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STEM APPROACHES IN TEACHING STUDENTS TO DESIGN ELECTRONIC LEARNING RESOURCES

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Abstract

The present-day education system in a rapidly developing world requires educational process adjustments, the introduction of actual technologies that allow training professionals capable of creative thinking, and later to work independently, study, and apply the acquired knowledge in their work. The research aims to justify theoretically and carry out methodological analysis of later pedagogical technology introduction in the process within a higher education institution. The article deals with the theoretical study of scientific literature on the issue of research, generalization, a comparison, an observation, and a survey. The paper considers the constructivism, project-based, or real-world problem-based learning approaches used. It describes the STEM (Science, Technology, Engineering, Math) learning approach, Authentic Learning, and 5E lesson planning model for teaching students to develop e-courses based on real problem solving, reviews the effectiveness of innovative technology and the influence on the quality of education. In the case of an e-course development class session, the results of the analysis show that the introduction of the STEM approach in learning contributes to the development of creative thinking, cooperation skills, teamwork, communication, critical thinking, and independent work. Thus, the application of this technology develops not only students' domain expertise, but also their soft skills.

Keywords: Authentic learning, e-courses, problem-based learning approach, STEM education, 5E Model

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1. Introduction

The relevance of the study is that the integration of STEM (Science, Technology, Engineering and Mathematics) approaches in learning is underdeveloped in this country. It occurs mainly within various international projects only through training teachers to interdisciplinary and integrated approaches in teaching STEM subjects, as well as spreading knowledge and skills by innovative teaching methods through STEM education (Ramzanov & Gordunova, 2020).

The popularity of STEM education is growing all around the world. There has been a demand for STEM majors in the US and many foreign countries recently. The current STEM education aims at developing necessary skills, i.e. critical thinking, collaboration, creativity, and teamwork (communication). These skills are also referred to as 21st Century 4C Skills. They allow one to adapt better to the changing conditions of today's world and will be especially relevant in the post-pandemic.

The number of studies and publications is increasing every year. Oshchepkov and Repin (2019) regard an issue of STEM technologies as a means of developing the creative activity of a learner, contributing to revealing his/her creative potential. And, as a result of their analysis, the authors came to the conclusion that simultaneous use of STEM technologies and a project-based learning method will not only promote creative thinking and creativity but also provide conditions for creative activities in a future occupation, as it requires using skills of cooperation, partnership, communication, sociability and collective engagement in creative interaction (Oshchepkov & Repin, 2019). Habig and Gupta (2021) conducted STEM research, research practices, and interest development as part of an informal science education program. Ong et al. (2020) investigate the effectiveness of using the STEM-based 5E learning model in improving learning. Analysis of the data shows an increase of knowledge enhanced pedagogical skills in STEM-based exploratory learning and improved classroom leadership skills to promote collaboration in the classroom (Ong et al., 2020). Duran and Duran (2004) examined the 5E learning model and its use in several career skills development science curricula. According to the results of the research on the effectiveness of the 5E model, Turan (2021) suggests several areas of research on the 5E learning model in the future. Another area of research in science and humanities teachers' different experiences in their view of the 5E learning model (Turan, 2021). In their study, Anwari et al. (2015) point out that knowledge, intelligence, experience, and practice are important components of improving metacognitive skills. In STEM lessons, students are given many opportunities to develop their thinking skills (metacognitive skills, critical and creative thinking). Thus, the introduction of STEM education in the classroom gives students the opportunity to understand the importance of integrating different disciplines and their applications. In addition, STEM education can motivate students' involvement in lessons (Anwari et al., 2015). In a study by Chen et al. (2020) the impact of STEM education with scientists or engineers on the interest of Hong Kong students in STEM careers and their stereotypes about STEM specialists was studied. Radloff and Guzey (2017) that viewing and reflecting on integrated STEM practices may enhance pre-service STEM teachers' conceptions of integrated STEM approaches, representing a practical method of preservice STEM teacher professional development. The results of the study by Donmez (2021) showed that the implementation of out-of-school STEM activities contributed to

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an increase of STEM career interest. Imangaliev (2021) proves a good definition, the background of the study, recommendations for inclusion, and its benefits in their study.

2. Problem Statement

At present, most teachers still use traditional teaching methods, which have stopped being flexible and adaptive due to the development of contemporary society and a live paradigm of higher education. Conventional teaching methods also fail to take into account students' perception of information, lack of motivation, interest in learning and feedback, which is not insignificant in present-day education. So the authors can conclude that due to innovative approaches in education, students develop an academic ability to acquire new content, analyzing it. They learn to draw conclusions, generalize and systematize the data obtained, discuss and apply it in practice in real life.

3. Research Questions

This article examines the introduction of the STEM approach in the learning process using the 5E lesson planning model as an example of the discipline Development of e-Learning Resources.

