to explain what an atom is', 'to understand what an element is', 'to know the symbols of the first 20 elements of the periodic table', etc. To implement BL approach, 'context, pedagogy, and technology' were selected as per the SLAM model. For instance, specifying science topics and activities (formal and non-formal learning context), selecting technology as per requirement such as the use of images, videos, animations, and games (virtual and physical interaction), and finally choosing pedagogy such as open discussions, games, think-pair-share, group work, etc. combined with formative assessment.

The first step was to select the science topics and objectives for the BL lessons. For this purpose, the curriculum and textbook followed in the school were referred to. The next step was to design the BL lessons as per the SLAM model and the availability of ICT resources in the school. The first cycle involved two lessons each lasting 40 minutes.

The first lesson was 'introduction to atoms and elements.' In this lesson, traditional teaching and learning activities like whole-class discussions, Questioning, Group work, and pair-work were blended with a YouTube video on 'Introduction to atoms.' As per the context dimension of the SLAM model, the IT lab was used as a closed learning environment after coordinating with the school coordinator and making changes in the timetable of grade 7. The pedagogical aspect of the lesson involved an open activity like whole-class discussion where the use of video helped to scaffold the students' learning process and formative assessment was used throughout the lesson to ensure students' understanding. The students reacted by taking interest in the video and were responsive while sharing a review of the video.

The second lesson of the first cycle was based on a blend of reading, group discussion, and an online quiz named Kahoot. As, time management emerged as a challenge in the first lesson, the researcher could not complete her assessment part. Therefore, the researcher planned a review of the previous topics through an online quiz Kahoot. However, the lesson did not go as planned. After reading and discussion activities, the researcher realized that the internet was not working in the IT lab. Hence, the students could not attempt an online quiz regarding the review of previous topics and play a game

related to elements and their symbols. As a plan B, the researcher used an online learning platform and a social network, that is, Google Classroom and WhatsApp group to remain connected with the students regarding their science learning where she shared the link to an online quiz with students that they were supposed to attempt. It helped the learners to easily attempt the quiz and share their results in the group.

On the basis of data collection and analysis, the first cycle presented following major learnings. Firstly, activities like online quizzes and learning games could not be implemented smoothly due to poor internet connectivity in the school. Secondly, because of limited IT resources and time, all the dimensions of the SLAM model could not be implemented in one lesson. Thirdly, the availability of IT labs was not guaranteed due to the school's busy schedule. As concerns students, it was entirely a new approach for them, and they had never learnt science this way before. However, it was observed during the lessons that they were exhibiting interest in different BL activities. It was also clear from the assessment activities that they were comprehending the science concepts. However, they took some time to adjust to the new mode of learning and thus were learning the use of technology to learn science through different BL activities. Although the majority of the students were responsive and active during the lessons, some of the students were hesitant towards this new approach.

Second Cycle

Based on the lessons learned during the first cycle, the researcher planned the lessons in the second cycle as per the limited availability of resources. The researcher also realized after the first cycle that there were not enough IT resources such as individual laptops and smartphones to be used in the science lesson. Therefore, she planned collaborative blended learning activities that students could easily do in groups by taking turns. Hence, the researcher planned all the lessons of her 2nd cycle as per the availability of laptops of students in the class to avoid any technical issues that emerged in the 1st cycle. Like, in the third lesson which was a blend of teacher's input, reading, pair discussions, and an online interactive digital game, the researcher made 6 groups and utilized 6 laptops in the lesson along with a high-speed internet connection which was arranged by the researcher herself. As a result, the lesson went smoothly, and students were able to participate in all the BL activities without any technical challenges. The researcher recorded their game scores as 10/10, 9/10, and 8/10 which indicated that they had comprehended the concept well.

In the third lesson, students read the rules of writing chemical symbols from the book, discussed the topic with their peers, and then practiced it in groups through an online digital game. As, the game contained different interactive modes such as matching, popping balloons, quizzes, etc., the students were enjoying the learning process. Similarly, the fourth lesson was a blend of images, animations, video, and group work. The topic was 'metals and non-metals' for which the researcher used virtual images of metals and non-metals as a starter.

