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DESIGN OF A LESSON PLAN IN THE CONTEXT OF STEM EDUCATION FOR PROSPECTIVE PRIMARY SCHOOL TEACHERS

Abstract

This paper explores the issue of organization and implementation of the educational process in the context of STEM education. The relevance of the research arises from the need to train students who are capable of implementing interdisciplinary integration in the educational process, to master the ways and methods of teaching through STEM, and to identify the possibilities for establishing interdisciplinary communication through common topics. The main goal of the study is to develop a lesson plan in the context of stem education for prospective primary school teachers. Stages of developing lesson plans based on STEM include the issue of teaching through STEM, analysis of school textbooks, use of digital resources, STEM lesson planning, and so forth. These actions culminate in the creation of STEM-based lesson plans. This workshop aims to integrate STEM elements, utilize PhET stimulations, and stimulate interest in science subjects. The results of the study demonstrated that students developed skills in problem-solving, critical thinking, cooperation, and interdisciplinary communication. The results of quantitative data during the study were analyzed as descriptive statistics.

Keywords: STEM education, lesson plan, interdisciplinary communication, integration, technology, workshop, statistics, experiment.

Basic provisions. Implementation of activities focused on fostering capabilities necessitates the enhancement and management of new technologies by prospective teachers. In this context, one of the main objectives facing universities is the employment of applied knowledge and the introduction of innovative methods. In this regard, it is essential to consider ways to incorporate STEM elements into the university and school programs. Such innovations are crucial to be introduced into the educational process nowadays. The central idea of the study is to determine the stages of lesson plan development in the context of STEM education for prospective primary schoolteachers. The implementation of this idea was guided by the following basic provisions: Scientific-theoretical studies on the issue of teaching in STEM education; Information about the stages of lesson planning in the context of STEM education; Data from a survey describing STEM-focused learning.

Introduction. Research in the current education system addresses the issue of teaching in the context of STEM education due to technological progress. STEM education is recognized as an integration of various disciplines focused on solving real problems. Therefore, an interdisciplinary approach enables the development of new knowledge and abilities in addition to enabling the resolution of complicated problems. By incorporating different academic subjects, teaching contributes to innovation and enhances critical thinking (Drake & Reid, 2018).

For the first time in Kazakhstan, the "STEM" concept was observed within the educational program of the development of education and science for 2016-2019. To implement this new education policy, the ways were planned in the curriculum to introduce STEM elements into the educational process, aimed at the development of scientific innovative technologies, natural science, and mathematics (Twlentaeva, Seylova

& Berkïmbaev, 2023; Abdikarimova, 2022). In this context, actions were planned to introduce interdisciplinary integrated projects focused on enhancing students' scientific and technological capabilities. These projects facilitate the cultivation of creative thinking, critical thinking, and communication skills. Vasquez et al., (2013) conducted a comprehensive review on STEM integration, emphasizing the essence of increased integration aimed at developing the connection of subjects. They identified four types of interdisciplinary integration:

- disciplinary – teaching concepts and definitions in the framework of a separate discipline;
- interdisciplinary - teaching concepts and definitions within the framework of common topics;
- interdisciplinary - teaching concepts and definitions within different disciplines;
- transdisciplinary – applying knowledge and skills obtained from various disciplines to solve global problems.

According to the methodological proposal from Y. Altynsarin National Academy of Education under the Ministry of Education of the Republic of Kazakhstan, STEM - education is a complex approach that includes teamwork and project work among students, facilitated by progressive teachers, modern technological equipment, integration of several sciences and academic subjects, creativity (Altynsarin Academy, 2022). Therefore, the issue of teaching the educational process in the STEM environment is one of the most relevant and demanding research.

Consequently, to instil students' interest in science from an early age, initiatives such as the development and support of "STEM laboratories" and "STEM education - new opportunities" topics in professional development courses for teachers of pedagogical professions are highlighted within the educational programs. This emphasizes the importance of designing a lesson plan in the context of STEM education within the educational process.

Materials and Methods. In this connection, it is crucial to review the research conducted by domestic and foreign scientists who have studied the issue of teaching within STEM education. A comprehensive literature review enables to reveal among many studies, confirming that the utilization of STEM elements in the learning process enhances students' critical thinking, increases interest in learning science, and fosters a positive attitude toward innovation (Vega et al., 2019; Yildirim, & Altun, 2015; Sanz-Camarero et al., 2023).