4. Purpose of the Study

The aim of the study is to analyze the application of STEM approaches in the educational process of university students. It also investigates the introduction of a problem-based approach promoting the development of skills necessary in today's rapidly developing world. Our main task is to train in-demand specialists with active, creative, critical, analytical thinking, capable of solving non-standard tasks, quickly adapting to changes, inventing and creating something new.

5. Research Methods

During the study the following general and specific methods were used: analysis of methodological literature, generalization, and analysis of results, the study of electronic learning resources; study and generalization of educational experience; conversations with university teachers, school teachers and students on the research subject; supervision of the learning process, analysis of the results of students' learning activities.

The pedagogical experiment on evaluation took place in the academic year 2020-2021 within the discipline Development of electronic learning resources where 12 IT students from K. Tynystnov Issyk-Kul State University and school teachers participated in.

6. Findings

What sets STEM education apart from classical education is the blended learning environment and showing students how the scientific method can be applied in everyday life.

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Let the authors consider one of the STEM education approaches (Authentic learning) using the 5E lesson planning model as an example of the discipline Development of e-Learning Resources (Açışlı et al., 2011).

In education science, constructivism was found out due to the psychologist Jean Piaget. He said ‘knowledge is not devolved, it is created’ (Waldherr & Walter, 2014).

If one transfers a cognitive approach together with constructivist ideas to the definition of learning, it will result in learning which is defined as an active process of knowledge development. The meaning is generated from individual experiences in realistic conditions by choosing from different options. Thus, testing knowledge takes place in the course of experience, rather than being isolated as a separate part of learning. The human brain keeps a distinct value in its memory, chosen from different points of view. Its fidelity is reinforced by additional connections of experiences. Therefore, the lessons designed on the principles of constructivism are often referred to as living learning. In other words, a student will only remember what they have processed and experienced (Tsygankov, 2018).

The 5E Instructional Model was proposed to simplify the process of designing course content according to constructivist theory. The planning of the STEM approach takes place according to this scheme; the lesson is divided into 5 steps. Each step has a different purpose. The names of the stages begin with the letter E in English:

Engage. The aim of this stage is to engage students in learning by getting them to focus on a phenomenon, an object, a problem, a situation, or an event mentally. A teacher measures students’ knowledge and background by asking them questions to further correction of the learning procedure. The questions may be the following, ‘Why did it happen?’ ‘What have I already known about it?’ ‘What can I learn about it?’ ‘What can be done to solve this problem?’

Explore. At this stage, a teacher creates an environment for exploration, observation, research through videos, audio materials, scientific articles, research, etc.

Explain. Here, terms and definitions that are not understood need to be explained. But before explaining through questions, discussions, it is necessary to understand how much the students have understood the new topic and gives the students a chance to compare, revise the proposed ideas.

Elaborate. Let a student do it on his/her own. At this stage, students carry out hands-on to solidify the knowledge they have got. This stage should involve them in further experiences that apply, enlarge or develop the concepts, processes or skills they study. Some students may still have misconceptions or understand some phenomena only through research experience.

Evaluate. It implies the assessment of the studied materials. The aim of this stage is assessment. Various forms of assessment can be used such as self-assessment, peer assessment, formal, informal assessment, etc.

Authentic learning offers the problems that allow students to learn from real-life situations. They use real-life applications and apply theoretical knowledge in real-life conditions. Students often go outside the classroom sessions. They may include field trips. The idea is that students become more engaged when they can apply what they study and get more prepared to solve professional problems.

Students are still passive in the process of learning in resident-based education. Knowledge is considered to be a set of facts and procedures that are transmitted from a teacher to a student. From this

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point of view, the aim of education is to master a larger range of these facts and procedures. On the other hand, a constructivist approach is used for authentic learning where learning is an active process. Teachers become facilitators and empower students to master their knowledge by engaging in independent research, problem-solving, critical thinking and reflection in a real-world context. Students no longer just memorize facts in abstract and artificial situations; they perceive and apply information in reality-based ways.

The main characteristics of authentic learning include the following:

- Current learning focuses on authentic, relevant, real-world tasks that appeal to students.
- Students are actively involved in research.
- Most of all, learning should be interdisciplinary. This requires the integration of content from several disciplines and results in outcomes that go beyond the subject area.
- Students are involved in complex problems and higher-order thinking such as analysis, synthesis, design, manipulation, and evaluation of information.
- Learning begins with a question or a problem that cannot be constrained to allow a student to give his or her answer.
- Students create a product that can be shared with the audience outside the classroom. These products are valuable on their own, not just for grades.
- The final products are certain, allowing them to be shared and reviewed. This feedback allows students to reflect and intensify their learning.
- Learning is carried out by students when mentors, peers, teachers, parents, and outside experts assist in the learning process.
- Authentic learning gives students an opportunity to explore a problem from different perspectives, allowing for competing solutions and different results instead of giving only one correct answer.
- Students are given an opportunity to come up with their own learning process and/or final learning product.

