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Development of pedagogical skills of students of technology and pedagogical specialties using STEM technologies

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Abstract: The purpose of the research is to theoretically substantiate the issue of incorporating STEM technologies in the educational process of higher education as a means of developing pedagogical skills of students of technology and pedagogical specialities. Additionally, the study aims and to assess the extent of knowledge regarding STEM education among future teachers and their preparedness to effectively integrate STEM projects into their professional practice. We used various methods, including analyzing the existing theoretical works of Ukrainian and foreign authors related to our research topic. We also utilized techniques such as generalization, systematization, and questionnaires. During the experimental research, we focused on determining the levels of awareness regarding STEM education and the preparedness of students of technology and pedagogical specialities to implement STEM projects in their professional roles. Based on the survey results, it was discovered that the majority of future specialists a positive view of utilizing STEM projects as a means to enhance their pedagogical skills.

Keywords: *Future teachers of Labour training and Technologies, Pedagogical skills, Professional training, STEM-education, STEM-projects, STEM-technologies.*

1. Introduction

The tremendous development of technologies, which are currently taking place all over the world, puts forward new requirements for the training and qualification of specialists. In the near future, professions related to modern technologies will be most in demand: IT specialists, big data engineers, programmers, and professions that do not yet exist.

According to the "Atlas of New Professions" (2022), in the future people will drive electric cars on "smart" roads, relax in virtual worlds and live in "smart" houses, on the roofs of which vegetables and fruits will grow. Doctors will be able to change the human genome and choose a molecular diet.

Forbes studied the atlas and selected 25 of the most interesting professions of the future, for which you can get a basic education right now, namely: an IT geneticist, a builder of smart roads, a designer of virtual worlds, an electric refueler, a designer of a "smart" environment, an intellectual property appraiser, and others. It is quite logical that all these words are not terms from a futuristic blockbuster, but quite real professions of the near future, because the speed of changes in the world is growing at a frantic pace, and the complexity of professional tasks is constantly increasing.

Specialists who not only possess theoretical knowledge, but also have experience in practical work with complex technological objects are already in demand. Brad Smith, vice president of Microsoft

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Corporation, noted that: "the shortage of qualified specialists has reached such a level that one can talk about a crisis of geniuses for high-tech companies" [1].

In this scenario, the role of school education and the teacher's readiness to implement modern technologies is growing. The task of the institution of higher education is to prepare the future teacher to work in the new technological conditions of society.

In many countries, the main policy is aimed at increasing the interest and involvement of students in career fields related to STEM disciplines, which is ensured by implementing the integration of disciplines [2].

Such countries are Great Britain, the United States of America, Canada, New Zealand, China, Japan and Singapore [3].

Modern reforms in the educational sphere and its digitalization causes new requirements to professional training in the higher educational establishments based on introducing innovations into pedagogical practice [4, 5, 6].

The structure of the teacher's activity is invariant for teachers of all specialties, the differences are only in the content aspect, which depends on the specifics of the subject taught and personal attitude to the educational process [7].

“Innovative” teachers are expected to have the set of general and professional competences which meets today’s requirements. In this context and taking into account society’s demands to educational space a new paradigm of STEM education becomes actual.

STEM is an integrated learning approach in which academic science and technology concepts are learned in real life. The goal of this approach is to create stable connections between school, society, work and the whole world, which contribute to the development of STEM literacy and competitiveness in the global economy [8].

Evidently, such an expansion of the teacher's competence profile requires new approaches to the development of the pedagogical skills of students of technology and pedagogical specialities as “a professional quality that ensures self-organisation of a high level of professional activity based on reflection and makes possible achieving the planned outcomes with minimal effort and in the shortest possible time” [9] in the conditions of digital transformation. We consider STEM projects to be the most effective tools for this purpose.

One of the trends in modern STEM education is the focus on the practical implementation of projects, students conducting independent research, acquiring practical skills and improving digital competences [10, 11]. Therefore, STEM education is especially important for the quality training of engineering and pedagogical students [12, 14].

