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TABLE OF CONTENTS

SIEF, Vol. 26, No. 2, February 28, 2025

COMMENTARY

Tapping into the Potential of Project-Based Learning by Exploring the Core Elements in Its Implementation

Dingliang Tan

Nanjing Normal University, Nanjing 210024, Jiangsu, China

"The whole of science is nothing more than a refinement of everyday thinking."
-Albert Einstein

PROJECT-BASED learning (PBL) is a student-centered instructional approach (Bhat & Dar, 2023), with which, students learn by actively engaging in a complex project that involves activities like project design, problem-solving, decision-making, and investigation. A project in PBL typically entails challenging questions or tasks, and students develop knowledge and skills through inquiry and problem-solving over an enduring period. PBL's benefits are many, such as the capability to enhance student motivation levels and cognitive engagement in the learning process (Blumenfeld et al., 1991) and its potential to improve students' language proficiency, critical thinking ability, and communication skills in language education (Du & Han, 2016). Benefits like these have drawn wide attention of the education world to PBL, leading to its popularity and large-scale application at all education levels. On the other hand, certain studies find that PBL does not suit all subjects and students (Aristidou, 2020) and may demand excessive time and resources. In heavily loaded courses with inadequate equipment of teaching resources, PBL's outcomes can be hampered (Handrianto & Rahman, 2018). Also, enacting PBL poses additional challenges to both the teacher's instructional organization and the students' learning attitudes. Nevertheless, its benefits by far outweigh its shortcomings. To fully utilize the former, it is necessary to develop thorough understanding of the essential elements in PBL's implementation.

Larmer and Mergendoller (2010) identify seven essential elements of meaningful PBL. (i) A need to know: Instead of making the project feel like busywork, the teacher can successfully activate students' need to know content by initiating it with an "entry event" that engages interest and sparks questioning. An entry event can be almost any

thing: a video, a lively discussion, a guest speaker, a field trip, or a piece of mock correspondence that sets up a scenario. (ii) A driving question: A good driving question captures the heart of the project in clear, compelling language, which gives students a sense of purpose and challenge. The question should be provocative, open-ended, complex, and linked to the core of what the teacher wants students to learn. (iii) Student voice and choice: It is important to ensure students' autonomy in implementing the project, allowing them the freedom to choose the topic within the driving question, research method, and what product to create. Meanwhile, the teacher can decide on the range of choice according to their own teaching style and students' actual needs. (iv) 21st century skills: A project should give students opportunities to build such 21st century skills as collaboration, communication, critical thinking, and the use of technology. A teacher in a project-based learning environment explicitly teaches and assesses these skills and prompts students to frequently assess themselves. (v) Inquiry and Innovation: In PBL, students begin with their own questions, search for resources and the discovery of answers, and ultimately generate new questions, test ideas, and draw their own conclusions. With real inquiry comes innovation, i.e., a new answer to a driving question, or a new product, or an individually generated solution to a problem. (vi) Feedback and revision: Formalizing the processes of feedback and revision during a project helps raise the awareness of creating high-quality products and performances in students. There are different forms of feedback to be adopted in PBL, including direct feedback from the teacher, mutual evaluation of each other's work in students, and feedback from experts or adult mentors. (vii) A publicly presented product: When students need to present their work to a real audience, they care more about its quality. The audience can include parents, peers, and members of the community. In addition, a few specific models for PBL's implementation have been advanced, such as the six-, eight-, and ten-step models (Du & Han, 2016). Despite the variations in their processes, all these models share the following pivotal steps: defining the question, laying out the plan, enacting research activity like investigation, drawing conclusions, presenting and evaluating the project product.

Exploration of PBL's theories and practical applications is ongoing. Systematic surveys of existing practical cases and research experiences help pinpoint central elements in PBL's implementation, providing valuable references and insights for future research and practices. *Implementation of Project Based Learning (PjBL) in Mathematics Education: A Systematic Analysis of International Practices and Theoretical Foundations* in this issue is an encapsulation of PBL applications in global mathematics education and its theoretical underpinnings. The research results of the study reveal that PBL is effective in improving students' academic achievement and 21st century skills but also faces challenges in its execution, such as inflexible schedules and inadequacies in professional skills of teachers. Also, the study gives a summary of the core implementation steps for PBL in mathematics teaching, which offers implications for improving PBL' implementation in other subjects (Himmi, 2025).

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COMMENTARY

Working to Tackle the Issue of NEETs

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"Intelligence plus character – that is the goal of true education."
-Martin Luther King, Jr.

A NEET (not in education, employment, or training) is a young person who is unemployed and not receiving education or vocational training. The term originated in the UK in the late 1990s, but with slight differences in its definition in various countries because of differential social and cultural contexts. The differences are mainly about the age range of NEETs and their intention of seeking a job or not (Batini et al). Each country has its own slang term for this group, such as "hikikomori" in Japan and "Ken Lao Zu" in China, pointing to the complexity and pervasiveness of the issue of NEETs. According to prior studies, the NEET status has a long-term negative impact on the individual's economic circumstances (Ralston et al., 2022) and is also linked to higher risks of suicide and criminal behavior (Rahmani & Rahmani, 2024). From the social perspective, the NEET phenomenon signals the problems faced by the economy and the labor market. Therefore, it is imperative to develop effective measures to prevent at-risk youngsters from becoming NEETS and tackle the challenges encountered by this category.

To this end, it is important to pinpoint the risk factors for the NEET tendency, particularly against the backdrop of worldwide economic headwinds. In their scoping review, Rahmani and Groot (2023) categorize all the risk factors into eight major groups: individual characteristics, education and school, work, health, addiction, social factors, family, and environment, emphasizing that education- and family-related variables have the most significant impact on NEET youth. Zudina's (2022) study finds that young people from low-income families are more likely to become NEETs while also observing that higher education's role in assisting youth to avoid the NEET trajectories is diminishing. Efforts to identify risk factors are beneficial for policy makers and relevant institutions accurately targeting those young persons with high risks of NEET and adopting pertinent preventive measures. At the same time, Rahmani and Groot (2023) acknowledge that research on risk factors of NEET is far from exhaustive due to issues such as the inexplicit definition of the NEET, methodological discrepancies, and inconsistency in sample char

acteristics. Future research in this area needs to focus on developing more thorough theoretical models and conducting more quantitative and qualitative analyses to explore in depth the psychosocial factors of NEETs and their consequences.

To help the NEET cohort resume education or enter the labor force, governments of many countries have implemented a variety of interventions, including but not limited to providing temporary job opportunities to aid NEETs in building up work experience; granting employers subsidies for labor costs and training expenditures or tax concessions to increase their willingness to hire NEETs; and offering youth employability and financial independence training courses (Stea et al., 2024; Maguire, 2015). On the other hand, certain researchers argued that current intervention policies were heavily influenced by certain stereotypes about the NEET cohort (Maguire, 2015). Often, the NEETs are labeled as "lazy" or "uninterested in work." In effect, the majority of them do not really enjoy their listless lives but instead, value employment and financial independence (Chen, 2011). Hence, there may be discrepancies between the actual needs and difficulties of the NEETs and the policymakers' perceptions, which necessitate more in-depth research into the challenges facing this category.

"Unfinished Adult Children": A Causal Analysis of the Issue of NEETs in China in this issue is a tri-partite analysis of the causes of the NEET phenomenon in China from the angles of higher education, home education, and personal factors of youth, aiming to provoke more interest in this group in all stakeholders and offer implications for the formulation and execution of relevant policies (Wang, 2025). Despite its focus on Chinese NEETs, the article can, still, provide valuable references for tackling the NEET issue on a global scale.

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ORIGINAL ARTICLE

Implementation of Project Based Learning (PjBL) in Mathematics Education: A Systematic Analysis of International Practices and Theoretical Foundations

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***Abstract**: Project Based Learning (PjBL) has emerged as a promising approach in mathematics education. This study aims to analyze the implementation of project-based learning (PjBL) internationally in mathematics education and to identify the underlying learning theories, such as the method of writing an article through SLR. A systematic literature review uses the "Publish or Perish" application for Scopus and Crossref searches. The selection criteria include accredited journal articles from Sinta 1, Sinta 2, or those already accredited by Scopus from 2014 to 2024 in English, focusing on mathematics/mathematics education. Out of the ten selected articles, further analysis was conducted. PjBL effectively enhances academic achievement. 21st-century skills include critical thinking, problem-solving, collaboration, communication, creativity, technological literacy, and student motivation in mathematics education across various countries. Implementing the PjBL model in mathematics involves a series of well-defined steps: presenting problems, preparing project plans and schedules, forming effective teams, providing support, integrating with the curriculum, using visual media, presenting and evaluating results, and reflecting on the process. The implementation challenges include inflexible schedules and teachers' need for more professional skills. The theories underlying the effectiveness of PjBL include constructivism, social learning, experiential learning, multiple intelligences, contextual learning, motivation, and problem-solving. PjBL shows significant potential in enhancing international mathematics learning. Implementation*

success depends on thorough preparation, appropriate support, and adjustments to the local context. Further research is needed to optimize the integration of PjBL with traditional methods, address implementation challenges, and analyze its long-term impacts.

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***Keywords**: Project-Based learning, Mathematics Learning, Learning Theory, Systematic Literature Review*

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Introduction

IN AN ERA of constantly evolving education, we face the challenge of preparing the younger generation to confront an increasingly complex world. For mathematics learning, often seen as a nightmare for many students, new ways are needed to teach concepts and foster creativity and problem-solving abilities. Project-based Learning (PjBL) is an educational method through which students learn through involvement in real and meaningful projects. This method is proven to enhance a variety of 21st-century skills that are critical for success in today's rapidly changing world. These skills include critical thinking (Zayyinah et al., 2022), problem-solving, collaboration (Aifan, 2021), communication, creativity, and technological literacy (Martínez, 2022). However, implementing PjBL in various international contexts and integrating learning theories into PjBL practice still require further research.

In math class, students memorize formulas and apply them to their chosen real projects. A class where active discussions, team collaboration, and the discovery of creative solutions become daily activities. This is the essence of PjBL, which has begun to transform the face of mathematics education in various parts of the world (Dimitra Kokotsaki et al., 2016). Recent research is beginning to show the great potential of PjBL in mathematics education. A study conducted by (Han et al., 2015) indicates that PJBL enhances academic achievement and helps bridge the gap between high-performing and low-performing students. This opens up the possibility that PjBL can be a means of creating more inclusive and equitable mathematics education.

In the context of modern education, 'formal education' starting from the school phase from primary education to higher education, can use the PjBL learning model (Fernandes et al., 2014) (Guo et al., 2020), which refers to a structured education system that combines a standard curriculum with a PjBL approach. This formal education usually takes place at a recognized educational institution, such as a school or university, where students follow a predetermined educational program but with particular emphasis on project-centered learning experiences (Chikurteva & Chikurtev, 2020) (Ozório et al., 2021). By combining the structure of formal education with the flexibility and relevance of PjBL, this model seeks to bridge the gap between theoretical learning and practical application in the real world.

Furthermore, PjBL aligns with modern learning theories that emphasize the importance of active knowledge construction by students. As expressed by (Tamim & Grant, 2013), PjBL allows students to construct their understanding, a principle that aligns closely with constructivist theory. This allows students to see mathematics not as a collection of formulas to be memorized but as a helpful tool in everyday life. However, despite its great

potential, implementing PjBL in mathematics education takes time and effort. (Bray & Tangney, 2016) remind us that the success of PjBL heavily relies on thorough preparation and appropriate support for students. In addition, the role of learning theories in the context of PjBL is also an important aspect that needs further exploration. Theories such as constructivism, experiential learning, and multiple intelligences are often associated with PjBL, but their practical implementation in mathematics education still requires further research (Dimitra Kokotsaki et al., 2016).

Recent studies show that PjBL has significant potential in improving students' mathematics achievement. For example, research conducted by (Lazić et al., 2021) in Serbia found that students who learned using the PjBL model achieved better results than those taught with conventional methods. Similar findings were reported by (del Valle-Ramón et al., 2020) in Spain, which indicated a more significant increase in mathematical knowledge among the group using PjBL. Nevertheless, implementing project-based learning (PjBL) also faces various challenges (Viro et al., 2020) identified several obstacles, including inflexible schedules, a lack of professional skills and motivation among teachers, and resource limitations. This indicates the need for a deeper understanding of how PjBL can be effectively integrated into the mathematics curriculum and how teachers can be supported in implementing this approach.

In this context, a systematic literature review (SLR) is essential to analyze the current application of international project-based learning (PjBL) in mathematics education and identify the learning theories directly implemented within the PjBL context. This SLR aims to synthesize the latest findings, identify best practices, and reveal gaps in existing research. Conducting this SLR aims to provide comprehensive insight into the effectiveness of PjBL in mathematics education, successful implementation strategies, and the integration of relevant learning theories. The results of this SLR can serve as a foundation for developing more effective and innovative mathematics teaching practices and provide direction for future research in mathematics education.

Research Methods

SLR aims to identify all relevant research (Petticrew & Roberts, 2008) to answer a specific question and assess the validity of each study by considering established criteria until concluding (Suri, 2020; Okoli & Schabram, 2012). The steps taken in the SLR research are adapted from (Himmi et al., 2023) as follows:

Developing Research Questions

In this study, the research questions were prepared based on the background described previously. Including:

Q1: How is the application of PjBL currently implemented internationally in mathematics education?

Q2: How are learning theories implemented in mathematics education within project-based learning (PjBL)?

Article Selection Criteria

In selecting the articles to be analyzed in depth for this research, inclusion and exclusion criteria have been established to address the research questions effectively (**Figure 1**). The criteria are as follows:

Developing Search Strategies

Searching for articles using the "Publish or Perish" application with the keywords "project-based learning, PBL implementation, learning theories in PjBL" in the Scopus Search menu.

Selection Process and Assessment of Article Quality

After obtaining articles through the search strategy, a review was conducted to assess the articles' suitability and compliance with the predetermined selection criteria. The steps are:

1. Evaluate titles, abstracts, and journal texts that contain the keywords project-based learning, PjBL implementation, and learning theories in PjBL
2. Choose articles published by Scopus or at least SINTA 2. SINTA (Science and Technology Index) is a ranking and indexing system developed by the Indonesian Ministry of Research, Technology, and Higher Education to improve the quality and visibility of domestic scientific publications. This system uses a ranking scale of six levels, from SINTA 1 to SINTA 6. SINTA 1 is the highest rating usually given to journals indexed in international databases such as Scopus or Web of Science. This ranking reflects the quality and impact of journals based on various predetermined criteria.
3. Focus on articles published in recent years to ensure the information and findings reflect recent developments in the field under study.
4. Priority is given to articles in English, given its status as the lingua franca in the global scientific community. This allows access to a broader spectrum of research and facilitates cross-country comparisons.
5. According to the specific research theme, the selected articles are in mathematics and mathematics education.