In the current research, it was noticed that STEM-oriented research is increasing in Kazakhstan (Kwdaybergenova, 2023; Baxıtova & Kasımova, 2020). For instance, within the framework of the updated educational program, interdisciplinary communication is implemented based on common topics fixed in curricula. However, regardless of the inclusion of some concepts in textbooks such as mathematics, natural science, and cognition of the world, many challenges prevail in incorporating STEM elements into the educational process. This challenge is connected with the need to enhance teachers' competency in STEM-oriented knowledge and skills.

According to Ching et al., (2019), STEM education should begin in primary school. Learning through STEM allows students to see the world as a whole, cultivating meta-subject and cognitive skills among learners (Yesnazar, 2023). Consequently, a basic objective is to direct students in choosing and refining the way they are interested in from primary school. Involving a subject of interest allows students to make predictions, draw conclusions, share experiences, make arguments, and analyze data, acting as a researcher. There is reason to believe that knowledge, skills, and abilities in this direction are cultivated in the context of STEM education. This is because teaching in STEM facilitates the learners' deep comprehension of subjects and the application of interdisciplinary knowledge in practice. In other words, STEM includes the implementation of natural sciences, technology, engineering, and mathematics through interdisciplinary and project-based approaches (Umutlu, 2022; Faulconer & Chamberlain Jr, 2022; Habig & Gupta, 2021). Therefore, presenting knowledge based on natural science within interdisciplinary

connections enables learners to enhance their ability to apply academic concepts and knowledge in practice. In this regard, Alatas and Yakin (2021) emphasized in their study that STEM education affects students' problem-solving skills and proves its effectiveness. One of the studies that comes close to our study, Alrwaished (2024), examined the skills and difficulties that develop in creating a STEM-based lesson plan.

It is imperative to prepare prospective teachers for STEM education. In our country, there is an insufficiency of studies concerning educational programs aimed at introducing STEM elements into the educational process. Therefore, focusing on the acquisition of STEM-oriented knowledge, skills, and abilities becomes essential. Attaining this goal entails designing a lesson plan in the context of STEM education.

STEM is considered an interdisciplinary approach that integrates science and technology, engineering, and mathematics. Therefore, it is necessary to organize lesson planning, and comprehensively develop common topics, common concepts, and understandings related to STEM education. According to researchers, it is very important to understand the relationship between disciplines (Pymthong & Williams, 2018).

STEM-based lesson plans aim to cultivate critical 21st-century skills. These plans provide an opportunity to foster science and math literacy and acquire engineering and technology. Studies have indicated that STEM education facilitates perspective teachers' personal and professional growth, enhancing their academic and cognitive skills (Çiftçi et al., 2022).

In his research, Ha (2023) investigates teaching practices in the STEM context. The author emphasizes activities such as educational robots and games, research-oriented engineering design games, and drawing and developing models, which contribute to enhancing students' scientific and technological literacy. Ibrayeva and Shaushekova (2023) developed a program titled "Early STEM Integration" aimed at STEM education. The content of the program includes topics focused on enhancing students' scientific and technical interests, leading to fostering their interdisciplinary knowledge, innovative ideas, and universal learning activities.

Ageyeva & Agranovich (2023) studying the issue related to training prospective primary school teachers, proposed ways to incorporate "STEM education in primary school" and "Steam - approach in primary school" as additional minors to the educational programs of higher education institutions. This introduction is intended to increase the scientific and technical literacy of students. It is an integrated practice-based study. Moreover, Abdrakhmanova and Kudaybergenova (2023) in their research proposed to introduce subjects related to STEM to educational programs of universities, to implement methodological seminars and trainings aimed at STEM education, thus contributing to the development of educational programs.

The current study found Bekbauova & Turebayeva's (2022) work on implementing the educational process in the context of STEM particularly interesting regarding the enhancement of students' knowledge. In the study, the scientist considered that "STEM education is an experimental teaching pedagogy integrated into contextual projects or tasks oriented to learning outcomes related to the development of students' important skills for choosing a perspective career using knowledge and skills". The author highlights not only the utilization of software equipment, 3D models, SketchUp program, and Blender program to increase interest in the subject but also the central role of the teacher as a mentor and educator rather than just an informant.