2. Literature Review

The theoretical basis of this study is a number of scientific works of scientists related to the outlined issues. The possibilities of STEM technologies in the educational process were studied by V. Kovalchuk, S. Balovsiak, Yu. Ushenko, N. Tkachenko, A. Kocharyan, V. Soroka, I. Sheludko, S. Maslich and others, who developed the theoretical and methodological foundations of forming pedagogical skills [5, 7]; ways of introducing STEM technologies into professional training of students of technology and pedagogical specialities [2, 9, 13, 14, 15].

The development of science and technology attracts the attention of more and more countries to exploring STEM education, and at the same time, the education of future STEM teachers does not lose its relevance.

The results of N. Zhaohao's research are scientifically valuable for us; the reasons and background of the STEM education policies of future teachers in the United States, Great Britain and Australia are combined, the qualitative research methods and comparative research models for analysis are comprehensively used. It is found that similarities between the three countries mainly include: policies to promote STEM teacher training implemented at the national level [16].

STEM education has a significant potential for developing the creative initiative of future teachers

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and involves them in active participation in the formation of general and professional technological competences, defined in educational program [8].

Investigating the problem of using projects implemented with the help of computer modelling in the framework of STEM education, V. Kovalchuk, L. Shevchenko, T. Iermak, K. Chekanyuk rightly note that this system creates conditions for developing and improving analytical and creative abilities of students, gives them the opportunity to try themselves in teamwork, develops their independence in acquiring new knowledge. This contributes to the integration of educational subjects, forming skills of using modern technologies and modelling in future professional activity. Independent creation of models provides the opportunity to better understand the main properties of objects, phenomena, processes, their components and the relationships between them. Accordingly, the ability to model, the skills of analysis, synthesis, critical thinking, and a methodical approach to the implementation of educational content by means of computer modelling within the framework of project activities are developed [9].

The crucial provisions of the STEM projects realisation are reflected in methodological recommendations for the implementation of STEM education, in particular, they emphasise that research and project activity is one of the leading and most effective means of forming the key competencies of students of education [18].

Invariably, project activity is one of the most promising components of the learning process in terms of a higher education institution, which creates the most optimal conditions for developing creativity of students of technology and pedagogical specialities promotes their self-realisation and the formation of all necessary professional competencies.

The range of understanding of the term "project" in this context is very wide, and within the framework of this implementation, "educational project" is rather a variant of a practical task of a problematic nature, the solution of which is sought by a group of students on their own, relying not on step-by-step instructions, but on open-ended questions.

The main goal of introducing STEM projects into the educational process of higher education institutions is to solve a clearly defined socially significant problem – information, research, practical or other direction. The project involves conducting research including setting a research question; formulation of the hypothesis; development of research methodology; collection, presentation and analysis of data [14].

An important direction of STEM education for students of engineering and pedagogical specialties is the design, implementation and application of computer systems for intelligent image processing [19, 21]. The works of S. Balovsiak, O. Derevyanchuk, I. Tereykovsky, Z. Hu, Yu. Ushenko and others. STEM projects of this field are closely related to the future professional activities of students and are used to solve applied problems. For example, computer image segmentation systems can be effectively used for automatic processing of vehicle images [22, 23]. In addition, during the implementation of such STEM projects, students improve their knowledge of digital image processing methods: filtering [24, 25], segmentation [26], contour selection [23], profile analysis [27], contrast enhancement [28]. In STEM projects, artificial intelligence tools [29, 30] are used to improve the accuracy of image processing, in particular, image recognition methods and fuzzy logic [31, 32], which also helps students acquire the latest digital competencies. To evaluate the results of students' learning, means of intellectual data analysis are used, in particular, clustering methods [33].

Thus, in the process of implementing STEM projects, it is necessary to start with project design and planning. A mandatory condition of the STEM project is the students' research work which involves their search for relevant information with further processing and presentation of the activity results. The finite result of work on a STEM project is a product created by project group members while solving a problem set by the teacher. At the final stage of the implementation of the STEM project, there must be a presentation of this product.

3. Research Methodology

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To identify the levels of awareness in the field of STEM education and the readiness of students of technology and pedagogical specialities to implement STEM projects in their professional activities in September – October 2023 at Oleksandr Dovzhenko Hlukhiv National Pedagogical University, a questionnaire for full-time and part-time students was conducted. 53 students studying in the last year of Bachelor's programmes (35 persons) and Masters programmes (18 persons) took part in the survey. The average age of the survey participants is 20 years.