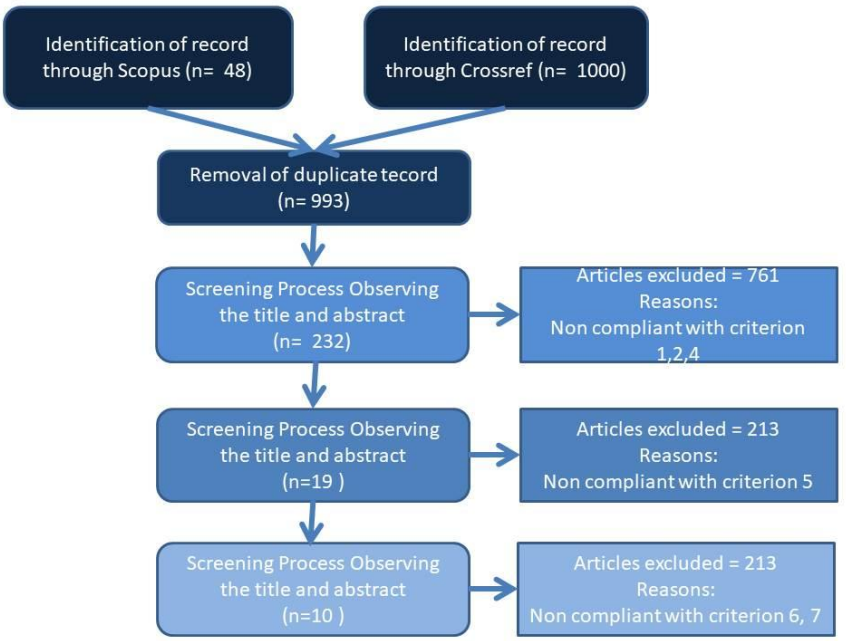

Figure 1. Flowchart of the Article Selection Procedure.

6. The use of quantitative methods in research is one of the criteria that make it possible to generalize the findings.
7. The selected articles have research subjects in the context of formal education. This is important to ensure the relevance of the findings and analysis to structure and officially recognized educational settings, such as schools or colleges, which use standard curricula and established teaching methods.

Applying these criteria helps ensure that the selected articles provide a sound and relevant basis for the research.

Synthesis Results

This synthesis analysis examined all articles obtained from search results using the Publish or Perish application and entered the specified keywords. Next, search results are filtered based on predetermined criteria, resulting in the image below:

Results and Discussion

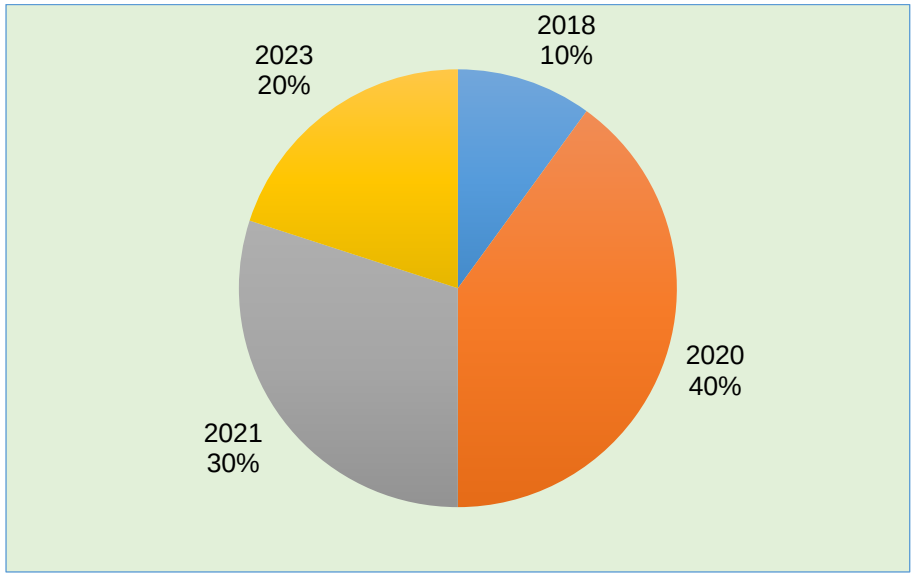

Figure 2. Percentage of Articles.

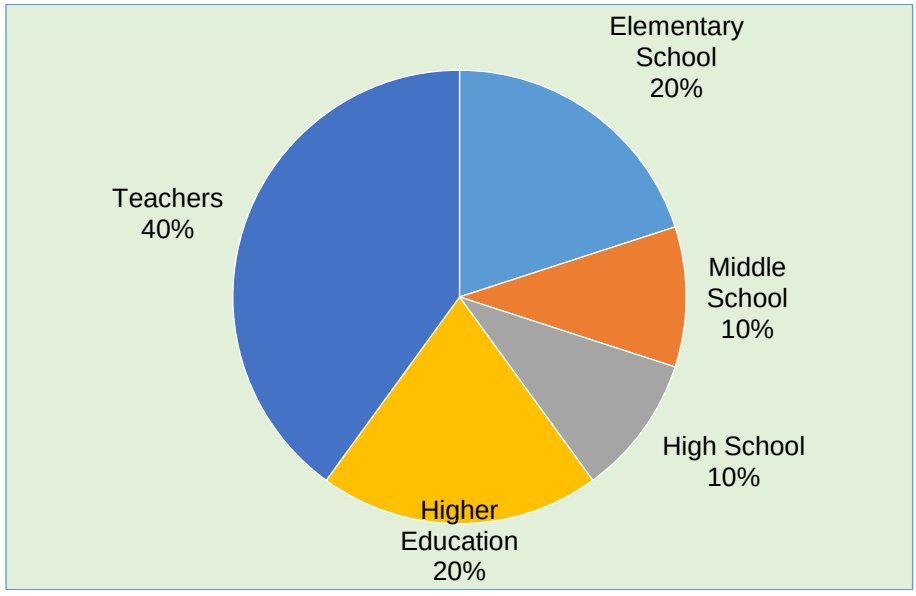

Figure 3. Percentage of Research Subjects.

Table 1: Selection Criteria Table.

No	Criteria	Inclusion	Exclusion
1	Publication Type	Articles used are from journals	theses, brief reports, and non-empirical studies
2	Specific Journal	Accredited journals at least Sinta 2 and international journals indexed by Scopus	non-accredited journals, or journals from Sinta 3-6 as well as international journals not indexed by Scopus
3	Publication Year	Articles published from 2014 to 2024	articles published outside the specified timeframe
4	Language	In English	Not in English
5	Field	Mathematics, Mathematics Education	not Mathematics, Mathematics Education
6	Method	Quantitative	Not Quantitative
7	Research Subject	Formal Education	Non-Formal Education

Ten articles that meet the established criteria were obtained based on the synthesis results of the available articles. As for the distribution of the article, as shown in **figure 2**:

Based on **figure 2**, **figure 3**, and **table 1**, it is obtained that 40% of the total articles are from the year 2020, 50% of the research designs are quasi-experimental, and 40% of the research subjects come from elementary schools.

The Application of PjBL in Mathematics Learning Internationally

Project Based Learning (PjBL) has become an increasingly popular approach in mathematics education across various countries. Research shows that PjBL enhances academic achievement and develops essential 21st-century skills for students. Several European countries have implemented PjBL in mathematics education with promising results. In Finland, (Viro et al., 2020) found that PjBL is an effective method for developing mathematical competencies and 21st-century skills. PjBL facilitates the development of teamwork skills and helps students connect mathematical theory with its practical applications. However, this research also identifies several challenges in implementing PjBL, such as inflexible schedules and teachers' need for more professional skills.

The study in Serbia by (Lazić et al., 2021) shows encouraging results. Elementary school students who learn with the PjBL model achieve better results than those who use conventional teaching methods. Interestingly, PjBL has proven effective in improving the performance of all students, including those who previously had low math scores. In Spain, (del Valle-Ramón et al., 2020) reported that students using PjBL showed a more

significant mathematical knowledge improvement than the control group. In addition, students who use PjBL are much more satisfied with this learning method. Research in Russia by (Rozhkova et al., 2020) at the higher education level also shows positive results. Engineering students who used PjBL showed better learning outcomes than those in the control group. Most students (84%) responded positively to using project-based methods in mathematics learning, with the main benefits perceived including improved teamwork skills, the development of independent learning skills, and an expanded perspective.

In Asia, research in Indonesia by (Septian et al., 2020) shows that PjBL effectively enhances students' mathematical representation skills. Meanwhile, (Hartono, 2018) reported a highly positive response (85.83%) from junior high school students towards project-based learning, with a significant difference between pretest and post-test results. Nevertheless, the implementation of PjBL in mathematics education can be challenging. (Diego-Mantecon et al., 2021) Mathematics teachers in Spain tend to avoid transdisciplinary projects and focus more on interdisciplinary projects emphasizing mathematics. Although there was no significant improvement in math scores, this study shows that the knowledge gained through PjBL tends to last longer.

In addition to the analyzed article (**Table 2**), it was also found that the United States (Remijan, 2016) discovered that PjBL can motivate high school students to learn mathematics, primarily when the projects focus on design and are relevant to real life. (Mdaka et al., 2023) In South Africa, They use teaching strategies that help students develop learning styles that facilitate shared experiences and collective reflection. In Turkey, (Ayaz & Söylemez, 2015) conducted a meta-analysis showing that PjBL significantly positively affects students' academic performance in mathematics compared to traditional teaching methods. In addition, a study by (Han et al., 2015) in Texas showed that PjBL in the context of STEM can affect student performance differently based on their ability levels, with a significant positive impact on low- and medium-performing students. Then, research (Frykholm & Glasson, 2005) describes how PBL can integrate mathematics with science, providing a meaningful context for students to apply mathematical concepts.

Overall, the implementation of PjBL in international mathematics education shows promising results. PjBL enhances academic achievement and develops essential skills such as teamwork, independent learning, and connecting mathematics with the real world. However, the success of PjBL implementation dramatically depends on thorough preparation, appropriate support for students and teachers, and adjustments to the local context and specific needs of the students.

Table 2: Article Analysis.

Code	Author	Research Design	Country	Results
P1	(Viro et al., 2020)	Experiment, Research Subjects Pre-service and In-service Teachers	Finland, Europe	PjBL is considered a development of mathematical/scientific competencies and 21st-century skills. The characteristics of project-based learning include developing teamwork skills and connecting theory and practice. PjBL is deemed suitable for revising and studying new mathematical content. The main obstacles to implementing Project-Based Learning (PjBL) include inflexible schedules, a lack of professional skills and motivation among teachers, and insufficient resources.
P2	(Lazić et al., 2021)	Quasi-Experimental, Research Subjects Third Grade Elementary School Students	Serbia, Europe	Students who learn with the PjBL students who learn with traditional methods. PjBL enhances the performance of all students, regardless of their previous math scores. Significant improvement is even observed among students with low scores. There is a significant interaction between the teaching method (PjBL) and students' math scores regarding their performance.
P3	(del Valle-Ramón et al., 2020)	Quasi-Experimental, Research Subjects Fifth Grade Elementary School Students	Spayol, Europe	The experimental group showed a more significant increase in mathematical knowledge than the control group. Students in the experimental group had much higher satisfaction with the learning method than the control group. Group work in PBL is effective in achieving learning objectives.
P4	(Septian et al., 2020)	Quasi-experimental, research subjects are students from the Mathematics Education Study Program	Indonesia, Asia	The achievement and increase in mathematical representation abilities in the experimental group were superior to those in the control group. The achievement of mathematical representation skill indicators in the experimental group is good, while the control group is adequate. The achievement of indicators based on cognitive styles in the experimental group is classified as good, whereas in the control group, it is classified as adequate. The PjBL model assisted by GeoGebra effectively enhances students' mathematical representation skills.
P5	(Hossein-Mohand et al., 2021)	Cross-sectional, the subjects of the research are secondary school mathematics teachers	Spain, Europe	The Flipped Learning, Project-Based Learning, and Gamification models positively impact several evaluated indicators. Project-based learning shows a negative relationship between two aspects of teaching practice indicators. These aspects include exchanging information and content through online spaces, participating in school projects related to digital technology, and using educational software to teach mathematics. They significantly impact the selection of active learning models and methodologies. ICT training and mathematics teachers' uses of technology are relatively minor in selecting models and methodologies.
P6	(Diego-Mantecon et al., 2021)	Experiment, Research Subjects: Mathematics, Physics, Chemistry, Biology, and Secondary School Technology Teacher	Spain, Europe	Out of 41 projects, 25 integrate mathematics content. Mathematics teachers avoid transdisciplinary projects and focus more on interdisciplinary projects emphasizing mathematics. Non-mathematics teachers need to pay more attention to the mathematical aspects of interdisciplinary projects. Interdisciplinary projects facilitate the development of mathematics more than transdisciplinary projects do. There is no improvement in students' math scores, but the knowledge gained lasts longer.
P7	(Rozhkova et al., 2020)	Experiment, Research Subjects: Engineering Students	Russia, Europe	The group using PjBL showed better learning outcomes than the control group. 84% of students responded positively to using project-based methods in mathematics learning. The main benefits of PjBL, according to the students, are teamwork skills (86%), development of independent learning skills (84%), and broadening of perspectives (83%). The project method helps students see the application of mathematics in real life and increases their interest in learning.
P8	(Hartono, 2018)	Quasi-Experiment, Research Subjects: Seventh Grade	Indonesia, Asia	The positive response of students to project-based learning (PBL) is 85.83%. There is a difference in student learning outcomes before and after

		Students of Junior High Schoo		implementing PjBL. The t-test results indicate a significant difference between the pretest and post-test.
P9	(Remijan, 2016)	Quasi-Experiment, Eleventh Grade Students of High School	Indonesia, Asia	Both learning models (STEM Project-Based Learning and STEM Problem-Based Learning) can enhance students' critical thinking skills. STEM PjBL is more effective in improving critical thinking skills than STEM PBL. There is a significant difference between the two learning models regarding enhancing critical thinking skills (Sig. 2-tailed = 0.01).
P10	(Monika et al., 2023)	Survey, Mathematics, Physics, Chemistry, Biology, and Technology Teachers in Malaysia	Malaysia, Asia	The knowledge and attitudes of teachers gained from professional development are high. Teachers' skills are at a moderate level. Teachers' knowledge, skills, and attitudes vary from moderate to high levels.

Learning Theories Used in Mathematics Education

Project Based Learning (PjBL) in mathematics education is supported by various learning theories emphasizing the importance of active student engagement, real-world contexts, and the development of complex skills. Several theories underpinning the effectiveness of Project-Based Learning (PjBL) based on research findings are as follows:

1. Constructivist theory was developed by figures such as Jean Piaget and Lev Vygotsky. This theory emphasizes that learning occurs when students actively build their knowledge. This is reflected in the findings of (Viro et al., 2020), which show that Project-Based Learning (PjBL) facilitates the connection between theory and practice in mathematics education. Students do not just passively receive information but actively construct their understanding through project experiences.
2. Vygotsky's social learning theory emphasizes the importance of social interaction in learning, supporting project-based learning (PjBL). (Rozhkova et al., 2020) They reported that one of the main benefits of PjBL is enhancing teamwork skills. This aligns with Vygotsky's concept of the Zone of Proximal Development, where students can achieve a higher level of understanding through collaboration with peers and teacher guidance.
3. The Experiential Learning Theory, developed by David Kolb, emphasizes the importance of concrete experience and reflection in learning. The findings (del Valle-Ramón et al., 2020) that show high student satisfaction with Project-Based Learning reflect how learning through hands-on experiences can enhance student motivation and understanding.
4. Howard Gardner's Theory of Multiple Intelligences. Project-based learning (PjBL) allows students to utilize various intelligences to

complete projects. This is reflected in the findings of (Septian et al., 2020), which show that Project-Based Learning (PjBL) effectively enhances students' mathematical representation skills involving various forms of intelligence.