The topic for the 5th lesson was 'compounds.' In this lesson, the researcher blended the activities like demonstration, reading, discussion, and a video on compounds. For demonstration, the researcher used two sets of toy bricks having different colors. That is, she used blue toy bricks to indicate atoms of carbon and white toy bricks to indicate atoms of oxygen. Then, she combined both types of toy bricks to indicate a compound. This time students watched the video in groups and discussed it as well at their own pace which

helped them to comprehend it well. After the video, the students from each group presented the differences between elements and compounds which reflected their clear understanding regarding the topic. In this lesson, the researcher also used the element of peer assessment.

The sixth lesson was a review of 'atoms, elements, and compounds.' In this lesson, the researcher used a PowerPoint slideshow of different images, reading material, and an online interactive quiz to blend the lesson. The slideshow of virtual images of sodium atoms and elements and chlorine atoms and elements and then how they make up a compound i.e., sodium chloride helped the researcher to clarify the difference between atoms and elements. Furthermore, the reading material about atoms, elements, and compounds also helped the students to understand the difference between these concepts. Finally, an interactive quiz on Quizizz grabbed students' attention and they showed great interest in the quiz.

The topics for the seventh and eighth lessons were 'naming the compounds and writing formulae'. In these lessons, the researcher blended reading, whole-class discussion, group work, and an online game and quiz to facilitate students regarding the topic. The students learned the rules of naming the compounds and writing formulae from the book, discussed them in groups, and presented their understanding by writing some examples on the board. The teacher facilitated the discussion and then involved them in collaborative work in which they played games on matching compounds with their names and formulas.

In view of the data evolving from the study, the emerging insights are presented under the following two major themes in this chapter. The themes presented as follows are based on the analysis of the focus group discussion with the students, interview from the science teacher, observation, and field notes taken by the researcher. This chapter also elucidates the discussion part.

a) Possibilities of implementing the BL Approach
b) Potential benefits of implementing the BL Approach

Possibilities of implementing the BL Approach

It was found in this study that despite the scarcity of IT resources, it is possible to implement BL in the science classroom by utilizing available resources and employing a more collaborative approach. For instance, the researcher planned the technology-based components of the blended lessons like quizzes, games, etc. in groups which allowed the researcher to involve each student in ICT-based activities by utilizing limited available resources. Secondly, this study showed that it is possible to introduce ICT into traditional science lessons with the cooperation of school management. As in this study, the school management allowed students to bring their laptops to science lessons, making it possible for the researcher to manage the IT resources and blend her lessons. Thirdly, the results of this study suggested that it is possible to encourage science teachers to use BL in their lessons with the help of relevant orientation and practice. In this study, the researcher discussed the use of different IT resources and implementation of each BL lesson with the science teacher in detail. In addition, the science teacher also keenly observed each BL lesson implemented by the researcher and shared her reflections about different IT resources used in the lesson and their positive effect on students' learning which helped her to develop a positive attitude towards using this approach.

Specifically, the data obtained from the observations, field notes, and focus group discussion showed the following possibilities for implementing BL approach in an elementary science classroom:

Firstly students could easily access online learning resources before as well as after the class. As, one student commented during focus group discussion that " This approach is quite interesting because technology enables us to explore and practice different games, quizzes, etc. in class as well as at home. As we don't like to open books at home but can revise science concepts through technology". Secondly, the students could easily rotate between different learning activities, such as online learning, small-group activities, and teacher-led instructions which provided a flexible learning environment to learners. Like, the observational data showed that during most of the BL lessons, students were constantly switching from one BL activity to another in order to grasp the topic comprehensively. Thirdly, BL provided the flexibility to learners to choose when and where to learn the course content and progress at their own pace. As, during focus group session a students mentioned that "In this approach, we can easily access online games, animations, and quizzes about different science concepts in class as well as at our home which allows us to learn science anywhere and revise topics for our exams".