The study was based on the assumption that the effectiveness of the process of developing the pedagogical skills of students of technology and pedagogical specialities largely depends on the implementation of STEM projects that provide for the active involvement of future teachers and their mentors in project and research activities.

4. Results and Discussion

The questionnaire we developed contained 8 questions. The first question "Are you familiar with the concept of STEM education?" provided one of three answer options: "yes", "I have an idea", "no". As evidenced by the results of the survey, the vast majority have ideas about STEM education – 53%; almost half of the respondents answered this question in the affirmative – 45%, while 7% of the study participants, unfortunately, do not have knowledge about the concept of STEM education (Fig. 1).

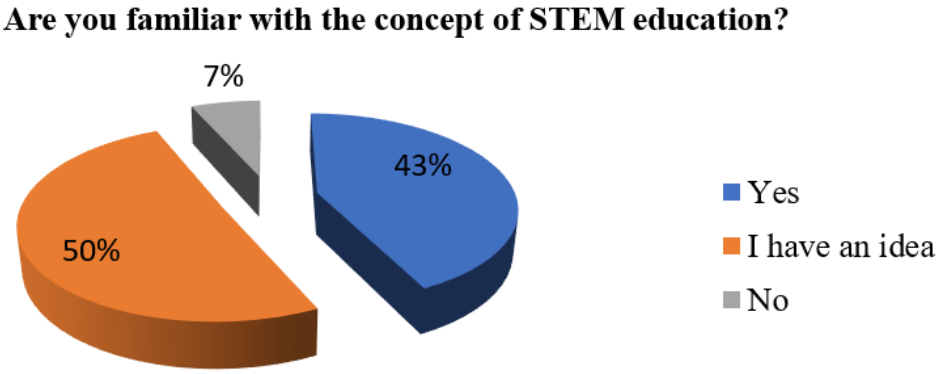

Figure 1.
The results of the survey on the awareness of students of technology and pedagogical specialities in the field of STEM education

The following questions included higher education students' assessment of the development of their own creative abilities ("How do you assess the development of your own creative abilities?"), project activity skills ("At what level are project activity skills developed?"), readiness to lead students' project activities ("Are you ready to lead the project activities of students at lessons of labour education and technology?").

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The results of the survey by this group of questions showed that the vast majority of students of technology and pedagogical specialities can improve ready-made ideas and use them (65%), while only 20% of research participants know how to put forward new ideas, and 15% of respondents consider it appropriate use ready-made ideas. 40% of experiment participants are ready to implement project activities, 45% have a partial idea in this direction, on the other hand, 15% of respondents are not ready to implement projects; almost half of the respondents indicated their readiness to lead project activities of students – 48%, 35% of future teachers believe that they are not sufficiently prepared, while 17% of

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respondents are not ready to lead project activities (Fig. 2).