5. Contextual Learning Theory, which emphasizes the importance of connecting learning with real-world situations, is very much in line with project-based learning (PjBL). (Hartono, 2018) reported a highly positive response from students towards PjBL, which may be attributed to the relevance of the projects to the students' real lives.
6. Motivation theories, such as the Self-Determination Theory developed by Ryan and Deci, also support PjBL. (Lazić et al., 2021) found that PjBL effectively improves the performance of all students, including those who previously performed poorly. This may be due to the increase in students' intrinsic motivation when they engage in meaningful projects.
7. Problem-solving theory, as developed by George Polya, is also relevant to PjBL (Diego-Mantecon et al., 2021) show that although there is no significant increase in math scores, the knowledge gained through PjBL tends to be more enduring. This may be due to the in-depth problem-solving approach inherent in PjBL.

Apart from the learning theories that have been put forward in the findings above, several additional theories support the effectiveness of PjBL in mathematics learning, including Situated Learning Theory (Lave & Wenger, 2013) which emphasizes that the most effective learning occurs in social contexts and authentic situations, which is in line with PjBL principles. Cognitive Apprenticeship Theory (Collins et al., 1991) describes how learning can be enhanced through observation, mentoring, and practice in authentic contexts, critical elements in PjBL. Self-Regulated Learning Theory (Zimmerman, 2022) explains the importance of students' ability to regulate their learning, which can be developed through PjBL. Connectivism theory (Siemens et al., 2005) emphasizes the importance of connections and networks in the digital era, which can be facilitated through collaborative projects in PjBL.

Based on the results of a synthesis of various articles, it was found that the main steps in implementing PJBL in mathematics learning include: a) Start by presenting a real-world problem or challenge that is relevant to the mathematical concepts being taught. This engages students and provides context for their learning (Tarakova, 2022; D Kokotsaki et al., 2016); b) Develop detailed project plans that outline the objectives, tasks, and expected outcomes. This includes defining the criteria that the project problem must satisfy (Fernandes et al., 2014; Tarakova, 2022); c) Creating a timeline for project activities, ensuring that students have a clear understanding of deadlines and milestones (Fernandes et al., 2014; Tarakova,

2022); d) organizing students into teams to foster collaboration and peer learning. This step is crucial for developing teamwork and communication skills (D Kokotsaki et al., 2016; Fernandes et al., 2014); e) Offer continuous support and guidance throughout the project. This includes monitoring project implementation and providing necessary resources and tools (D Kokotsaki et al., 2016; Azizah et al., 2023); f) Ensure that the projects are aligned with the curriculum and learning objectives. This helps in making the learning experience more relevant and comprehensive (Azizah et al., 2023; D Kokotsaki et al., 2016); g) Incorporate visual media to enhance understanding and engagement. Visual aids can help students grasp complex mathematical concepts more easily; h) Have students present their project results through written reports, oral presentations, or other formats. This step helps in reinforcing their learning and improving communication skills (Tarakova, 2022; Fernandes et al., 2014); i) Conduct a comprehensive performance-based evaluation to assess the effectiveness of the project and the learning outcomes. This includes both self-assessment and teacher assessment (D Kokotsaki et al., 2016; Fernandes et al., 2014) and j). After the project is completed, reflect on the process and outcomes. Use this reflection to make necessary adjustments and improvements for future projects (Guo et al., 2020).

Applying the project-based learning model to mathematics education significantly enhances students' understanding (D Kokotsaki et al., 2016), engagement (Tarakova, 2022), and achievement (Sumartini et al., 2019). It promotes the development of essential skills such as problem-solving, critical thinking, and teamwork, making mathematics learning more effective and relevant to real-world applications (Guo et al., 2020). Integrating visual media further enriches this learning experience (Lizunkov et al., 2020), providing students with a clearer and more engaging understanding of mathematical concepts.

Overall, PjBL in mathematics learning is supported by various learning theories emphasizing the importance of active student involvement, authentic context, collaboration, and the development of complex skills. Integrating these theories in Project-Based Learning (PjBL) helps explain its effectiveness in enhancing students' mathematical understanding and essential 21st-century skills.

Conclusion

Implementing Project-Based Learning (PjBL) in mathematics education has proven effective in improving students' academic performance, developing 21st-century skills, including critical thinking, problem-solving, collaboration, communication, creativity, technological literacy, and student motivation in various countries, and enhancing learning motivation.

Implementing the PjBL model in mathematics involves a series of well-defined steps: presenting problems, preparing project plans and schedules, forming effective teams, providing support, integrating with the curriculum, using visual media, presenting and evaluating results, and reflecting on the process. PjBL facilitates the connection between mathematical theory and its practical applications, helping students see the relevance of mathematics in real life. Studies from various countries, including Finland, Serbia, Spain, Russia, and Indonesia, show positive results from implementing project-based learning (PjBL) in mathematics education. This indicates that project-based learning (PjBL) can be adapted and is effective in various cultural contexts and educational systems. Various learning theories, including constructivism, social learning, experiential learning, multiple intelligences, contextual learning, motivation theory, and problem-solving, support PjBL. The integration of these theories explains the effectiveness of PjBL in developing mathematical understanding and broader skills. Although effective, implementing Project-Based Learning (PjBL) faces challenges such as inflexible schedules, more professional skills among teachers, and adequate resources. This indicates the need for systematic support and professional development for teachers. PjBL offers a more holistic approach to learning mathematics, allowing for the development not only of conceptual understanding but also skills such as teamwork, independent learning, and complex problem-solving. Further research is needed to optimize the integration of Project-Based Learning (PjBL) with traditional teaching methods, address implementation challenges, and analyze the long-term impact of PjBL on students' understanding and retention of mathematical concepts.

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ORIGINAL ARTICLE

A Technology-Based Project with a Study that Simultaneously Evaluates STEM Awareness, STEM Self-Efficacy Beliefs, and 21st Century Skills

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***Abstract**: This study seeks to determine the pre-service science teachers' STEM self-efficacy beliefs, STEM awareness, and 21st century skills at the beginning and end of a technology-based project. 28 pre-service science teachers, all aged 20-24, were included in the study. They were the 3rd or 4th grade pre-service science teachers studying at 13 universities in Turkey. From a quantitative perspective, three different data collection tools were included in the study. The first of all, the "STEM Awareness Scale", the second data collection tool was "The Self-Efficacy Scale Related to STEM Practice", the third data collection tool was the "Multidimensional 21st Century Skills Scale" and from a qualitative perspective a survey form including 7 open-ended questions were administered. This study was found to have contributed positively to STEM self-efficacy beliefs and 21st century abilities, and it continued to contribute positively to STEM awareness, but not statistically. It can be suggested that such activities must be designed and organized not only for pre-service teachers but also for 21st century learners such as teachers, all faculty members working at the university, and all students, etc.*

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Keywords: *STEM Self-Efficacy Beliefs, 21st Century Skills, Pre-Service Science Teachers, Technology-Based Project*

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Ethical Declarations: *All procedures performed in this study followed the ethical standards of the Department of Health Standards on Human Research (DOH/QD/SD/HSR/0.9) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The first author is the project organizer and applied to TÜBİTAK by receiving an official letter signed by the Vice Rector of Giresun University. The project was accepted by TÜBİTAK and announced to universities across Türkiye. Participants participated on a voluntary basis and were selected according to certain criteria. In addition, both written and verbal participation consent was obtained from the participants. The project and the selection criteria of the participants are available on the Giresun University website (http://etkilesimlimateryal.giresun.edu.tr). This statement is an ethical rule that must be followed in order to carry out the event.*

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AI Declaration: *The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

Introduction

THERE are a lot of researches about STEM and a lot of explanations how STEM boomed in education. But mostly common point is that STEM education is effective in teaching STEM disciplines and positively affects students' future career choices. STEM education is an integrated approach to enable students to develop creative problem-solving techniques, and the development of future innovators (Er & Başeğmez, 2020).

STEM education aims to provide students with environments in which they can gain experience and prepare them to become future scientists, technologists, innovators, or engineers because STEM education focuses on solving problems using real-world examples rather than traditional educational programs (Breiner et al., 2012). However, it is widely accepted by several developed countries that STEM has a lot of positive impacts on education systems all over the world, but at this point, a serious problem has arisen because the teachers who will implement STEM in their classrooms are unqualified and insufficiently trained for STEM education (Nowikowski, 2017). This problem forces the education system to change teacher preparatory programs. In Turkey, some universities add STEM courses to their teaching programs as obligatory or elective lessons in order to overcome the problem mentioned above. As in this project, some initiatives can be taken by the researchers, such as scientific projects.

Implementing STEM education is a good starting point to gain 21st century skills because STEM education does not provide only effective teaching but also has an important role in helping individuals acquire 21st century skills (Capraro et al., 2013). According to Çeliker (2000) the combination of STEM education and 21st century skills are equally critical. Teachers' knowledge and expertise in a single field are insufficient to raise individuals suitable for countries' 21st century skills without interdisciplinary work (Çorlu et al., 2014). STEM education prepares students for the 21st century by providing them with the necessary skills (Tsupros et al., 2009). It promotes the development of 21st century skills such as cooperation, questioning, critical thinking, and problem solving (Sanders, 2009; Khalil & Osman, 2017).

There a lot of skill lists explaining what the 21st century skills are by different organizations. The Partnership for the 21st century skills (P21, 2002), which is one of the organizations, listed the 21st century skills as learning and innovation skills, knowledge, media and technology skills, and life and career skills (Kyllonen, 2012). Individuals who have the 21st century skills should be creative, innovative, solution-oriented, highly motivated, strong in communication, and technology lover, etc. (Aydeniz, 2017; Ültay et al., 2021).

According to Rotherham and Willingham (2009), these skills such as problem solving and critical thinking, which enable the solution of many problems, are as old as human history and they should not be referred to as 21st century skills. However, the meaning attributed to it has changed. In order to raise individuals who can keep up with the times, we should organize effective teaching programs that can provide them with these skills. Effective programs emphasized sustained or sequential activities rather than unstructured, one-time opportunities; relied on active student participation; emphasized personal and social skills by allocating time specifically to develop those skills; and explicitly identified which skills they developed (Kyllonen, 2012). In the new world order, teamwork skills, self-reflection or time management are considered more important than knowing mathematics or science. STEM education as mentioned above can provide good opportunities for students to gain 21st century skills (Bybee, 2010).

For teachers and even pre-service teachers, teaching competence is crucial to the implementation and quality of STEM education in schools and is influenced by teachers' learning experiences during preparatory programs (Song & Zhou, 2021). Preparatory programs or in other words internship programs can provide different teaching experiences for pre-service teachers to gain teaching competency and self-efficacy in a real classroom. Teachers of the real classrooms can also gain benefits from the implementation of pre-service teachers in their classrooms through these preparatory programs. Teachers, for example, may learn new teaching approaches, models, and so on from pre-service teachers' implementations. By the way, teaching competency and self-efficacy for pre-service teachers will be developed. Teaching competence is also directly related to teachers' self-efficacy. At this point, it can be talked about a multi-faceted interaction in between the teacher and the pre-service teachers and also in between teaching competence and self-efficacy of the pre-service teachers.

According to Bandura (1994), an advocate of Social Cognitive Theory, self-efficacy is a person's ability to do a job. Bandura referred to one's personal judgments of one's abilities to organize and execute actions to achieve set goals. Bandura (2006) suggested four sources, including performance accomplishments, vicarious experience, social persuasion, and psychological responses, which either strengthen or weaken self-efficacy. According to Rockinson-Szapkiw et al. (2022), while performance accomplishment is related to one's experience in performing a specific task, vicarious learning refers to experiences and requires the individual to observe another person performing the task. For this reason, both pre-service teachers and teachers have experienced both of these aspects (performance accomplishments and vicarious experience). When pre-service teachers or teachers accomplish a task successfully, their self-efficacy increases, if do not accomplish, then it lowers. In this project and other STEM classes

because direct feedback is provided, pre-service teachers' self-efficacy is expected to evolve (Stewart et al., 2020).

Self-efficacy is defined as a person's own belief about being successful or not on a task (Salar, 2021). Self-efficacy has emerged as a key factor in academic motivation, goal setting, and performance (Richardson et al., 2012). Self-efficacy is necessary for the effective use of self-regulation skills to achieve mastery and plays a causal role in the development and employment of academic competences (Schunk & Pajares, 2007). Also, self-efficacy skill significantly affects a person's career choices in the future (Stewart et al., 2020). Dorssen et al. (2006) discovered that informal STEM activities are one of the most promising ways to encourage young people to reconsider career paths that they had previously dismissed due to faulty beliefs. As a result, as happened in this project, students benefit from being exposed to informal opportunities that help them form accurate perceptions of STEM careers (Blotnicky et al., 2018). Accurate STEM perceptions affect and shape STEM awareness in a good direction.

Individuals with a high level of STEM awareness are those who are concerned about STEM education. It is possible that these individuals will shape their own attitudes and behaviors in response to the STEM approach over time (Çetin, 2021). According to Şahin's study (2019), it has been reported that pre-service science teachers who participate in STEM activities become more aware of and have a positive attitude toward STEM disciplines. Salar (2021) and Nadelson and Seifert (2013) stated that STEM awareness is a key factor for a good STEM teaching experience. According to Edwards and Loveridge (2011), teachers frequently fail to recognize available learning opportunities due to a lack of pedagogical awareness of how to teach science.

The Research Problem

This study is a part of an online project supported by Scientific and Technological Research Institution of Turkey (TUBITAK). Within the scope of this study, STEM awareness, STEM self-efficacy beliefs and 21st century skills of pre-service science teachers were tried to be determined and answers were sought for the following sub-problems:

- Is there a significant difference between the pre and post-test scores of pre-service science teachers on STEM awareness levels, STEM self-efficacy beliefs, and 21st century skills?
- What are the opinions of pre-service science teachers about 21st century skills after receiving STEM training?

Methodology

The study can be described as a case study with a more quantitative perspective, as it tries to measure pre-service teachers' STEM self-efficacy belief, STEM awareness, and 21st century skills at the beginning and end of the STEM education part of the project. The study's qualitative dimension was to seek the thoughts of pre-service science teachers' 21st century skills by a survey form. As it is known, case studies focus on a group's characteristics, and in this study, pre-service science teachers participated in an online project funded by TUBITAK in Turkey. The project, which was called "Designing and Developing Interactive Teaching Materials Suitable for the New World Order," was a short-term project and lasted for four weeks in 2021-2022 spring semesters.