Summarizing the abovementioned research, the researchers comprehensively explored the research problem, revealing a gap in the studies aimed at lesson planning in the context of STEM education. Therefore, it is very important to apply the knowledge of different subjects in teaching a particular subject. In this regard, the purpose of this study is to develop a lesson plan in the context of STEM education for prospective primary school teachers. This study aims to address the following questions: How should we design a lesson plan in the context of STEM education? What are the challenges

faced in planning a lesson in the context of STEM education?

Results. The study was conducted among students enrolled at Ozbekali Zhanibekov South Kazakhstan Pedagogical University. The sample group was randomly selected from the fourth-year students of the educational program 6B01301 "Pedagogy and Methodology of Primary Education Teacher Training".

The survey and descriptive statistics methods were employed during the research. The study was conducted during the fall semester of the 2023-2024 academic year.

Therefore, the following demographic criteria were applied for the respondents who were randomly selected for experimental work, as outlined in Table 1:

Table 1. Respondent Demographics

Criterion	Gender		Age		Nationality			Prior education	
Group	Female	Male	18-21	22-25	Kazakh	Russian	Uzbek	School	College
Control group (n=19)	5,3%	94,7%	84,2%	15,8%	94,7%	5,3%	-	84,2%	15,8%
Experimental group (n=22)	-	100%	90,9%	9,1%	81,8%	13,6%	4,6%	86,4%	13,6%

In the sample group, in the control group of the 4th year of the educational program 6B01301 - "training of a teacher of pedagogy and methods of Primary Education", men - 5.3%, women - 94.7%; the average age was 20 years; the largest share of nationalities was determined as Kazakh-94.7%. In the experimental Class, A woman was 100%, the average age was 21 years; Kazakh - 81.8%, and Russian - 13.6%.

The survey was conducted in September 2023, the purpose of it was the confidentiality of the responses provided, and the right to withdraw from the participation at any time that was explained to respondents.

Analysis of the survey results underscored a lack of STEM knowledge among students. Therefore, to compensate for these gaps, practical lessons related to the development of STEM-based lesson plans have been incorporated into the curriculum under the "Methodology of Science Teaching" subject. These lesson plans were developed based on suggestions from teachers of mathematics, science, and digital literacy. We will consider the study in five stages (Table 2):

Table 2. Stages of developing STEM-based lesson plans

Week	Schedule	Topics	Hour
1-2	Introduction	Introduction to the STEM approach	1
		Consideration in regulatory documents	1
3-5	Issues of Teaching through STEM	Analysis of psychological and pedagogical works	1
		Ways and methods of teaching through STEM	1
		Study and discuss STEM-focused articles	1
6-8	Analysis of school textbooks	Study of Primary Education textbooks	1
		Identifying possibilities to establish interdisciplinary communication through common topics	1
		Identifying ways to integrate STEM elements	1
9	Utilization of digital resources	Possibility of utilizing PhET simulations for STEM education	1

10-12	STEM Lesson Planning	Choosing appropriate lessons	1
		Implementation of learning objectives in interdisciplinary communication	1
		Connecting common topics with elements of engineering, mathematics, science, technology	1
Total			12

In the first stage, we explored the current state of STEM education in regulatory documents, methodological guidelines, and educational programs.

In the second stage, we investigated pedagogical theories concerning STEM education, as well as different ways and methods of teaching through STEM, etc. Moreover, we conducted a comprehensive analysis of STEM-oriented articles from journals obtained from the Google Scholar and Scopus databases.

In the third stage, we analyzed the existing school textbooks and revealed the possibilities for teaching interdisciplinary communication. Discussions facilitate the development of STEM-based lesson plans, emphasizing the ways of integrating mathematics, natural science, engineering, and technology fields.

In the fourth stage, we scrutinized the possibilities of utilization of innovative digital technologies, including PhET simulations for STEM education.

In the fifth stage – we discussed the first experiments on STEM-based lesson plans. Students gained experience in mathematics, science, labour training, etc. through the interdisciplinary integration of subjects.

Students actively engaged in 1-hour workshops for 12 weeks, designing and implementing STEM-based lesson plans.

