

21st-century skill integration in Jordanian 9th-grade mathematics textbook

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ABSTRACT

This study analyzes to what extent 21st-century skills permeate the 9th-grade mathematics textbook created in the settings of Jordan. This study employed the descriptive-analytical method of research. The sample included the student book and the exercise book of the mathematics textbook. The study used an analysis card as the study's research instrument. Textbook content includes 21st-century skills of over five thousand nine hundred occurrences. The highest percentage was of critical thinking and problem-solving skills which was at 34.62% while self-initiation and self-directed learning skills came at 30.66% of the total. The third were communication skills at a total of 24.00% and fourth were creativity and innovation skills which was 9.64% while technical and information skills were at 0.83% and the last were cooperation and teamwork skills at 0.25%. This led the study to conclude and recommend that the 9th-grade mathematics textbook includes a greater amount of skills and activities related to digital culture as well as more realistic scenarios that foster the creative teamwork and thinking of learners.

Keywords: 21st-century skills, critical thinking, problem-solving, mathematics education, Jordanian curriculum, 9th-grade, communication skills, creativity and innovation

INTRODUCTION

This age is characterized by rapid changes and successive developments in the scientific, cognitive and technological domains, which have imposed themselves on the nature of mathematical knowledge necessary to meet the challenges of the 21st-century. Mathematical excellence is no longer measured by developing an individual's mathematical skills. Rather, it is measured by the learner's ability to employ various skills in his daily life and employ them in dealing with contemporary technical vocabulary that has spread in various fields, which requires reviewing the school curricula to prepare a thinking generation that possesses the various knowledge and life skills that qualify it to live with the events of the 21st-century (Mansi, 2013). Numerous educational systems have responded to identifying 21st-century skills and integrating them with educational systems, especially in school curricula to help students adapt to the changing world, keep pace with successive changes, and assist them to compete according to the needs of the labor market (Amrouni & Bragel, 2023).

The significance of 21st-century skills is a fundamental driver of success in academic levels and work practice, as it prepares students for new jobs that have not yet been created by providing them with an accurate set of skills that will enable them to get future jobs. In addition, students need to learn how to process and analyze information, increase access to knowledge in the Internet age, and learn how to apply facts and ideas to complex and real-life problems (Al-Shammari, 2024). 21st-century skills are defined as a set of life skills, applied skills, non-cognitive skills, labor market skills, and skills for dealing with others, which students should know and master to engage in the labor market and make appropriate decisions in their daily lives in accordance with the requirements of the current era (Al-Casey & Azzam, 2018; Voogt & Pareja Roblin, 2023).

Moreover, Scott (2015) defines these skills as the basic competencies and skills for success in work and life, as it includes cooperation, critical thinking, creativity, and communication. 21st-century skills help in achieving several goals that students aspire to achieve by actively contributing to society so that students become able to live in a technical and information environment and possess the skills of thinking, positive awareness, and dealing with others. Abboud (2020) points out that incorporating 21st-century skills into curricula enables students to apply what they have learned, relate it to their daily lives, and

provides opportunities for students to learn cooperatively by collecting information or building new ideas. It also helps them understand deeply and use knowledge in new and innovative ways. The necessary skills needed by students from kindergarten to secondary education have been classified into three main areas, and a number of sub-skills fall under each main skill (Al-Eid, 2019; Hajjah, 2018; Trilling & Fadel, 2013).