In the first 5 days of the project, training on teaching methods and techniques and digital applications was given every day. For example, each day, one modern teaching method and one digital applications (Kotobee™, Educaplay™, Thinglink™, etc.) were mentioned, and sample teaching materials were shown and discussed. To give an example, on the first day of the project, STEM was presented online by ZOOM™ and some example teaching materials were shown to the pre-service teachers by the second researcher. On the same day, the first researcher presented Kotobee™, which was a program allowing pre-service teachers to design digital interactive teaching materials and interactive e-books. At the end of each day, pre-service teachers designed and developed digital interactive teaching materials in which they used STEM, Kotobee™, or other approaches and digital applications. This teaching experience was carried out on the day that STEM was taught. It is good to note that all of these pre-service science teachers knew the STEM teaching methods in their undergraduate programs at their universities before attending this project. In addition, they have just learned the Kotobee™ application and received feedback from the field expert for the relevant application throughout the week. For three weeks, the pre-service science teachers and the researchers engaged in an interactive process of receiving this input. During these three weeks, pre-service teachers revised the interactive lesson plans they had created in accordance with the researchers' recommendations and displayed the final product in the exhibition. Three weeks following the theoretical applications, the procedure came to a close with the exhibition and administration of post tests.

After the project is accepted by TUBITAK, an announcement is made through an open call so that 3rd and 4th grade students of science teaching departments in all universities in Turkey can apply. Purposive sampling was used to select participants for the study. The sampling was created by including people, events, objects, or situations with qualifications determined in relation to the problem. Because certain criteria were used to choose which pre-service instructors would participate in the study, criterion-based sampling was determined to be appropriate (Büyüköztürk et

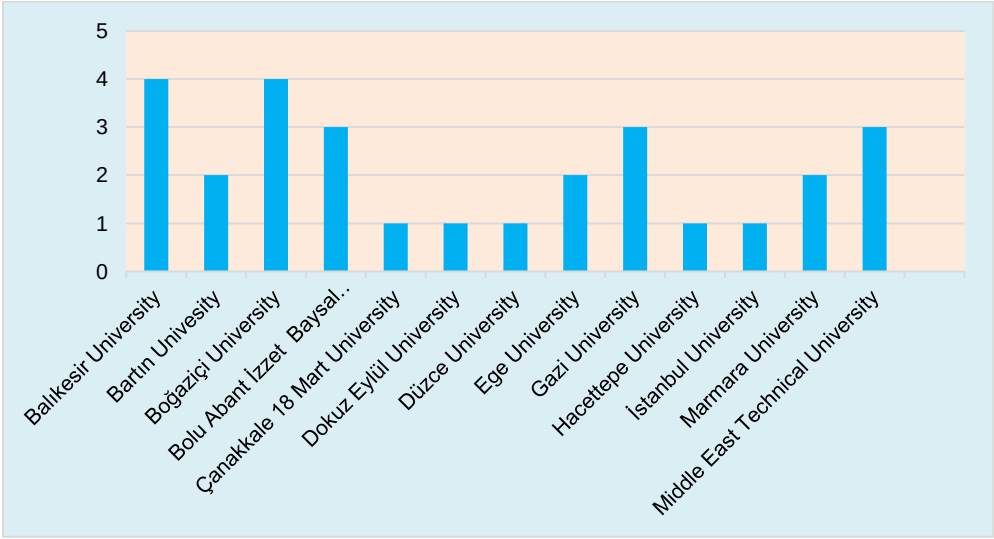

Figure 1. The Number of Participants and the Distribution of the Universities.

al., 2015). In the determination of the participants, applications were received through the website (URL-1) opened to the project in the 2021-2022 academic year. Among the many applications made, 30 participants who best met the application criteria were selected as permanent and 15 participants as substitutes. Controls were provided by making technical trial applications of the computer hardware of the determined participants. Participants who could not provide sufficient technical equipment for the project were excluded and technical trial applications were carried out with the designated reserve participants. As a result of these practices, 30 main participants were determined. 28 of the 30 main participants participated in the implementation process full-time, but 2 participants could not participate full-time due to various reasons. 28 pre-service science teachers, all of them were girls (by chance) aged 20-24, were included in the study.

They were the 3rd or 4th grade pre-service science teachers studying at different universities in Turkey in the academic year mentioned before. The number of participants and the distribution of the universities they studied were presented in **Figure 1** below.

Data Collection Tools

From a quantitative perspective, three different data collection tools were included in the study. The first of all, the "STEM Awareness Scale" (SAS), was a Likert type questionnaire and was developed by Buyruk and Korkmaz

(2016). SAS, which consisted of 17 items, was used to determine pre-service science teachers' STEM awareness levels. The first 12 items were in the "positive view" and the last 5 items were in the "negative view" sub-dimension, so the negative ones were reverse coded and included in the analysis. For the positive view "STEM gives students high-level thinking skills" and "STEM education enhances collaborative work in students" can be given as examples and for the negative view "STEM applications distract students from the lesson" and "Practicing STEM activities wastes time" can be given as examples.

The second data collection tool was "The Self-Efficacy Scale Related to STEM Practice" (SES) developed by Yaman et al. (2018) and was used to determine self-efficacy beliefs related to STEM practice of pre-service teachers. The SES consisted of 18 likert type items. "I am academically proficient in the science process skills required when designing a STEM activity", "I can easily interpret the results of STEM-related activities" and "I can determine the objectives to be gained in STEM activities in accordance with the characteristics of the student and the environment" can be given as example items for SES.

The third data collection tool was the "Multidimensional 21st Century Skills Scale" (MCSS) which was a Likert type scale, developed by Çevik and Şenturk (2019) and was used to determine the pre-service science teachers' 21st century skills. The scale was developed for people/students between the ages of 15-25 and consisted of 41 items. Because 16, 17, 18, 19, 20, 21, and 35th items were negative, they were coded reversely. "I get different information and ideas by following various sources", "I think about the needs that may arise in the world in the future and I do research about it" and "I do not like people who criticize me" can be given as example items for the MCSS.

From a qualitative perspective, a survey form was used to collect data about the pre-service science teachers' 21st century skills. In the survey form, 7 open-ended questions about 21st century skills were asked to the pre-service science teachers. Firstly, the draft version of the questions was created based on the literature. Secondly, expert opinion was obtained from two education experts, one in science education, and the other in chemistry education, leading to the draft revision. The researchers made an online pre-application, as a pilot scheme, to 4 pre-service science teachers, and were not found any problems with the clarity and responsiveness of the form. Finally, the survey form was finalized. This form was created on Google forms, the survey administration software offered by Google.

Implementation Process

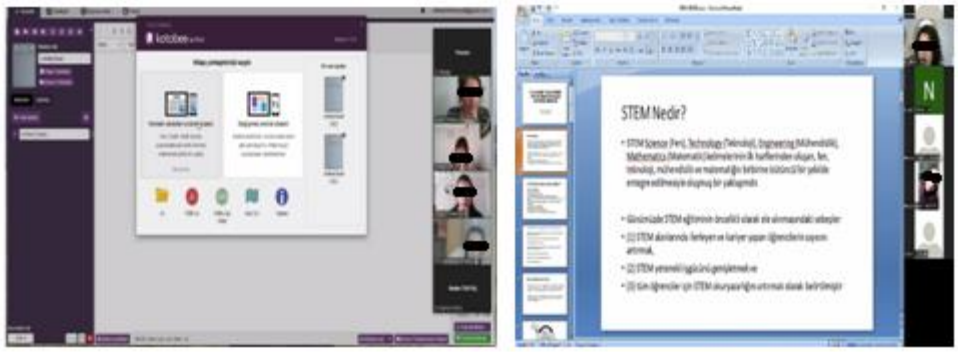

Figure 2. Implementation Process Sample Screenshots.

Before the implementation, the pre-service science teachers were administered the SAS, SES, and MCSS scales as pre-tests. At the end of the project, the same scales were performed again on the participant as post-tests. Also, the survey form was filled by the pre-service teachers at end of the project.

To begin with, the uses of "Interactive Teaching Materials in Learning Environments Prepared according to the STEM Approach" were explained theoretically (1 lesson hour - 60 minutes) by the second author. The Kotobee™ application, which is one of the e-book applications and provides the opportunity to prepare digital interactive teaching materials, was introduced by the first author (3 lesson hours - 3*60=180 minutes). Following, technical and topic-based workshops were held on Kotobee™ and STEM with the participation of both authors (2 lesson hours - 2*60=120 minutes). At the end of the day, activity plans (1 lesson hour - 60 minutes) based on the STEM approach, including the Kotobee™ application, were carried out with the participation of both authors. This whole process was done online. Sample screenshots of the implementation process are presented in **Figure 2** below.

All application process of the research is schematized in **Figure 3**.

Data Analysis

Quantitative data (SAS, SES, and MCSS) were analysed by the SPSS statistics package program (version 22). Since the sample size was below 30 and the data did not show a normal distribution (as a result of the normality test), nonparametric tests were preferred. Wilcoxon Signed Rank tests were used to determine if there were significant differences between pre and post-tests. Also, descriptive analyses were applied for each sub-dimension of the STEM Awareness Scale. The answers given to the scales were interpreted as

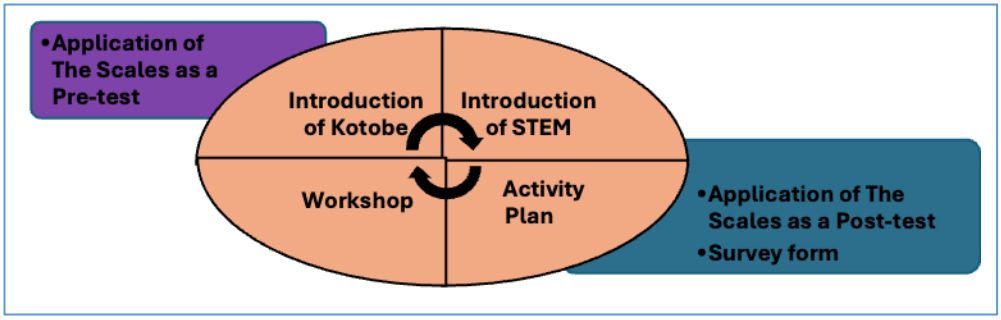

Figure 3. The Process of the Research.

Table 1. Values Used in Interpreting the Arithmetic Mean of the Scale.

Interpretation of Scoring	Range Rating	Interpretation
1.0-1.79	Strongly disagree	Very low
1.80 - 2.59	Disagree	Low
2.60 - 3.39	Neither agree nor disagree	Middle
3.40 - 4.19	Agree	High
4.20 - 5.00	Strongly agree	Very high

all values used are given in **Table 1**. Similar analyses for the relevant scale are also included in different studies (Özdemir & Cappellaro, 2020; Akgün & Türel, 2021).

Qualitative data (survey form) were analysed via content analysis. Two authors thoroughly examined the obtained data and developed codes appropriate for the participant's responses. The two researchers' agreement and disagreement were then determined (Miles & Huberman, 1994). The agreement coefficient (reliability) was calculated as 0.90. The codings were matched based on similarities and differences, and subcategories/categories were identified by grouping them under various titles. The data were submitted to the field expert for finalization in order to ensure the relevance of the categories by the codes. Accordingly, the obtained data were finalized in line with the received feedback.

Validity and Reliability

The validity and reliability of the quantitative scales used in the study were carried out by the developers of the scales. Accordingly, Cronbach alpha values of reliability coefficients were calculated. In the SAS scale development stage, Buyruk and Korkmaz (2016) did the exploratory factor

analysis, and as a result, the scale consisted of 17 items. The Cronbach's alpha reliability coefficient of the scale was found to be 0.93 by Buyruk and Korkmaz. For this study reliability coefficient was calculated as 0.89. According to the results of the exploratory factor analysis conducted by Yaman et al. (2018), the SES scale consisted of 18 items. The Cronbach's alpha reliability coefficient of the scale was found to be 0.97. For this study reliability coefficient was calculated as 0.94. Cevik and Senturk (2019) performed the exploratory factor analysis as a part of the validity studies. As a result of the analysis, a 41-item scale was created. The Cronbach's alpha reliability coefficient of the scale was found to be 0.86. For this study reliability coefficient was calculated as 0.81. Usage permissions for all scales were obtained from the scale owners via e-mail.

The survey questions were formed by the researchers. Then they were checked by a science education expert for readability, understandability, and compatibility. After this stage, the final version was ready for the survey. All participants were informed about the recording of the survey data and their consents were taken.

Apart from these, participation in this project was based on the participants' willingness. They wanted to participate in this project willingly and so that they filled an online application form on their own, they were informed about the data collection phases, and the recording of the data. Participants were coded as P1, P2, P3, …, P28.

Findings

In this study, STEM awareness, STEM self-efficacy beliefs, and 21st century skills of pre-service science teachers were tried to be determined. The findings relating to the research problems are offered below for this purpose.

Findings on 1st Research Question

The framework of the first research problem is "Is there a significant difference between the pre and post-test scores of pre-service science teachers on STEM awareness levels, STEM self-efficacy beliefs, and 21st century skills?" **Tables 2** and **3** below present the findings of the first research problem. **Table 1** shows the results of the descriptive analysis calculated on the scores of the pre-service science teachers on the SAS, SES, and MCSS scales.

As seen in **Table 2**, the average scores of all the tests increased in the post test. Table 3 shows the results of the Wilcoxon Signed Ranks analyses calculated on the scores of the pre-service science teachers for the SAS, SES, and MCSS scales.

Table 2. Descriptive analysis of Scales.

Scales	N	Mean	Std. Deviation	Min.	Max.	Mean Ranks
SAS-pre	28	75	14.00	17.00	85.00	14.69
SAS-post	28	77.21	8.20	59.00	85.00	12.31
SES-pre	28	61.46	14.26	31.00	85.00	15.36
SES-post	28	76.28	11.69	47.00	90.00	11.33
MCSS-pre	28	168.64	28.82	76.00	202.00	15.03
MCSS-post	28	183.36	15.93	152.00	205.00	11.56

Table 3. Wilcoxon test results for SAS, SES, and MCSS Scales.

Scales		N	Mean Rank	Sum of Ranks	z	p
SAS	Negative Ranks	13	12.31	160	-394	0.694
	Positive ranks	13	14.69	191		
	Ties	2				
SES	Negative Ranks	6	11.33	68	-3.076	0.002
	Positive ranks	22	15.36	338		
	Ties	0				
MCSS	Negative Ranks	8	11.56	92.50	-2.319	0.020
	Positive ranks	19	15.03	285.50		
	Ties	1				

Table 4. Descriptive analysis of SAS.

	Items	N	Mean	Std. deviation
Pre-test	Positive perspectives	28	4.49	0.14
	Negative perspectives	28	4.23	0.28
Post-test	Positive perspectives	28	4.65	0.08
	Negative perspectives	28	4.31	0.30

As seen in **Table 3**, the result shows STEM awareness levels were not statistically significant in favour of the post-test. On the other hand, scores on the Self-Efficacy Related to STEM Practice Scale and the 21st Century Skills Scale were found to be statistically significant in favour of the post-test. In order to determine the STEM awareness levels of prospective teachers, descriptive analyses were applied for each sub-dimension of the SAS scale. The values obtained as a result of the analysis are shown in Table 4 below.

As seen in **Table 4**, the change in stem awareness levels from a positive and negative perspective according to the pre- and post-test is shown, and it can be said that the awareness level has increased in both aspects.

Findings on 2nd Research Question

The framework of the second research problem is "What are the opinions of pre-service science teachers about 21st century skills?" **Tables 5, 6, 7, 8, 9, 10**, and **11** below present the findings of the second research problem.