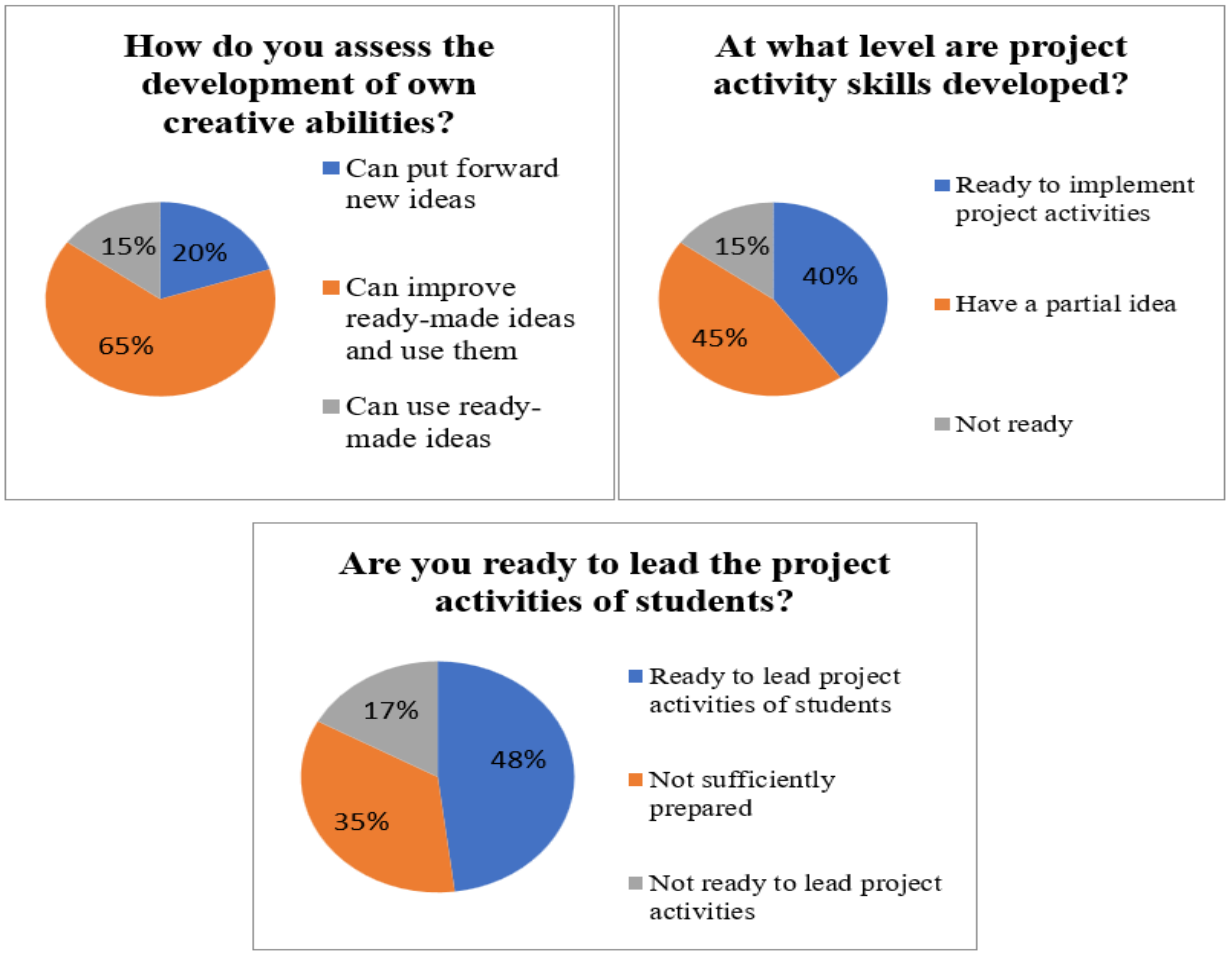

Figure 2.
The results of the survey regarding the future teachers' assessment of creative abilities, the formation of project activity skills and readiness to lead the project activities of students.

Among the multiple-choice questions were: "Which component of the content of your university studying, in your opinion, is insufficient?", "What other disciplines, in your opinion, should be included in the content of your vocation preparation to develop pedagogical skills in the use of STEM technologies?", "What skills of project activity do you possess?", "What skills do you need to master in order to implement STEM projects?".

To the question "Which component of the content of your studying at the university, in your opinion, is insufficient?" 24% of respondents consider art (creativity); 26% – technology, 24% – engineering, 16% – science, 10% –mathematics. The vast majority of respondents believe (55%) that the content of their basic preparation should include the discipline "Fundamentals of project activity", 22% – "Psychology of creativity", "Educational robotics" – 18%, "Modern IT technologies" – 10% (Fig. 3).

Among the project activity skills possessed by the respondents were the search for information and ways to solve the problem (35%), willingness to correct mistakes (28%), flexibility, perseverance (25%), reflection of project activity (12%). According to the respondents, such skills as independent search for means and methods of project implementation (35%), generation of new ideas (30%), development of

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creative qualities (25%), project presentation (10%) require further improvement in the context of project activities (Figure 4).