Potential benefits of implementing BL Approach

This research study revealed several potential benefits of the BL Approach in science learning. Firstly, it has the potential to increase students' interest in science learning. The observations conducted by the researcher as well as her critical friend and comments made by the students during focus group discussions indicated improvement in students' interest, curiosity, and motivation level to learn science. Though, at first it was an entirely new approach for them to learn science using technology, their curiosity and excitement were noticeable in the concluding lessons. When a student was interviewed, she said "When we constantly listen to the lecture and keep on reading books, we get bored and tired. However, whenever we learn through this approach, we instantly get ready to study." One of the students also associated the BL approach with the technological shift in their lives by saying "The children of our age take a lot of interest in games and applications so I suggest that technology should also be used to make us learn the subjects like Science." In the beginning, students were not used to this approach and sometimes even expressed confusion whenever involved in a learning activity that used technology. In other words, they did not know that they could also do several online interactive activities relating to science. Conversely, at the end of the intervention, the researcher observed a noticeable change in their perspectives regarding the use of technology in learning. Like, as a student commented during an interview "This approach is quite interesting because technology enables us to explore and practice different games, quizzes, etc. in class as well as at home. As we don't like to open books at home but can revise science concepts through technology." In the beginning, students used to associate science subjects with boredom while at the end of intervention, there was an evident change in their attitude towards science learning. As a student quoted "When we are involved in different activities and learn things using technology, we remain active as compared to just listening to the lectures and reading from books". Hence, it suggests that the BL approach has the potential to enhance students' interest and attitude towards science learning.

Secondly, according to the analysis of focus group discussions and observations, BL helped learners to remember and comprehend science concepts easily. As commented by a student during a focus group discussion "When we learned science along with technology, it was easy for us to remember everything, and we did not get tired. However, when we used to learn science by just listening to the lecture and reading, it was likely for us to forget things easily and we used to get a little bit tired and bored as well." When inquired further, the students explained that technology like games, quizzes, images, videos, etc. are quite interactive which helps them to remember and comprehend science concepts easily. Like, a student said that "Learning through technology is fun and it is quite interactive, therefore we can easily learn through it." It was also found that BL assist learners to listen as well as have a look at the science concepts they study which increases their understanding level.

Thirdly, the use of BL informed the teacher as well as students about the potentials of technology regarding their teaching and learning practices. Previously, the students were not aware of different technological resources which can help them in their learning. Like, a student shared her views that "The way you teach us science is quite change from the way we used to learn previously. In your class we used to play games, watch videos, see images, and attempt online quizzes. So, we came to know that we can also learn science by using technology and it can help us to improve our science concepts and prepare for our papers as well." In the same way, the teacher shared her observation that it was informative for her to learn about different interactive technological resources which can enrich students' science learning experience. As, she stated that "I came to know about different relevant technological resources like online games, animations, and quizzes which I can easily access and integrate into my science lessons and make them more interactive and engaging." Hence, this finding suggests that BL enable teachers as well as students to broaden their science teaching and learning practices by exploring a variety of relevant technological resources which can enhance their science teaching and learning experience.

Fourthly, the following findings from the observational data and field notes disclosed that BL promotes a culture of student-centered learning as it gives flexibility to students to explore and learn science by different means. For example, when students were asked to play an online game regarding 'naming the compounds', the students explored and played different modes of games as per their interest and learned at their own pace. Similarly, when they were learning about the properties of metals and non-metals via video, they supervised their own learning. As, the researcher observed during the lesson that they were resuming the video, taking notes, and discussing it with each other frequently to grasp the concept which reflected their active role in their own learning. Similarly, when students were asked to give presentations on a science concept, they not only used their understanding from the lecture but also read from books, use images, videos, and available technological resources to understand which showed their active agency in the learning process.