As seen in **Table 5**, a significant number of pre-service teachers stated that researching, questioning, and producing solutions on information and technology (12), keeping up with technological developments (10), and using technology effectively (9) as the definition of information and technology literacy. Major of pre-service teachers thought themselves as information and technology literate. Moreover, they stated that they keep up with technological developments (9), use information and communication technologies in daily life (8), use technology correctly and efficiently (6), provide reliability of the information source (6), check information from different sources (6).

For example, P21 explained in this way "Information literacy can be defined as people who access information, analyze it and research it. I think that technology literate refers to people who use technology, benefit from it and can produce solutions to various technological problems. In this respect, I think that I am information and technology literate. I take care to research the information I want to access from the right sources. In this research process, I benefit from technology and I think that I can analyze which sources are reliable."

As seen in **Table 6**, the definition of critical thinking skill is including analyser/evaluator (16), questioner (15), and filters the mind and logic (9). Major of pre-service teachers thought themselves as having critical thinking skills. They explained critical thinking skills behaviour as evaluating the positive and negative aspects (10), being capable of deduction (7), and respecting/evaluating different opinions (6). For example, P5 explained in this way: "Critical thinking skills are the ability to reason and present ideas in the face of a problem or event. A person with critical thinking skills researches events, situations, and obtains information and offers solutions to problems. I don't think I have much critical thinking skills. Because I am very emotional, I only stay in the moment of the situation."

As seen in **Table 7**, when pre-service teachers face with a problem, they try to understand what/cause of the problem (20), develop a solution proposal (17), behave solution-oriented (11), and ask for help (8). For example, P25 explained in this way "First, I research the source of the

Table 5. Codes Related to the 1st Question of The Survey Form.

1. a) What is Information and Technology Literacy?		
Code	**Pre-service science teachers**	**f**
Researching, questioning and producing solutions on information and technology	P7-9, P14, P16, P18-19, P21-25	12
Keeping up with technological developments	P1, P9, P11, P16-17, P20, P23-25, P28	10
Using technology effectively	P5-6, P8, P11, P13-15, P21, P28	9
Ability to explain information	P5, P16, P18, P20-22, P25	7
Information integration into technology	P3, P7, P10, P15, P26, P28,	6
Being receptive to new information	P3, P7, P9, P25, P28	5
Digital Literacy	P12	1
1. b) Do you think you are information and technology literate?		
To be information and technology literate	**Pre-service science teachers**	**f**
Yes	P2, P6-9, P11, P13-14, P18, P21-22, P26, P28	13
Partially	P1, P5, P10, P12, P15-17, P19, P24, P27-28	11
No	P3-4, P25	3
1. c) How do you act in this regard, what do you pay attention to?		
Behavior to be information and technology literate	**Pre-service science teachers**	**f**
Keeping up with technological developments	P4, P9-13, P19-20, P26	9
Using information and communication technologies in daily life	P1, P7-9, P17, P24, P26-27	8
Using technology correctly and efficiently	P5-6, P8, P13, P24, P28	6
Reliability of the information source	P2, P14, P16, P21-22, P28	6
Checking information from different sources	P4-7, P21-22,	6
Learning new and correct information	P3, P16, P20	3
Finding solutions for interests and needs in daily life	P12-13, P26	3

Table 6. Codes Related to the 2nd Question of The Survey Form.

2. a) What does critical thinking skill mean?		
Definition of critical thinking skill	**Pre-service science teachers**	**f**
Analyzer / Evaluator	P7, P9, P11-12, P14-16, P19-22, P24-28	16
Questioner	P1-2, P7-8, P10, P14, P17-18, P20-24, P26, P28	15
Filters the mind and logic	P1, P4-7, P11-12, P18, P28	9
2. b) Do you think you have critical thinking skills?		
Having critical thinking skills	**Pre-service science teachers**	**f**
Yes	P1, P3, P6-7, P9-11, P14-17, P19, P22, P25, P27-28,	16
Partially	P2, P4-5, P8, P12, P18, P20-21, P23-24, P26	11
2. c) How does a person with critical thinking skill behave?		
Critical thinking skills behavior'	**Pre-service science teachers**	**f**
Evaluating the positive and negative aspects	P1, P6, P8, P10, P14-15, P24-27	10
Being capable of deduction	P4,P7,P14,P19,P22,P25,P28	7
Respecting/evaluating different opinions	P4,P7,P15-17,P22	6
Multidimensional thinking	P4,P7,P21,P28	4
Queries	P7,P9,P26	3
Offering a solution	P5,P11,P28	3

Table 7. Codes Related to the 3rd Question of The Survey Form.

3. a) How do you act when faced with a problem? Why?		
Behavior towards to problem	**Pre-service science teachers**	**f**
Understanding what/cause of the problem	P2-5, P7, P10-11, P13, P15-23, P25, P27-28	20
Developing a solution proposal	P2-6, P8-10, P12, P14-15, P18-19, P22, P24, P27-28	17
Solution-oriented	P1, P5-7, P10, P15, P17, P21, P25-26, P28	11
Asking for help	P10, P15-17, P22, P25-27	8

Table 8. Codes Related to the 4th Question of The Survey Form.

4. a) Do you think you are an innovative person?		
To be innovative person	**Pre-service science teachers**	**f**
Yes	P1-7, P9, P11-19, P21, P23-25, P27-28	17
Partially	P8, P10, P20, P22, P26	5
4. b) How do you act when faced with a new situation? Why?		
Behavior against new situation	**Pre-service science teachers**	**f**
Adapt	P5-7, P11, P14-16, P18-19, P28	10
Difficulty adapting to the process	P3, P8, P13, P17	4
Observation	P4, P7, P26	3
Data collection	P4, P25, P27	3
Learning and practice	P23, P25	2

Table 9. Codes Related to the 5th Question of The Survey Form.

5. a) Do you consider yourself an entrepreneurial person?		
To be an entrepreneurial person	**Pre-service science teachers**	**f**
Partially	P1, P3-5, P7, P10-12, P16-19, P21-22, P27	15
Yes	P2, P6, P9, P14, P20, P25, P28,	7
No	P8, P13, P15, P23-24, P26	6
5. b) How does an entrepreneur behave?		
Entrepreneurial person behavior'	**Pre-service science teachers**	**f**
Being able to generate new ideas	P7, P12-16, P26, P28	8
Being open to innovation	P7, P9, P13, P15-16, P26, P28	7
Being Sociable	P7-8, P12, P16, P19, P28	6
Risk Taker	P8, P16, P18, P21, P25-26	6
Being Self-confident	P4, P8, P11, P25, P27, P28	6
Brave	P1, P8, P11, P15, P25	5
Willing, curious and determined	P1, P2, P20, P22, P25	5
Forward thinking	P4, P9, P20, P27, P28	5
Motivational	P4, P9, P16, P28	4
Strong communication orientation	P8, P16, P24, P28	4
Planned and Scheduled	P14, P16, P21, P28	4
Capable of Evaluating Opportunities	P8, P10, P20	3
Able to Implement Ideas	P11, P14, P23	3
Able to Manage the Process	P19-20, P28	3
Able to Use Time effectively	P20, P28	2

Table 10. Codes Related to the 6th Question of The Survey Form.

6. a) Do you think you have social responsibility?		
To be a social responsibility	**Pre-service science teachers**	**f**
Yes	P1-2, P4-10, P12, P25-28,	14
Partially	P3, P11, P14-19, P21-24, P28	13
No	P20	1
6. b) What does it mean to be socially responsible?		
Definition of social responsibility	**Pre-service science teachers**	**f**
Consciousness of social responsibility	P4-5, P7, P9-10, P12, P14-18, P20, P23, P25-28	17
Being environmentally conscious	P4, P8, P10-11, P21, P25, P27	7
Ability to perform tasks optimally	P6, P9, P19, P22, P24, P28	6
Know your responsibilities	P1-2, P4, P28	4
not bothering anyone	P18, P28	2
Being planned and programmed	P2	1
Ability to offer solutions	P3	1
Being interested in activities and events in social life	P14	1
Ensuring that everyone has equal opportunity	P18	1
Good relationship	P21	1

Table 11. Codes Related to the 7th Question of The Survey Form.

7. a) How does a person with leadership skills behave?		
Definition a person with leadership skills	**Pre-service science teachers**	**f**
Able to manage the process	P2, P4, P7, P10, P13-15, P17, P20, P26-28	12
Able to manage people	P5-6, P17-19, P24, P26-28	9
Capable of leading	P2-3,P8, P11, P18, P28	6
Communication skill	P7,P9, P21, P23, P25, P28	6
Solution oriented	P1, P8, P16, P18, P22	5
Fair	P4, P19, P21, P26, P28	5
Does not hesitate to take responsibility	P1, P10, P20, P25	4
Able to Approach Different Thoughts With Understanding	P3, P8, P21, P28	4
Sample person	P5, P25, P28	3
Reassuring	P4, P12, P21	3
Get your cooperation	P5, P7, P28	3
Can assign	P5, P7, P28	3
Having a different perspective	P20, P23,P28	3
Able to generate creative ideas	P4, P21	2
7. b) Do you think you have this skill?		
To be a person with leadership skills	**Pre-service science teachers**	**f**
Partially	P3-4, P8-9, P11-19, P21, P24, P26, P28	17
Yes	P1-2, P5-7, P10, P20, P25, P27-28	10
No	P22-23, P28	3

problem. Then, I think about what can be done to solve it. I get ideas from those around me. I try to proceed within the framework of logic. I try to make my decisions impartially and in the most accurate way."

As seen in **Table 8**, all pre-service teachers see themselves as innovative. They stated that when they face with a new situation they try to

adapt (10), have difficulty adapting to the process (4), observe (3), collect data (3), and learn and practice (2). For example, P19 explained in this way "I am a person who is open to innovations in every subject. I like differences. I try to understand, adopt and adapt to the situation."

As seen in **Table 9**, the majority of pre-service teachers see themselves as entrepreneurial. A significant number of pre-service teachers stated that the entrepreneurial person generates new ideas (8), is open to innovation (7), is sociable (6), is a risk-taker (6), and is self-confident (6). For example, P16 explained in this way: "When an entrepreneurial person comes to mind with an idea or encounters a problem, he/she does everything within the framework of logic to bring that idea to life. He/she is enterprising, has high morale and a lot of interest. He/she is innovative. He/she takes risks where necessary. If he/she makes a plan and a program when starting a business, he/she will progress in this business. He/she discovers and produces new things. He/she likes to establish dialogue with people. I think I am at least partially entrepreneurial."

As seen in **Table 10**, almost all pre-service teachers thought that they had social responsibility. A significant number of pre-service teachers stated that the definition of social responsibility includes consciousness of social responsibility (17), being environmentally conscious (7), and the ability to perform tasks optimally (6). For example, P10 explained this question in this way: "Being socially responsible means being sensitive to society. It is usually used for studies related to the environment. Because the environment is a structure that concerns society, not the individual, I think I have social responsibility because I separate my garbage according to recycling. Although this may seem like a small thing to most of us, if we had this awareness as a society, our batteries would not pollute our lands, our seas would be cleaner and our ecosystem would be more effective."

As seen in **Table 11**, the majority of pre-service teachers thought that they had leadership skills. A significant number of them stated that the definition of a person with leadership skills consists of managing the process (12), managing people (9), being capable of leading (6), and having communication skills (6). For example, P4 explained this question in this way: "They can put forward creative ideas, they need to be able to solve the obstacles that come their way in line with their goals with the least damage, they exhibit professional behaviors in terms of trustworthy, fair, positive process and time management. I think that I have some skills exist and some do not because some are truly born leaders."

Discussion

According to the study, it was determined that there was no statistically significant difference in pre-service science teachers' STEM awareness

levels before and after the application. This result can be explained by the fact that pre-service teachers view STEM positively and are aware of the STEM approach. Furthermore, it can be associated with the fact that the pre-service teachers are in the 3rd and 4th grades, inferring that STEM awareness rises with grade level (Sondergeld et al., 2016; Ergün, 2019). Although there is no statistically significant difference after the STEM application, there is an increase in favor of the post-test among the minimum rankings. This rise can be interpreted mathematically as the application's positive contribution to pre-service teachers' STEM awareness.

As a matter of fact, when we look at the studies on STEM awareness, it is seen that they have positive perspectives toward STEM. For example, in the study conducted by Ergün (2019), the relationship between the STEM awareness levels of pre-service science teachers and their entrepreneurial aspects was examined and it was stated that pre-service teachers had a positive awareness of STEM. The fact that pre-service science teachers' awareness of STEM education is generally positive is also considered important in terms of the implementation of STEM education.

According to the study, pre-service science teachers' participation in this project showed that it helped to increase their STEM self-efficacy beliefs. The reason it is thought to be effective is due to the inclusion of STEM-related workshops and activity plans in practice. Namely, in the workshops, the Kotobee™ application was experienced in detail by the pre-service teachers, and digital interactive teaching materials were tried to be prepared by using the Kotobee™ application in accordance with the STEM approach. Afterwards, activity plans were developed for the use of the digital interaction teaching material in the learning environment based on the STEM approach. This whole process supports the self-efficacy of pre-service teachers. Pre-service teachers integrated the digital interactive teaching materials they developed into the activity plan based on the STEM approach. Thus, they felt more confident about STEM applications as a result of having a say. The effective implementation of STEM education in the classroom is closely related to the teachers' knowledge and beliefs, and it is important to create a positive change in their self-efficacy toward STEM practices (Ring et al., 2017). Therefore, both pre-service and in-service teacher professional development is required for STEM practices (Darling-Hammond & Bransford, 2005). At this point, a positive contribution was made to the STEM practices of pre-service teachers, who are the teachers of the future. The lack of experience of teachers in STEM education or the difficulties experienced during the experience can be shown as the reason for the low perception of self-efficacy. Wang (2012) stated in his study that physical facilities and external factors that will support the teacher, such as technology, application area, and material, are also challenging when science teachers are applying STEM education.

In this study, it is an inevitable result that the self-efficacy of pre-service teachers who develop digital interactive teaching material and integrate this interactive material into the learning environment is based on the STEM approach. Studies have shown a positive association between self-efficacy and teacher effectiveness (Sehgal et al., 2017). Considering that there is a positive relationship between teaching self-efficacy and teaching experience (DeChenne et al., 2012), the increase in pre-service teachers' self-efficacy beliefs towards STEM practices can also contribute positively to their teaching experience. According to Hoy and Spero (2005), the high self-efficacy of pre-service teachers who do not have teaching experience and do not experience the real classroom environment is due to the fact that they see teaching in the aforementioned subjects as something they can already do. It is thought that this situation may also be valid for the self-efficacy of STEM practices revealed by the participants of this study.

The research shows that the 21st century skills of pre-service science teachers are positively affected. This result may be related to pre-service teachers' awareness of the STEM approach. Because the STEM approach, is aimed at developing 21st century skills in learners, the STEM activity encourages students to think more scientifically (NRC, 2010; Dönmez Usta & Ültay, 2022). Learning with technology allows teachers and students to be more creative and productive in their learning (Hasibuan et al., 2022). Having 21st century skills is also directly related to the education 21st century learners receive (Dönmez Usta, 2021). Information technologies support students in the process of acquiring knowledge and restructuring it according to their needs (Hopson et al., 2001). In this context, it is thought that enriching the learning environments of 21st century learners who grew up with technology will contribute to their skills and learning. Therefore, the technology-enriched learning environments included in this study can be said to positively affect 21st century skills. Furthermore, it can be associated with the fact that the pre-service science teachers are in the 3rd and 4th grades; as the grade levels increase, their 21st century skills and their tendency to use technology increase. These findings are similar to those of studies in the literature (Ješkov & Luk, 2022; Oztürk, 2023). Besides, STEM has positive results in developing students' thinking skills and is able to improve students' 21st century skills in science learning (Castro & Jimenez, 2022). Considering that developing 21st century skills is one of the main goals of STEM education (NRC, 2012), it can be said that pre-service teachers have this awareness.