Discussion. At the end of the workshop, students were interviewed. The interview comprised four questions focused on STEM learning. The questions are arranged as follows: Have you acquired the concept of STEM? Were you able to use STEM elements in designing your lesson plan? What challenges did you face in developing STEM-based lesson plans? Were you able to integrate concepts and ideas from different subjects? Then, we analyzed the responses from students and compared them with the results obtained from the original data.

The survey responses comprised in the range of 1-100 points. Table 3 shows the results of the survey conducted on the experimental group both before and after the experiment.

Table 3. Comparative findings obtained from experimental and control groups (descriptive statistical description)

Outcome		Pre-workshop assessment		Post-workshop assessment		Change
		M	SD	M	SD	
1-question	EG	48,4062	12,11200	72,1875	10,34700	+23,7813
	CG	48,0938	11,60467	46,0313	11,74043	-2,0625
2-question	EG	45,5625	11,95674	69,8750	10,65212	+24,3125
	CG	45,0938	10,62972	41,9375	10,58434	-3,1563
3-question	EG	53,4375	8,64697	67,0938	6,08202	+13,6563
	CG	52,9063	8,75236	53,3125	8,49074	+0,4062
4-question	EG	58,8750	11,88860	80,9688	7,46814	+22,0938
	CG	57,9375	11,05102	59,1250	10,78156	+1,1875

During the study, it was found that students faced challenges in integrating STEM elements and establishing connections between subjects in the development of STEM-based lesson plans. This study was proposed as an integrated approach to lesson planning. Therefore, as a result of its implementation in the educational process, students demonstrated improvement in problem-solving, critical thinking, cooperation, and interdisciplinary communication skills. These findings are supported by other scientific studies (Maiorca & Mohr-Schroeder, 2020; Özçakır & Çalışıcı, 2022; Wang et al., 2022). In addition, STEM education contributed to the enhancement of 21st-century skills (Drake & Reid, 2020).

Analysing primary education textbooks, identifying ways to integrate STEM elements, and identifying possibilities to establish interdisciplinary communication through common topics enabled us to develop STEM-based lesson plans (Ching et al., 2019; Pymthong & Williams, 2021).

The effectiveness of such STEM-based lesson plans has been proven in several studies (Aykan & Yıldırım, 2022; Alrwaished, 2024; Hernández & Muñoz, 2020), and our results showed higher indicators compared to other studies.

Thus, the results of the study demonstrate that teaching in the context of STEM education facilitates significant improvement in students' problem-solving capabilities, critical thinking skills, collaboration, and interdisciplinary communication. Moreover, it contributed to the development of group work abilities and research skills among students. Students were guided and assisted by physics, chemistry, biology, and engineering specialists in designing lesson plans in the context of STEM education, thereby establishing cooperative relations. Furthermore, students engaged in critical planning to address global issues in developing STEM-focused lesson plans. This process enables to fostering of practical skills

Presenting these outcomes, we realize STEM is a new method of lesson planning and recommend incorporating lesson plans focused on STEM into the educational process. The stages outlined in our study provide students with the opportunity to utilize an integrated approach and scientific-methodological support.

Conclusion. The researchers believe that it is appropriate to further update the research and include students from primary schools, other educational organizations, and universities. This study addresses the research questions of how to effectively plan lessons in the context of STEM education.

In summary, our investigation comprises the stages of lesson plan development in the context of STEM education for prospective primary school teachers. These stages include introduction to the STEM approach, teaching through STEM, analysis of school textbooks, utilization of digital resources, and STEM lesson planning. The workshop we have developed encompasses an integrated methodology enabled to foster scientific, creative, and critical thinking skills among prospective primary school teachers. Through the development of STEM-oriented lesson plans, learners establish interdisciplinary integration, and intra- and interdisciplinary communication based on common topics. Therefore, STEM-based teaching will undoubtedly arouse curiosity in science, increase aspirations, and have a positive effect on every student.

To further improve the research results, we offer the following recommendations:

- development and integration of STEM-based lesson plans into the educational process;
- implementation of STEM elements in the teaching of methodological subjects;
- improvement of the stages entailed developing STEM-based lesson plans;
- presenting the research findings at scientific and practical conferences.

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