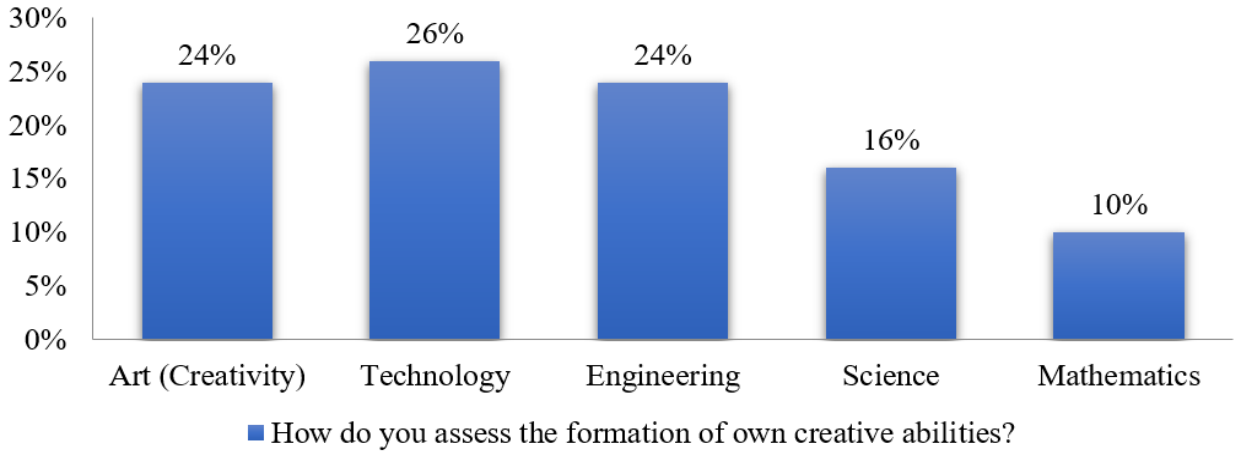

Figure 3.
The results of the survey of students of technology and pedagogical specialities regarding the expansion of the content of professional preparation in higher education institutions.

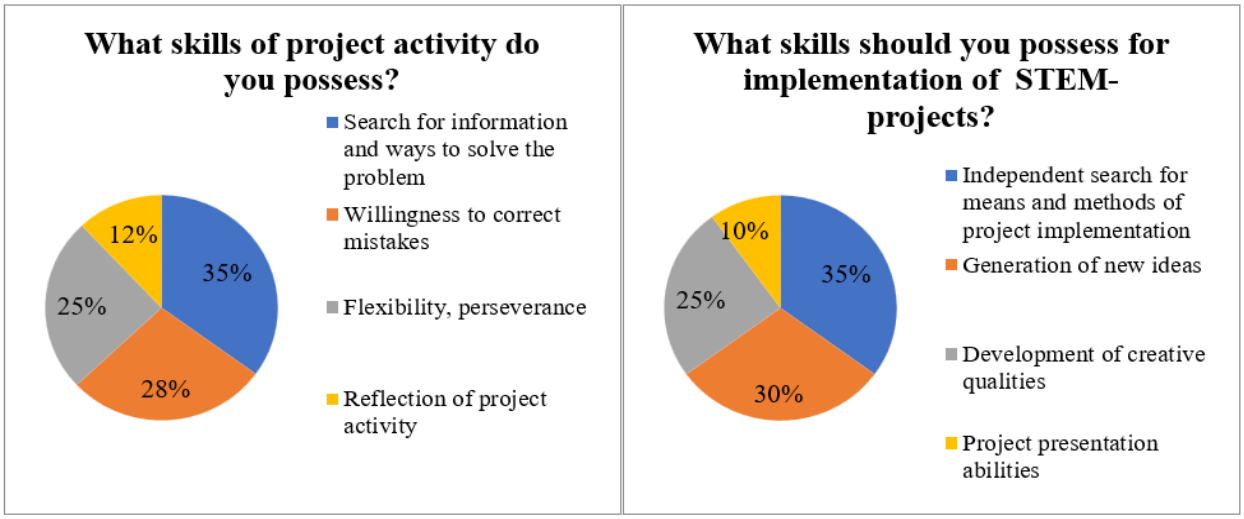

Figure 4.
The results of the survey of students of technology and pedagogical specialities regarding the skills necessary for the implementation of STEM projects.