Considering that the integration of information technologies into the learning-teaching process is directly related to 21st century skills such as information, media, and technology skills (Henderson et al., 2010); it is positive that most of the pre-service teachers define information and communication literacy as researching, questioning, and producing solutions

on information and technology. Namely, technological innovations can be said to provide valuable educational tools for 21st century education (Yu & Durrington, 2006), and the effective use of technology by following technological developments contributes positively to the definition of information and technology literate in this research. Besides, the fact that the majority of pre-service science teachers think that they are technology literate (all of the answers were "yes" or "partially") supports this finding. Given that information and technology literacy is defined as an individual's ability to access, configure, and apply information by appropriately using various technological hardware and software in any situation (Trilling & Fadel, 2009); it is encouraging that the majority of pre-service teachers think this behavior to be literacy as researching, questioning, and producing solutions on information and technology while keeping up with technological developments using technology effectively. From this perspective, it is possible to conclude that the introduction and usage of the KotobeTM program, which enables the construction of digital interactive e-books, contribute to information and communication technology literacy, one of the 21st century skills. In this context, the fact that pre-service teachers recognize and use this and similar digital applications also contributes to the development of such skills. Within this context, it is possible to say that the use of relevant digital applications by pre-service teachers in both face-to-face and online learning environments will contribute to information and communication technology literacy.

As a result of the findings obtained from this study, pre-service teachers defined critical thinking as "analyzer, evaluator, and questioner". Critical thinking is a way of thinking that aims to analyze, evaluate, interpret, and make sense of things and is based on making decisions with free will (Facione, 1990). The definitions of this talent by pre-service instructors in this content correspond to the notion of critical thinking. Brahler et al. (2002) stated that critical thinking skills are related to the learning environment, the social context of learning, and the teaching style of the teacher. For this reason, it can be said that teachers should develop students' critical thinking skills by using teaching strategies that encourage students to think critically. Thanks to its interdisciplinary approach, STEM education can be considered an educational approach that includes high-quality learning, using knowledge to solve problems encountered in daily life, and high-level and critical thinking (Bybee, 2010). In this study, it can be stated that conducting workshops and developing activity plans for the use of digital interactive teaching materials, namely e-books, which they developed in the learning environment based on the STEM approach contributed to critical thinking skills. It is believed that the positive contribution of pre-service science teachers' critical thinking skills, who are the teachers of the future, will also be successful in helping their pupils obtain these skills in the future. As a

result, this study also contributed to the pre-service teachers gaining experience in the subject of critical thinking.

Considering that STEM education is an interdisciplinary educational approach (Cooper & Haverlo, 2013) that seeks solutions to real-life problems and enables the transformation of theoretical knowledge into practice and product; it is positive that most of the pre-service teachers defined a problem as "understanding what/cause of the problem, developing a solution proposal, solution-oriented and asking for help". STEM education also provides the development of high-level thinking skills such as complex problem-solving, establishing cause-and-effect relationships, inferring, and critical and creative thinking (Murphy et al., 2019). In this context, it is thought that the STEM education in this study contributed positively to the problem-solving skills of pre-service teachers.

Learning activities that students carry out through projects and play an encouraging part in the learning process should be included in training aimed at enhancing students' entrepreneurship skills (Ruskovaara & Pihkala, 2015). In this regard, technology will pique students' attention and inspire them to create new projects; therefore, it is critical to present well-supported innovations (Lepuschitz et al., 2018). This study, in which technology-supported innovations are given, can be stated to have made a good contribution to the description of an entrepreneurial person as being able to produce new ideas, being open to innovation, and being sociable. It is believed that pre-service teachers' engagement in this project adds to their appraisal as entrepreneurs as well.

The majority of pre-service teachers believe they have social responsibility. Besides, they feel that acting with the consciousness of social responsibility necessitates this awareness. Similarly, most of the pre-service teachers think that they have leadership skills, albeit partially. They believe that a person with leadership skills should also be able to manage the process. As a result of the project, these thoughts of the pre-service teachers were expressed in the 21st century. This can be explained by the fact that there is a statistically significant difference in favor of the post-test in their scores for their skills. In this case, both the development of digital interactive teaching materials throughout the study and the integration of these developed digital teaching materials into the learning environment for STEM education had positive results.

Conclusion

The following results were found at the end of this implementation:

- This project was found to have contributed positively to STEM self-efficacy and 21st century abilities, and it continued to contribute positively to STEM awareness, but not statistically.

- It was also determined that pre-service teachers have an adequate understanding of 21st century abilities such as information and technology literature, critical thinking, innovative, and entrepreneurial thinking, etc. In addition, pre-service teachers generally see themselves as having 21st century skills, albeit partially.
- According to this study, it is determined to result that increasing the self-efficacy of pre-service teachers who develop digital interactive teaching material and integrate this interactive material into the learning environment based on the STEM approach. Because pre-service teachers have gained experience on this subject.

The experiences pre-service teachers gained with the opportunity to develop digital interactive teaching material and integrate this interactive material into the learning environment based on the STEM approach make this study even more important. Based on these results, the following recommendations are presented.

- In addition to pre-service science teachers who will be the teachers of the new world order, opportunities for such activities must be provided for pre-service teachers in different branches. It can also be suggested that such activities must be designed and organized not only for pre-service teachers but also for 21st century learners such as teacher, all faculty members working at the university and all students, etc.
- The fact that all participants in this study were female was entirely by chance and is a limitation of this study. In addition, since gender was not selected as a variable in this study, it is not considered to be a situation that affects the results of the study.
- The study is limited to data collection tools and can be carried out in studies where different variables are measured.
- The study is limited to Kotobee™ application and STEM education. It is recommended to conduct studies using different digital applications and learning approaches.

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REVIEW

"Unfinished Adult Children": A Causal Analysis of the Issue of NEETs in China

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***Abstract**: The issue of NEETs (not in education, employment, or training) has recently garnered more attention in Chinese society. In China, the current slang term comparable to NEETs is the "unfinished adult children," referring to those young persons who are not successful in entering the workforce after graduation. This article focuses on analyzing the causes of the issue in China in three dimensions. In the dimension of tertiary education, college enrollment expansion, low alignment between educational supply and demand, and inadequate career planning and employment training have contributed to youth employment difficulties. In terms of home education, flawed educational expectations and parenting have compromised the social adaptability of the young generation. Personal problems with NEETs, such as irrational employment attitudes, low employment competitiveness, and self-lenient tendency have also exacerbated their predicament. Recommendations for addressing this issue are also proposed.*

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Introduction

THE SLANG term "unfinished adult child" (UAC) in China is derived from the expression of "unfinished buildings" in the construction sector. "Unfinished buildings" are buildings whose construction is halted, or whose completion is delayed indefinitely, because of issues like the funding chain disruption or planning adjustment on the part of the property developers. The UAC was recently coined to describe the group of youngsters who are from ordinary origins and fail to find desired employment after going through more than ten years of formal education, falling into a state of stagnated growth (Rui, 2024). Despite the term's prevalence, it is unquestionably disrespectful to label this cohort as UACs, as they are still in the transition from school life to employment, and their lives as adults have just begun. The slang term is somewhat a negation of the potential possibilities of their future lives, disregarding the complexity and specificity of the individual's life experience.

Comparatively, the NEET, an acronym for "not in education, employment, or training," is far more an appropriate term. A NEET is a young adult who is unemployed and not receiving further education or vocational training, depending on their family for a living (Sun, 2005). While the UAC is an emergent term, the NEET is not new in the Chinese literature. Search results of Chinese journal databases such as the Chinese Network of Knowledge Infrastructure (CNKI) shows that researchers' interest in the NEETs can be traced to the beginning of this century (Xiao, 2005). More recent studies in this area suggest that more highly educated young persons are joining the NEET cohort (Tan & Wu, 2021; Chen, 2024). A portion of Chinese graduates from prestigious universities have also chosen not to enter the workforce after graduation. These graduates have made arduous academic efforts and enjoyed top-notch educational resources since their young ages but end up being NEETs, which provides justifications for the emergence of the term "UAC" in China.

Regardless of the name for this cohort, NEETs, UACs, boomerangers, or "indoor guys," they share a commonality, namely, having difficulty becoming mature adults with stagnation in professional and social development or even utterly withdrawing from society after finishing secondary or tertiary education. Such a state of existence hampers the growth of the individual, which is also unfavorable for the advancement of society as a whole. Hence, it is imperative to delve into the sources of these inactive and non-ambitious life attitudes. This article tries to analyze the causes of the issue of NEETs in China from the angles of higher education, home education, and personal factors. NEETs and UACs will be used alternately to denote the cohort in question.

Issues Associated with Higher Education in China

The Impact of the College Enrollment Expansion Policy

At the turn of this century, China introduced the college enrollment expansion (CEE) policy, delaying the youth's entry into the labor market, in order to alleviate the employment pressures facing its urban areas. The move was also meant to improve human capital to prepare for the future industrial upgrading. Looking back, the policy did play a positive role in lightening the employment pressure at that time and enhancing the education levels of the population on a big scale. On the other hand, it has brought on adverse effects on the employment rates of college graduates in later years. According to Wu and Zhao (2010), even in years around 2010 when China saw rapid economic growth and steady increases in job opportunities, the consequences of the policy for the employment of college graduates had been evident: increased unemployment rates and decreased salary standards. In recent years of economic downturn, Chinese college graduates could only face a tougher employment market, particularly in the context of the ever-increasing numbers of graduates year by year. Against this backdrop, the rise in the number of NEETs is unavoidable. Nevertheless, the youth's and their parents' enthusiasm for pursuing higher education has not been dampened by the apparent drop in graduate employment rates because there remain significant income gaps between college and high school graduates, making higher education a potentially valuable experience for the individual. Yao et al. (2013) examined the changes in the labor market ensuing the release of the CEE policy from the perspective of the return of investment (ROI) in human capital to discover that the ROI of higher education was significantly higher than that of non-higher education. Therefore, parents still deem it advantageous for their children to receive tertiary education.

Furthermore, China's expansion of college enrollment has posed negative impacts on the quality of its higher education, which worsened the employment prospects in college students (Jia, 2006), leading to increased numbers of NEETs. To manage the potentially adverse impact of the CEE policy on the quality of tertiary education, Chinese educational authorities established the employment rate of graduates as a measure to evaluate the instructional quality of colleges and universities, aiming to urge higher education institutions to improve their education standards while also modifying their specialty planning and heightening their connection with the economy (Xie et al., 2005). Nevertheless, instead of focusing on enhancing the quality of education, the management of certain Chinese colleges has chosen to manipulate the figures related to graduates employment rates by illegitimate conduct like creating fake hiring contracts (Zhang et al., 2016). Improving educational quality involves substantial inputs of time, energy

and financial resources, whereas presenting ostensibly desirable employment rates are by far easier. In the biased pursuit of employment rates, some higher education institutions willfully shortened the established instructional periods to allow students more time to find jobs (Zhang & Chai, 2019). Others decided to lower the assessment standards to reduce failure rates as employment rates also relate to graduation rates, producing a host of graduates with inadequate expertise and skills. These graduates may struggle with securing decent jobs and can easily become NEETs.

A Mismatch between Specialty Arrangements and the Labor Market Needs

The current defective planning of specialties in Chinese tertiary education institutions hampers the employment prospects in college graduates, constituting an unfavorable factor for the scale of the NEET cohort. First off, many Chinese universities show shortsightedness in their curriculum design. They tend to inordinately focus on presumed popular disciplines within a short term, without contemplation on the long-term, potential needs for talent (Feng, 2009). In the meantime, they are more concerned with the nationwide popularity of their specialties than their compatibility with the local industrial needs. Jiangxi Province in China, for instance, has a strong demand for talent related to the secondary industry while also having a high demand, as a major agricultural province, for professionals specializing in emerging subjects such as agricultural modernization and green agriculture. However, majors serving the tertiary industry predominates the curricula of Jiangxi-based universities, whereas those related to primary and secondary industries constitute a disproportionately small percentage (Zhou, 2018). Furthermore, when planning the curriculum for their disciplines, Chinese higher education institutions focus more on its benefits for the development of the school per se, with inadequate consideration of the actual needs of the future employers of their graduates (Li & Nan, 2018). This results in their emphasis on academic competence cultivation over practical skill development in students. A prominent illustration of this issue is that even those high-performing students with excellent academic achievements might have no idea how to apply their professional knowledge to the practical work in their internship and needed to start learning from scratch. Some of them could not secure job contracts after completing the internship due to their inability to adapt to workplace requirements in a timely manner.

In addition, a portion of Chinese universities fail to establish distinguishing qualities of their respective curricula, resulting in highly homogenous selections of specialties. The selection of disciplines and specialties manifest the distinctiveness of a school (Zhu, 2012), representing its focuses and advantages. No university can own all the most outstanding

specialties in the world. Yet, some Chinese universities have the fixation with a comprehensive and all-encompassing specialty program. This not only causes the loss of their respective distinctiveness but also engenders curricular structures with a high degree of homogeneity. As a result, some majors are run by too many schools, producing excessive numbers of graduates with the same education background, while other specialties that are truly in demand do not enroll enough students. This leads to the undesirable situation that the supply of graduates of certain majors cannot meet the demand, whereas the supply of others may substantially exceed the demand.

Inadequacies in Career Planning and Employment Training

One chief reason for NEETs' withdrawal from society is their difficulty adapting to the workplace environment. Any setbacks encountered in the job-seeking process or in the workplace can easily provoke their avoidance mentality (Chen, 2024). Their inability to smoothly transition from the educational setting to the workplace is partly due to the ineffective career planning and employment training from the school.

Although the majority of Chinese colleges offer career planning courses, their outcomes prove less ideal than expected. The reason for this, according to Li (2019), is that these career planning courses lack systematic arrangements, often consisting of sporadic lectures or online teaching videos. With such courses, students can hardly develop sufficient awareness of career planning or understanding of the labor market (Ji et al., 2015). Most of them neither has necessary job-seeking skills nor get prepared for the future workplaces. Furthermore, Chinese colleges typically offer career planning courses in the last academic year, seldom running them in lower grades. Given that career planning is a long-term process of adjustment, in which students progressively formulate an explicit understanding of their own strengths and qualities, the employment environment, and job requirements, career planning training should start as early as possible instead of being treated as a last-minute handling.

Additionally, one-size-fits-all employment training is pervasive in Chinese colleges, despite the fact that employment expectations and developmental prospects of individuals vary tremendously. Huang and Tang (2024) argue that college students need differentiated employment guidance because their employment decision-making is potentially affected by a variety of factors, such as gender, the family background, and the major. Nonetheless, with the dearth of targeted employment guidance, a sizable portion of soon-to-be graduates feel profound helplessness in job seeking. They look for jobs using group mentalities rather than independent thinking,

disregarding their individual circumstances and interest. This blind practice can severely compromise their competitiveness in the job market, easily leading to their falling into the predicament of "graduation with ensuing unemployment."