Discussion

Considering the results presented above, some significant inferences can be made. Firstly and significantly, this study found that BL has the potential to improve student's interest

and attitude towards science learning as they showed increased levels of excitement and curiosity during most of the BL activities. Osman and Hamzah (2020) also found in their study that students exhibit a greater level of interest and motivation in BL classrooms. Similarly, Kumar (2010) asserts in his study that BL enables learners to remain active in the learning process which also supports the findings of this study. In the same way, Susan and Chris (2015) in their study found that BL helps learners to be more active and creative in the learning process.

Secondly, this study found that BL not only assists learners in improving their comprehension of science concepts but also impacts their learning experience positively because of its interactive nature. As, it was observed during the lessons that students found the science content presented in the form of videos, quizzes, etc. as comprehensible and interactive. Hence, their association of science subjects with boredom was replaced with interest and excitement which aligns with the study of Bouilheres et al. (2020) who found that BL can impact students' learning experiences and their engagement with the course content positively. Similarly, Susan and Chris (2015) also highlighted the exhibition of activeness, interest, and creativity as significant potential benefits of BL as found in this study. In the same way, a study conducted by Alsalhi et al. (2019) noted that teaching science through BL had a positive influence on students' science assessment scores. Besides the positive influence on students' comprehension and test scores, BL also promoted a student-centred culture as per the findings of this research study. Capone (2022) in their study also found that the discovery aspects, and practical, and collaborative nature of BL allowed students to be active throughout the learning process, thus stimulating a student-centred learning environment.

Thirdly, BL not only proved to be an insightful approach for students to learn science, but it also enlightened the science teacher regarding various interactive technological resources which ultimately helped her develop a positive attitude towards BL. This finding suggested that if teachers are exposed to practicing BL, they can develop a positive attitude toward it which aligns with the study of Saboowala and Manghirmalani-Mishra (2020) who mentioned in their study that those teachers who are exposed to the BL approach by either being part of the implementation or by attending webinars/conferences are more likely to develop positive attitude towards BL. Another study conducted by Qasem and Nathappa (2016) also relates to the findings of this study in which they found that BL offered a better learning environment to teachers through varied technological resources which helped them to broaden their self-learning strategies. Similarly, in a study by Yılmaz and Malone (2020), science teachers developed a positive attitude towards the use of BL when exposed to different BL activities.

CONCLUSION

This action study explored the possibilities of implementing this approach in the context of Sindh, Pakistan. The study revealed that although the BL approach required infrastructure and adequate IT resources to be implemented, it can be employed even with a limited availability of IT resources. Several potential benefits emerged because of the implementation of the BL approach in science. It not only improved students' interest and attitude towards science learning but also helped learners comprehend complex science concepts because of the use of a variety of interactive resources in the science lessons. As,

students were mostly involved in interactive tasks like discussion, watching videos, playing games, preparing presentations, and attempting quizzes, it promoted a student-centered learning environment where students were found actively participating in their learning process. In addition to contributing positively to the learning process of students, the science teacher also learned how she can use a variety of available technological resources to blend her science lessons. As, she found the IT resources used in the science lessons effective, engaging, and new for her which contributed to her professional learning. This study has some significant implications for science teachers, teacher educators, and school management, as well as for future researchers. Firstly, this study showed that despite the limited availability of IT resources, it is possible to implement BL in science classrooms with a more collaborative approach and effective resource management. Hence, this finding encourages science teachers in this context to employ this approach in their science classroom even with limited availability of resources. Moreover, it was also found in this study that the BL approach improved students' interest and attitude towards science learning which implies science teachers to use this approach in their instructional practices. Improvement in students' understanding of science concepts was another significant finding of this study which suggests science teachers use the BL approach in their daily teaching and learning practices. Moreover, the interactive nature of technology and its potential to engage students in an active learning process indicate school management to extend support to science teachers in terms of providing IT resources and relevant orientation, capacity, and training so that they can use this approach effectively.

ACKNOWLEDGMENT

I am much obliged to my supervisor, Dr. Ali Nawab, for his continuous guidance and support throughout my research study. He facilitated me during each phase of my study by giving his valuable feedback on my work. His valuable suggestions always assisted me in improving my work and added rigor to my study.

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