To the question "What are the difficulties in the implementation of STEM education at the university", the vast majority noted insufficient equipment in STEM laboratories – 45.5%; lack of experience in the practical implementation of STEM technologies – 32%; lack of clear instructions on the implementation of STEM projects – 15%; low level of motivation – 7.5% (Fig. 5).

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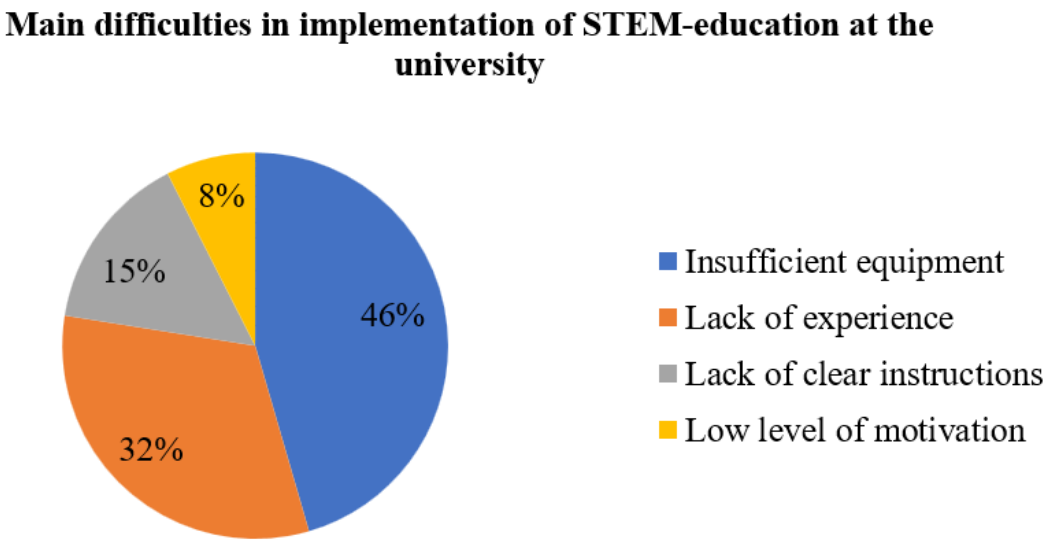

Figure 5.
Survey results regarding the main difficulties in the implementation of STEM education at the university.

Summarising the results of the survey of students of technology and pedagogical specialities, many respondents positively evaluate the use of STEM projects as a means of developing pedagogical skills, at the same time, they need the development of skills to work on STEM projects, as well as the ability to manage students' project activities.

5. Conclusions

During the survey, it was found that the vast majority of students of technology and pedagogical specialities have sufficient knowledge of the concept of STEM education, are ready to carry out project activities and lead students' project activities. Among the skills of project activity possessed by the respondents, the search for information and ways to solve the problem, willingness to correct their mistakes, flexibility, perseverance, reflection of project activity were highlighted. According to respondents, such skills as independent search for means and methods of project implementation, generation of new ideas, development of creative qualities, project presentation require further improvement in the context of project activities.

Among the difficulties in the implementation of STEM education, insufficient equipment of STEM laboratories, lack of experience in the practical implementation of STEM technologies, lack of clear instructions on the implementation of STEM projects, as well as a low level of motivation were noted.

The results of the conducted experimental work confirmed that the support and active use of STEM projects should be carried out on the basis of targeted development programmes, which, in turn, should include the active involvement of future teachers and their mentors in project-research activities. At the same time, in the course of training students of technology and pedagogical specialities for professional activity, first and foremost, it is necessary to conduct vigorous activities aimed at involving students in global trends in education, among which STEM comes to the fore.

It is found that the process of professional preparation in higher education institutions for the implementation of STEM technologies requires the introduction of additional disciplines into educational programmes, as well as the creation of conditions for developing project skills as a component of the pedagogical mastery of students of technology and pedagogical specialities.

Thus, STEM projects become a kind of simulator for future teachers, which allows generation of the situation of the future lesson of labour education and technologies, discussion on it creation of, and exchanging opinions and an educational product that will be successfully implemented in practical

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pedagogical activities in the future.

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