In short, despite the CEE policy having played positive roles in enhancing the quality of the Chinese population and promoting scientific, cultural, and economic development of the society, the negative consequences it brought on have not been properly addressed. The consequential harm to the quality of higher education has had an adverse impact on the employability of college graduates. The disconnection between the specialty arrangements of higher education institutions and the job market, as well as the inadequacies in career planning and employment training for college students, adds further complications to the employment of graduates. Due to multiple factors, a portion of youngsters have failed to get sufficiently prepared for life as adults even after receiving higher education. As a result, they become NEETs or concerning UACs in the eyes of their parents.

Deficiencies in Home Education

The word "unfinished" in the UAC also implies the pathetic outcomes of family investment in education. Home education plays as important a role as school education in fostering the child's growth. Problematic Home education is equally attributable to the existence of NEETs.

Illegitimate Parental Educational Expectations

"Studying hard for being admitted into a prestigious university, securing a well-paid job, and living a wealthy life" is the purpose of education shared by many Chinese parents for their children. While it may appear reasonable, it bears serious flaws. First, such an educational expectation is based on instrumental rationality (a type of reason focusing on the achievement of specific objectives and maximization of outcomes via rational calculation and efficient means), with disregard for the child's personal aspirations (Xiong, 2017). Those children who identify themselves with this educational expectation from parents may gradually forgo their own ideas about future careers, becoming aimless in the job market. Second, parents with this educational expectation equate the purpose of education and work to the attainment of wealth and social status, disregarding higher-order meaning inherent in them. These parents, who materialize education and work, are often unable to give their children enough emotional support when the latter encounter setbacks in the process of seeking employment. Children who have social adaptation difficulties may receive contempt from parents who

evaluate educational outcomes by mere economic returns, which could exacerbate their social avoidance and, in the worst cases, prompts them to become NEETs (Chen, 2024). Third, parents with oversimplistic understanding of the association between education and future life are often ignorant of the complexity and uncertainty of the world. In effect, top-ranking university education does not necessarily end in a desirable job, and a well-paid job does not necessarily predict a life without other challenges. Parents with the said misconception of education are typically unable to identify the NEET tendency in their children or implement effective interventions. When their children really develop into NEETs, they may give up on them without knowing how to correct them.

Aside from the above popular educational expectation among parents, educational researchers are also critical of overly high educational expectations from parents. Unreasonable parental education expectations can bring to the child inordinate academic pressures while also causing overinvolvement of parents in child schoolwork (Li & Hu, 2021). This is detrimental to the physical and mental health of the child and may also lead to their psychological disorders in adulthood, making it difficult for them to adapt to normal social life (Yi, 2014).

Improper Parenting

Unfavorable parenting styles can increase the risks of becoming a NEET in children. First, parents who are overly preoccupied with kids' academic performance often neglect the development of psychosocial competences in them. Existing educational research reveals that Chinese parents tend to make excessive financial investments in child education, such as paying for costly extracurricular tutoring of various forms in a bid to improve the kids' academic results (Yi, 2014), but paying little attention to character building, independence acquisition, and social responsibility cultivation in the latter (Yan, 2014). This biased focus of education can predispose them to NEET trajectories. Second, authoritarian parenting also dampens psychosocial competency development in children. Shen (2006) emphasizes that controlling parents are more likely to produce children with emotional alienation and low desires for social interaction. While the latter may behave submissively in childhood to meet parental expectations, they can become adults with inactive lives attitudes in the future. Third, permissive parenting can significantly elevate the child's vulnerability to NEET status. Parental limitless indulgence is an impediment to the nurturing of autonomy and self-regulation in underage children. Also, it can give the adult children the illusion that they have no need to worry about financial burdens like living costs; they may feel at ease and justified in remaining unemployed. This explains why youngsters from richer families are more likely to end up

depending on their parents after experiencing employment difficulties (Wu, 2015).

Personal Factors in the NEET Cohort

Irrational Employment Attitudes

Irrational employment attitudes are the source of tremendous gaps between employment expectations and the workplace reality in graduates. Those with low psychological modulation capacity may lose faith in their employment prospects after experiencing certain undesirable workplace environments. Illegitimate employment attitudes in the NEET cohort are mainly manifested in the following aspects: (i) A conservative choice of jobs. A portion of college graduates show strong preference for posts in state-run businesses and public institutions, so-called "stable jobs" (Chen, 2010; Li, 2019; Huang & Tang, 2024). Even if they do not see any hope of joining a state-run company or becoming a civil servant for the time being, they will not consider other employment options but instead linger in homes, concentrating on preparing for the selective examinations for those public posts. Parents of this group tend to be supportive of their children's attempts to secure "stable jobs." As a result, the temporary suspension of employment may develop into a permanent unemployment state. (ii) Inordinately high employment expectations. Some college graduates set high requirements for their jobs in terms of the salary, alignment with the major studied, developmental prospects of the profession, and work locations. Yet, few jobs can perfectly meet all these requirements (Chen, 2010; Li, 2019). The big discrepancy between their ideal standards and the actual work environment often demotivates them in job seeking. (iii) A lack of a long-term career goal. Job hopping is more prevalent in young people without mature career planning (Chen, 2024). While changing jobs rationally is deemed beneficial for personal development and optimization of human resource distribution, young Job hoppers without long-term career goals can soon lose motivation for re-employment, likely lingering in the jobless state for a long time. In addition, a considerable number of graduates have chosen to participate in the examinations for postgraduate programs just for following the suit of their peers or evading the work pressures, without considering the programs' association with their future professional development. Such aimless practices often end in examination failure, prompting these graduates to become chronic NEETs.

Low Competitiveness in the Labor Market

Low employment competitiveness of some graduates is mainly due to their deficits in professional skills and recurrent education awareness (Chen, 2010; Chen, 2024). Professional skills are the most fundamental prerequisite for employment; organizations are certainly reluctant to employ underprepared graduates. As discussed earlier in this article, the defective higher education system is partly accountable for the gap between what is taught in colleges and what is expected from graduates by the employers. Nevertheless, individuals, after leaving the campuses, are responsible for their own further education. Those who are neither fully professionally prepared for their careers nor willing to continue to learn are bound to be unwelcome in the workplace.

Moreover, poor knowledge on workplace interpersonal relationships can also undermine the employment competitiveness of graduates. Learning to handle the complicated workplace relationships is a key element of workplace adaptation (Chen, 2024). Compared to relatively simpler interpersonal relationships on campus, the hierarchical relationships between superiors and subordinates and the somewhat competitive ones between colleagues in the workplace are far more challenging. Those graduates who fail to come to terms with the shift may quit the jobs that feel overwhelmingly stressful because of the interpersonal pressures entailed. Also, this negative experience may discourage them from seeking other work opportunities.

Being Overly Self-Lenient

In the context of the economic downturn, setbacks in seeking employment are unavoidable. It is acceptable for the youth to stay unemployed and live an inactive existence temporarily. Nevertheless, they risk becoming NEETs if they overly indulge themselves in escapism, giving up work and training opportunities.

Self-lenient tendency can lead to the formulation of low self-reliance personality in young people, with which comes a decline in psychological regulation capacity as well as a zero-risk disposition, propelling them to the NEET status (Huang, 2019). Specifically, a youngster adopting the self-lenient policy may disregard self-limitation like self-discipline and senses of responsibility, denying the necessity of further developing skills needed to adapt to society. Also, initiating a career and integrating into society necessitates a potent capacity for psychological regulation. However, the self-lenient policy and its consequential denial of personal responsibilities often result in deficits in psychological regulation capacity in young people, depriving them of the motivation for further growth. In addition, the zero-risk disposition is a psychological tendency of seeking absolute security by escaping from the reality. In the face of uncertainties in life, young persons

can easily feel helplessness and indulge themselves in those effortless and risk-free activities like browsing the internet and playing video games for psychological comfort. In the long run, this indulgence may exacerbate their alienation from society, dampening their professional development.

Against the backdrop of the high penetration of social media, NEETs can gather on online platforms and establish their own social circles. Nevertheless, these social circles may intensify their self-lenient tendency, worsening their NEET state, instead of providing any positive assistance. Members of these NEET circles can develop strong identification with peers. A common mentality among the NEETs with online social circles is that unemployment is not a serious issue to an individual, since there are numerous out-of-job youngsters, as indicated by the cyber world. This mentality gives them an excuse for self-indulgence and inactivity, exacerbating their tendency to solely blame the external environment for their employment failure, rather than prompting critical examination of their own attitudes.

Conclusions and Discussion

The issue of NEETs or UACs in China is the product of multiple factors. This article explores the problems associated with the issue from the angles of higher education, home education, and the NEET cohort itself. The tripartite analysis reveals a common problem shared by higher education institutions, NEETs' families, and NEETs themselves, namely, the significance of career planning training has been undervalued to varying degrees. Moreover, the schools and parents tend to focus on academic ability training but neglect the education of essential competencies critical for the youth's after-school life. The study also finds an inconsistency in both higher education and home education. The college may set high admission standards but relax the assessment criteria for graduation; the parents focus their educational investment on the kid's pre-tertiary education stage to ensure their enrollment into an ideal college, but with little concern about the actual outcomes of higher education. This educational context, coupled with the low social adaptation awareness among a portion of students, can easily instigate the increase in the number of NEETs in China.

The NEET status is certainly detrimental to the mental health and social adaptation of young persons, and the existence of NEETs is a waste of the families' educational investment and human capital of society. The issue may even undermine the stability of social development. Preventing college students from becoming NEETs and assisting NEET youth to recover normal life as adults requires multifaceted efforts from all stakeholders. First, career planning training should be treated as an integral part of the nation's educational system, spanning basic and higher education, to help students

progressively foster self-understanding and establish future career orientation, as well as rational notions of employment. Second, higher education institutions in China should further improve the quality of tertiary education by optimizing curriculum design and strengthening practical education so as to enhance graduates' employment competitiveness and ensure their workplace success. Third, change in the focus of home education is warranted. Chinese parents should pay more attention to the development of all-round competencies, including social adaptability, of their children, rather than just focusing on their academic performance. Home education should include the provision of social practice for children to improve their social skills, which are crucial for workplace integration in their future careers. Fourth, the government needs to advance more potent policies to assist with college graduates' employment or entrepreneurial endeavors while also helping NEETs restore confidence and direction in life by providing professional psychological counseling and vocational training. Lastly, businesses should take a more active role in the school-industry partnership programs to offer more internship and job opportunities to graduates. It is also important to engage the third-sector entities in assistance efforts for NEETs, utilizing their services like voluntary skill training to facilitate the latter's integration into society.

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REVIEW

Chinese Endeavors to Enhance the Welfare of Left-Behind Children: A Literature Review

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***Abstract**: The issue of left-behind children has been a serious concern of Chinese society. The Chinese government and other entities have experimented with a wide range of measures to create a sound environment for their growth. This article is a survey of existing assistance measures for improving the welfare of left-behind children in China based on a literature review of 27 prior studies. The study spots four chief categories of measures in the literature: legislative protection, social support, school assistance, and technological backing, giving each of them a detailed description. The outcomes and challenges of the work on the care and protection of left-behind children are also discussed.*

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Introduction

IN CHINA, a left-behind child is a child aged between 0 and 17 who has both or one of their parents working outside their home places, experiencing at least six months of separation from them (Lyu et al., 2024). According to the Ministry of Education of China, the number of left-behind children in Chinese rural areas was 12.9 million in 2020. In the meantime, data released by the Ministry of Civil Affairs of China in 2020 show that the country had 6.44 million underprivileged rural left-behind children in that year. Rural left-behind children may encounter various difficulties in home and school life. First off, they receive an education of unstable standard due to subpar educational resources in rural China, particularly in its remote and border areas. Furthermore, the lack of home education as a result of the absence of the parents is unfavorable for their character building, putting their mental health at risk (Zhang, 2016). Additionally, they are more susceptible to safety hazards because of flawed safety management of the school and inadequate supervision from the family and rural community (Zhang & Li, 2016).

As per Yu's (2017) analysis, the causes of the issue of rural left-behind children in China are three-fold: First, the development gap between urban and rural areas has prompted a massive population of young and middle-aged rural labor forces to migrate to cities for better employment opportunities; second, the registered residence (Hukou) system and its consequential constraints regarding education, medical care, housing, and other issues hamper migrant workers' ability to have their family settled in cities; third, the fading traditional intergenerational bonds, as well as weakened ties of kinship, undermines the quality of custody for those left-behind children entrusted to their grandparents or relatives in native places.

In response to all these predicaments of left-behind children, governmental and non-governmental organizations have taken action to ensure the provision of care and protection for this group. The Ministry of Civil Affairs in China has provided financial support in various forms to improve their living conditions. For instance, its "Specialized Program for the Treatment of Severe Illnesses in the Poverty-Stricken Population" mandates the left-behind children's access to free medication when suffering from serious illnesses. Certain third-sector organizations have established permanent bases in remote rural areas to supply prompt services and care to vulnerable groups in villages, including left-behind children (Wang & Pan, 2020).

This article, using the method of literature review, seeks to investigate the endeavors of Chinese society to improve the welfare of left-behind children in recent years, drawing on research results of prior studies. Using search words including "left-behind children," "assistance,"

"protection," "care," and "support," this study retrieves 27 articles from the database of China National Knowledge Infrastructure, published by journals listed in "A Guide to the Core Journals of China" and the "Chinese Social Science Citation Index" (CSSCI). A review of these studies finds that there are four chief categories of measures for guaranteeing the care and protection of left-behind children: legislative protection (N=6), social support (N=9), school assistance (N=8), and technological backing (N=4). It is hoped that summarizing prior experiences in this area can provide evidence and valuable references for further exploration of more effective supporting systems for left-behind children in China.

Legislative Protection

On the basis of certain fundamental rules from its constitution, China has formulated a series of laws targeting its underage population, such as the Minors Protection Law, Juvenile Delinquency Prevention Law, and Compulsory Education Law, to safeguard the legitimate rights and interests of children, including left-behind children (Hou, 2018). To ensure that the protection work for left-behind children adapts to changed social circumstances, the Minors Protection Law was revised in 2020, with its article 21 stipulating that parents and other guardians shall not leave children under the age of eight unattended or allow children under the age of sixteen to live independently without supervision. Article 22 of the law provides that parents who are unable to assume the responsibility of custody due to reasons such as working away from home shall delegate the guardianship of their children to a qualified entity. This stipulation on guardianship entrusting is helpful in mitigating safety and security risks in left-behind children (Li, 2017).