The problem chosen to study the development of e-courses by students was the low level of knowledge of distance learning tools by school teachers. As far as is known, in many countries, all educational institutions have been moved to distance learning because of the incidence of COVID-19 infection. Not all educational institutions were ready to move to a distance learning mode. School teachers ran into this problem too.

Engage. At this stage, questions are asked to understand the level at which teachers have mastered the tools for creating e-courses. Students are given an overview of the statistics, information about the platforms for e-course development (Moodle, Canvas, Learnme, Google Classroom).

Explore. Conduct the research among school teachers and find out those of them need help with designing e-courses.

Explain. Register for a course according to the principles and technology of e-course creation.

Elaborate. At this stage, students enhance collaboration with school teachers to design an online course in their subject area.

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Evaluate. The presentations of the created e-courses are evaluated. There are observations on the SWOT evaluation, etc.

It is worth noting that along with the development of e-courses, students will learn not only the principles and technologies of designing an electronic educational resource, but also the didactic properties of the content generation, interface structuring, and approaches to determining the quality of such resources, etc.

If lesson purposes are analyzed according to Bloom's taxonomy (Table 1), a typical form of learning includes lectures, discussions, exercises, review questions, homework, and additional technical aids such as videos and websites. Attending lectures as well as watching videos promote passive learning where students can define, list, explain ideas and concepts, and apply information to similar and new situations. It is called low-order thinking. When the STEM approach is used in student learning one will get high order level of knowledge where students can analyze, evaluate the knowledge gained and develop their e-learning resources.

Table 1. Analysis by Bloom's Taxonomy

Level		Intelligence skills
High-order thinking	Design	Develop new things (design, makeup, construct, suppose, develop, formulate, be an author, research)
	Evaluate	Constitute a position or a decision (discuss, argue, defend, reason, choose, support, evaluate, criticize)
	Analyze	Make connections between ideas (distinguish, organize, link, compare, contrast, distinguish, investigate, experiment, question, test)
	Apply	Apply information to new situations (complete, implement, solve, use, show, interpret, work, plan)
Low-order thinking	Understand	Explain ideas and concepts (classify, describe, discuss, explain, identify, find out, recognize, inform, choose, translate)
	Memorize	Recall facts and basic notions (give definitions, enumerate, memorize)

If the conventional form of learning is considered according to Edgar Dale's pyramid (Table 2), a student remembers only 30% to 50% of the information.

Table 2. Edgar Dale's pyramid analysis

People remember		Type of activity	As a result, people are capable of
High level of abstraction	10% of what one has read	Reading	Define, list, describe, make oneself clear
	20% of what one has heard	Listening	
	30% of what one has seen	Looking at a picture, watching a video	Display, apply, perform
	50% of what one has heard and seen	Looking at an exhibit item, observing a presentation, observing particular actions	
Low level of abstraction	70% of what they have said or written about themselves	Participation in a discourse, giving a speech	Analyze, develop, design, evaluate
	90% of what one has said or written about their actions	Simulating a real activity, performing a real action	

To promote students' active learning, lectures should include discussions, case studies, hypothetical scenarios, review issues, and project assignments. Active or involved learning i.e. learning

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through problem-solving using own experiences and skills, promote mutual and active learning, broadening of students' skills and their critical thought of ideas and practices.

Student learning results based on Bloom's re-examined taxonomy (Anderson et al., 2001) mean that students can show what they have learned something, can make sense of it, can apply what they have learned, analyze information, can evaluate information, and create something new.

According to Edgar Dale's pyramid, students get 90% of their knowledge by doing a project based on a real-life problem.

Analyzing the current experience of teachers in applying innovative technologies in the learning process shows that it is impossible to achieve a high level of thinking using routine teaching methods alone.

The results of the students' survey show that classes with STEM approaches seem to be more interesting. The students become more motivated and interested in achieving certain learning outcomes, which ultimately improves the quality of education.

The benefits of STEM education introduction:

1. It helps create a competitive state by producing skilled and flexible professionals;

2. It promotes fundamental scientific discoveries;

3. It increases the number of scientists, technologists, engineers, and mathematicians who can design original products and completely new industries for the 21st century;

4. It will provide the technical skills and digital literacy necessary for people to earn the appropriate wages and make better decisions for themselves, their families, and society;

5. It strengthens democracy by preparing all citizens to make a conscious choice in a technological world;

6. It prepares and engages all students regardless of their gender, race, or background.

7. Conclusion

In conclusion, the approach can be applied to many disciplines and the transition away from the traditional lesson through the use of new technologies in the learning process allows eliminating the monotony of the educational environment and the learning process. It can create conditions for changing the activities for students and improve the quality of education. The use of innovative technologies and techniques is an important element in motivating students, even more, developing their ability to independent work, active perceiving the learning content, and helping to hold their interest in the subject.

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