Despite the positive roles of these laws in protecting the rights of rural left-behind children, advocates for this group made the point that there should be more specific legislation targeting these children, given their peculiar childhood life experiences and psychological characteristics, which are significantly different from those of non-left-behind children (Zhang, 2020). To this end, relevant authorities have successively released a few specialized policies aimed at enhancing the protection of the rights and interests of rural left-behind children. In 2015, the State Council of China announced the National Plan for Child Development in Impoverished Areas, which emphasizes the importance of improving the care service system for left-behind children and clarifies the respective roles of the school, parents, and other possible guardians in this system. The plan also proposes the provision of mental health guidance for left-behind children to curb the occurrences of problematic behaviors in them. In the next year, 2016, the State Council released the Opinions on Strengthening the Work on the Care

and Protection of Rural Left-Behind Children. This plan is the first umbrella policy on the issue of left-behind children from the central government. The policy marks a significant step in the national action to support left-behind children as it advances a comprehensive protection system spanning multiple aspects, including enhanced care services, robust assistance and protection mechanisms, and measures for progressively reducing the number of left-behind children (Tong, 2016). Furthermore, the issue of left-behind children, a consequence of China's social transformation, is primarily caused by the huge urban-rural gap in economic development. To solve this issue, it is imperative to revitalize rural China across the board by adjusting the economic structure in rural areas to enable the rural population to have desirable employment opportunities in their home places or places in the proximity of their hometowns (Pu, 2019). In 2018, the State Council launched the Rural Revitalization Strategy, which included as major components the improvement of the social security system in rural areas, the enhancement of the care of rural left-behind children and other disadvantaged rural children, and the establishment of a dynamic monitoring mechanism for these children.

The said laws and policies have served as a basic legislative framework for the care and protection of rural left-behind children. Yet, more practical action is warranted to give full play to them (Hou, 2018; Pu, 2019; Zhang, 2020). First and foremost, more awareness and education about this issue are needed. It is imperative to heighten the awareness of self-protection in left-behind children by teaching them knowledge on how to evade criminal infringements; in the meantime, education on the safety of left-behind children should also be strengthened in adults like parents and teachers to increase their attention on the safety and security of these children. Second, there should be effective complaint and reporting channels in place so that those left-behind children coming across infringements or their parents can report their issues in a timely manner. Third, law enforcement efforts should be strengthened to impose prompt punishments on illegal and criminal acts that violate the rights of rural left-behind children. Fourth, relevant departments and individuals must be held accountable for the implementation of left-behind children protection measures stipulated by relevant laws and policies. Lastly, it is also important to develop local regulations on left-behind children protection. Subsequent to the State Council's release of the Opinions on Strengthening the Work on the Care and Protection of Rural Left-Behind Children, provincial and municipal governments have laid out corresponding implementation plans. Nevertheless, according to Yuan and Hu's (2018) review of these regional plans, the common inadequacy in them is the lack of third-party supervision and evaluation of guardianship of left-behind children, leading to the

absence of a guardianship deprivation mechanism. This is among the pronounced issues to be addressed by the local governments.

Social Support

Parental absence results in affective deprivation in left-behind children, significantly increasing mental health risks in them. Furthermore, flawed home protection makes them more susceptible to safety threats. In addition, the incomplete family structure among migrant worker households leads to partial or complete loss of family functioning (Qiu, 2016), thereby increasing the incidence of problematic behaviors in left-behind children. To address these issues, various sectors of Chinese society have actively engaged themselves in aiding this group.

Measures for maintaining and strengthening parent-child communication: First off, dedicated phone lines provided by third-sector organizations have proved an effective device for aiding left-behind children in maintaining affective bonds with their parents (Sun, 2017). This measure can, to some extent, compensate for the lack of parent-child interaction in migrant worker families. With the proliferation of reports on physical and emotional injuries in left-behind children, an increased number of parents come to realize the potential detrimental effects of the long-time separation from their children. Many migrant worker mothers choose to return to their home places to live with their children, which mean they must give up employment in the city, resulting in exacerbated economic difficulties in their families. In this context, creating local employment opportunities for these mothers has become a meaningful endeavor to retain them in hometowns (Chen & Wang, 2018). Small-scale guaranteed loans, across-the-board tax and fee reductions, and social security subsidies provided by the government have been helpful in motivating them to start their businesses or become self-employed. At the same time, more practical skill training has been provided to rural mothers to enhance their capacity to seek out employment or initiate their own business, expanding their opportunities to participate in the labor force (Liu et al., 2016).

Heightened Emotional Connections with Others: The one-on-one assistance project is deemed an effective strategy for making up for the inadequacy of emotional support in left-behind children (Sun, 2017). In this project, each left-behind child has a teacher as his or her confidant in the school, and a volunteer acts as a surrogate parent or mother for him or her during their after-school hours. In certain regions, college students, especially those who were former left-behind children and have achieved academic excellence, are recruited as volunteers to keep regular contact with left-behind children in rural schools. They can serve as role models as well as emotional support providers for the latter (Wang & Liu, 2020).

Warning Mechanisms: Establishing a multi-agency warning mechanism is a workable measure for preventing problematic behaviors in left-behind children. For example, Qiu (2016) explored the possibility of creating a family malfunctioning warning mechanism with personal profiles of children living in separation with parents. Such a warning mechanism is helpful in spotting and reacting to behavioral problems in left-behind children in a timely manner by tracking their home economic status, school performance, and health states.

Roles of the Rural Community: The rural community plays a vital role in providing assistance to left-behind children and building a safe environment for their growth (Li et al., 2019). Currently, the rural community primarily provide following services to left-behind children (Liu et al., 2016; Li et al., 2019; Wang & Liu, 2020): (i) assigning a village-based, dedicated official to manage the affairs relating to left-behind children in their jurisdiction; (ii) pooling local resources to establish the "left-behind children's home" to provide a favorable environment for their after-school learning, extracurricular activity, and cultural life; (iii) engaging professionals to provide psychological counseling for left-behind children if needed and increasing safety and security protection publicity for the guardians of these children through lectures, village broadcasts, educational videos and manuals. In addition, some researchers claimed that the rural neighborhood community played a more significant role than rural grassroots administrative organizations in safeguarding the safety of left-behind children in that neighbors were more likely to get involved in their day-to-day life and give enduring oversight and protection (Du, 2024). Specifically, the neighborhood community can provide multiple forms of care for left-behind children, including life care, emotional care, emergency assistance, moral guidance, academic tutoring, and more. At the same time, certain researchers also expressed the concern that accelerated urbanization might pose threats to the existence of the neighborhood community (Chen & Wang, 2018; Du, 2024). Therefore, it is necessary to take action to strengthen the ties between neighbors, which are a protective factor for the healthy growth of left-behind children.

In addition to emphasizing the significance of multi-agency efforts to improve the well-being of left-behind children, researchers also noted that the media had the responsibility to give objective reports on them, correcting the biased understanding of them as "problem children" in the popular public and preventing the tendency of stigmatizing them as a problem group (Zhu & Bo, 2020; Cui & Xiao, 2022). It is important to diffuse the fact that problematic behaviors in a portion of left-behind children are the product of the ongoing socioeconomic transformation as well as the longstanding bi-partite social and economic system in China, which classifies the whole population into two categories, urban and rural. They are a group of children

with basic psychological and emotional needs unmet. Blindly stereotyping and labeling them as problematic can only exacerbate the issue.

School Assistance

As per Ye & Cheng's (2018) study, aside from material and financial aids, left-behind children need additional educational assistance and emotional support, of which the school is the ideal provider. China's central government and provincial governments have made it clear that schools are an important part of the system for helping children who have been left behind. These requirements include setting up a profile and contact system, starting the paired-assistance program, making an emergency response system, and improving and strengthening mental health education for students who have been left behind (Qi, 2017).

On top of these mandatory requirements from the government, rural schools have developed more specific measures to meet the diverse needs of left-behind children. First, hold the teacher accountable for the academic progress of left-behind children in their class. The teacher shall be the first responder when a left-behind child encounters learning difficulties. Helping these children develop positive attitudes toward learning is beneficial for improving their academic results. To do so, the teacher needs to listen patiently to left-behind children on their current challenges or give pro-active encouragement to fuel academic aspirations in them (Zhao et al., 2020). Second, place special weight on social-emotional development in left-behind children. Social-emotional skills are crucial for the all-round development and lifelong well-being of this group. Pu et al. (2024) argued that home-school co-education is an effective approach to promoting the development of social-emotional skills in left-behind children. Nevertheless, the schools have reported less-than-desirable outcomes of their cooperation with the students' families because they can only communicate with the parents through phone calls and have few opportunities for in-person meetings with the grandparents or other relatives as guardians (Zheng & Li, 2014). To address this issue, the school needs to resort to the administrative power of the local government and public opinion of the community to raise the awareness of home-school co-education in the parents or other guardians of left-behind children. Third, improve after-school service. When the custodian is unavailable, the left-behind child risks is going unattended during the after-school hours. After-school service can ideally make up for this gap (Ma & Cui, 2024). After-school service typically includes components such as homework tutoring, club activity, and mental health education. Sports, collective social activity, and individualized psychological counseling in after-school hours are deemed exceptionally effective in mitigating the loneliness (Zhang & Zhu, 2019), boosting self-confidence,

and promoting mental health development in left-behind children (Ma & Cui, 2024).

With the continuously improved left-behind children welfare system in China, the educational environment of these children has been significantly enhanced in recent years (Zhou & Wang, 2021). Specifically, rural compulsory education schools are better structured, with large-size classes becoming rare; students with rural boarding schools enjoy better material conditions, particularly the significantly improved accommodation; the financial aid system is accessible to impoverished students, resulting in a prominent decline in dropout rates in left-behind children. Amid the ongoing advancement of educational technology, rural schools have the potential to provide more personalized, higher-quality education for left-behind children by harnessing more abundant educational resources and adopting more advanced teaching modalities. In the meantime, rural schools need to strengthen mental health education and provide sound psychological counseling services to help left-behind children develop healthy, upbeat mentalities. In addition, they should increase partnership with the community and student families for a more complete care and protection network for left-behind children to support their all-round development.

Technological Backing

Liang (2020) made the point that families of left-behind children varied by economic status, parental education level, and educational notion, and that not all of them are the victims of the early left-behind life. That implies the need for more targeted welfare policies for these children. Due to the large number of left-behind children in China, collecting and managing data on this population and their families was a challenging task. The use of information technology (IT) in education can help realize personalized assistance for left-behind children.

The current introduction of big data, mobile internet, and other forms of IT in education have largely facilitated the formulation of more precise assistance policies, establishment of an across-the-board assistance system, and improvement of the standard of rural education. First off, collecting, storing, processing, and analyzing personal information about left-behind children in a large region can be completed in an efficient manner by establishing a big data platform and collecting relevant data on a household basis. This is beneficial for the government's comprehensive knowledge of the developmental states of left-behind children as well as its reaching data-based decision-making on left-behind children welfare (Zhou et al., 2019). Furthermore, assistance efforts for the large population of left-behind children in varied circumstances often involve multiple entities (such as

government departments, non-governmental organizations, businesses, and individuals) and can turn out to be disorderly. Yet, with the help of IT, establishing a nationwide information system for left-behind children has become feasible. Such a system can gather and record detailed information on the specific needs of each left-behind child, providing accurate guidance for various assistance actors using data analysis. At the same time, thanks to the advances in mobile internet technology, assistance providers in different regions can develop synergies to jointly address problems faced by left-behind children (Zhao & Tian, 2017). Additionally, the applications of digital technology in education helps rural schools access richer instructional resources and enhance their teaching outcomes by promoting the balanced distribution of educational resources.

There are many successful experiments in applying IT to boost the welfare of left-behind children. For example, Lin et al. (2017) developed a WeChat public platform targeting the issue of deprived parental companionship and undesirable interpersonal relationships in left-behind children. The platform hosts regular interactive activities for the community of left-behind children and their parents. The researchers conducted a two-month follow-up survey, which reveals that the platform is effective in strengthening the relationships between left-behind children and their parents and instigating more active peer communication. Fu et al. (2022) investigated the effects of "smart homework" as an application on assignment completion in left-behind children using data from 78 counties (districts) in 11 municipal regions in Jiangxi Province. The application integrates big data and artificial intelligence technology into the traditional homework design, collection, and grading processes. It can design and assign stratified homework tasks to students with distinct academic levels (Ke et al., 2022), while also providing real-time feedback to them, assisting with their self-regulation of learning progress. According to Fu et al.'s (2022) research findings, the use of "smart homework" can not only improve the quality and efficiency of homework completion in left-behind children, largely lightening their afterschool academic burdens, but also is effective in alleviating their psychological pressures.

To sum up, the application of IT has helped increase the involvement of assistance actors, expand the coverage of assistance measures, and improve the efficiency of the implementation of these measures, providing strong impetus for the improvement of welfare in left-behind children.

Discussion

At the time when the Opinions on Strengthening the Work on the Care and Protection of Rural Left-Behind Children were released, researchers argued that left-behind children welfare systems in China were still in their infancy,

with relevant government departments underperforming and few third-sector entities being mobilized (Shi, 2016). However, recent years have seen noticeable progress in this regard as a result of the aforementioned assistance measures taken by various stakeholders. First off, a basic care service system for left-behind children has been established. Wu (2021) conducted a field study involving Guizhou, Anhui, Sichuan, and Hebei Provinces, each with a large population of left-behind children. The study suggests that China has developed a preliminary left-behind children support model where government procurement of care and protection services predominates, with contributions from other social entities, and that basic care and protection networks entailing governmental leadership, family custody, school supervision, and community involvement are in place for left-behind children. Furthermore, the joint efforts of all stakeholders have resulted in a significant decline in the number of rural left-behind children; the occurrences of left-behind children being left unattended have been reduced to almost zero (Luo, 2021). Furthermore, with the increased number of assistance actors, more diverse varieties of aiding measures have emerged, ranging from material backing to mental health as well as spiritual life support. For example, a total of 4421 village-level children's homes and psychological counseling rooms have been created in Guizhou Province, involving inputs of roughly 530 million CYN (Wu, 2021), to assist the physical and mental development of left-behind children.

Still, certain issues deserve special consideration in future work on the welfare of left-behind children. First, dedicated professional staffs are warranted to ensure the services for left-behind children are of high quality rather than mere formalities to avoid the waste of resources. Second, some studies suggest that the decline in the number of left-behind children may be partially due to the decreased fertility rate in China. In effect, the percentage of left-behind children among Chinese school-age children remains relatively high (Wu, 2024). Hence, relevant authorities must be cautious about using the number of left-behind children as an indicator of the effectiveness of their assistance efforts. Third, illegitimate assistance measures and the hype from irresponsible media and businesses have negative impacts on the welfare of left-behind children (Qu, 2017). Thus, a rigid accountability mechanism is necessitated to prevent casual decision-making; regulation of media coverage needs to be strengthened to avoid dissemination of misleading information on left-behind children in the public. Lastly, it is noteworthy that a portion of left-behind children may end up becoming migrant children, leaving home places to join their parents. Still, migrant children face more difficulties than their urban peers. The erratic nature of migrant workers' employment makes the development of migrant children welfare policies a challenging task (Li & Liu, 2024). How to guarantee the rights of migrant children is pending further research.

Conclusion

This survey is an encapsulation of current assistance measures for rural left-behind children in the dimensions of legislative protection, social support, school assistance, and technological backing, exhibiting the current state of the care and protection of left-behind children in China. Based on prior experiences in this regard, future work should focus on addressing those unresolved issues to build a more efficient, complete left-behind children welfare system to provide more comprehensive and sustainable services and support for this group.

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(The 26 Studies included in the literature review are marked with asterisks)

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