1. Learning and innovation skills: These include the following sub-skills:
 - a. **Critical thinking and problem-solving skills:** They are concerned with developing students' abilities to criticize the issues they face, enable them to use appropriate thinking methods to solve problems, propose solutions and alternatives effectively, then select the best solution, and evaluate the effectiveness of the solution in addressing the problem at hand.
 - b. **Communication and cooperation skills:** They are concerned with helping students cooperate among themselves and the individual contribution that each student makes to team members and making the necessary concessions in order to achieve a common cooperative goal.
 - c. **Creativity and innovation skills:** They are concerned with enabling students to apply modern scientific theories in different life situations, provide innovative solutions to the problems they face, be able to think creatively, and implement innovations in an innovative and effective ways with others.
2. Second: Information, media and technical skills: They include the information literacy skill that focuses on the student's ability to use digital tools and social media effectively in searching for, managing, analyzing and evaluating information, and considering ethical aspects when using technology. Media literacy skill is concerned with producing new information through modern and advanced means of communication and the mechanism of communicating it to others through various media means. The information and communication technologies (ICT) culture skill concerns the way students interact with information technology and depends on the understanding and effective use of information technology in a range of diverse contexts and purposes.
3. Third: Life and work skills: They include the following sub-skills:
 - a. **Flexibility and adaptation skills:** They are concerned with developing the student's ability to change his actions and the steps he takes in dealing with new situations he faces with with high efficiency without harming morals and values.
 - b. **Initiative and self-direction learning skills:** They are concerned with developing the student's ability to begin carrying out tasks independently, self-motivate to work with integrity, and setting learning goals and planning well to achieve them.
 - c. **Social skills and multiculturalism:** They are concerned with students' need to communicate with others, listen effectively, speak in a professional manner with others, understand multiple cultures, be open to diverse ideas, and accept social differences
 - d. **Productivity and accountability skills:** They are concerned with developing students' ability to complete tasks in a specific period of time, feeling responsible for any task they undertake, managing projects by achieving the goals that have been set, setting work priorities and planning them well, paying attention to the quality of production and taking responsibility for the expected results.
 - e. **Leadership and responsibility skills:** They are concerned with developing some personal qualities among students such as commitment, responsibility, flexibility and self-confidence, promote lifelong learning, and working in the interest of society.

Accordingly, with the researchers' analysis of many classifications of 21st-century skills, the current article has adopted the following skills: critical thinking and problem-solving skills, creativity and innovation skills, cooperation and teamwork skills, communication skills, technical and information skills, initiative and self-direction learning skills. Al-Eid (2019) believes that the integration of these skills into education curricula will enable educators to achieve many goals that they have not been able to achieve for many years because these skills enable students to learn and achieve in academic subjects and provide an organized framework that ensures students' engagement in the learning process and helps them build confidence. More importantly, these skills also prepare students for innovation and leadership in the 21st-century and to participate effectively in life (Altarawneh & Al-Ghammaz 2023).

In the same vein, Al-Hosani and Shahat (2022) confirm that integrating 21st-century skills into the school curricula leads to the development of management, self-development, and the involvement of students in scientific issues so that they are able to face the challenges of life that exist in the 21st-century. Jaquiz (2015) adds that to make 21st-century skills meaningful and applicable to students, the key is to transform them into tangible classroom applications that are linked to curriculum content. Mathematics curricula at the various educational levels represent the basic foundation for providing students with 21st-century skills, which they seek to include in their contents, focus on them in order to teach different thinking styles, and help students solve problems and create critical and creative thinking to face life with all its variables (Al-Zahrani, 2021).

Mathematics curricula are also considered among the most fertile curricula for developing thinking and creativity because they provide activities and issues related to other branches of knowledge, as they provide the mathematical principles and generalizations necessary to solve problems. Mathematics textbooks seek to provide important activities, exercises, and skills for students to acquire in the current era (Al-Takhaina, 2022). In 2009, the partnership for 21st-century skills (P21) developed a set of recommendations for developing mathematics curricula to ensure the development of 21st-century skills among students (Al-Balawi & Al-Balawi, 2019; Al-Hwaish, 2018). Among these recommendations are that it is necessary to design mathematics curricula in light of 21st-century skills, provided that the curriculum includes models of mathematical activities that encourage

thinking, scientific research, and problem-solving. Other key recommendations include integrating 21st-century skills into mathematical concepts, generalizations, and skills, involving mathematics teachers in the design process to ensure they support and understand ideas that demonstrate 21st-century skills, training students to apply the basic concepts of 21st-century skills and demonstrate their mastery of them, and providing student-centered teaching that develops 21st-century skills and linking results to students' experiences.

The recommendations also comprise the need for mathematics teachers to pay attention to diversifying teaching methods for evaluating student learning and providing lessons and study units that include the basic concepts and skills that students need to know. Locally, teaching mathematics in Jordan aims to develop all types of thinking, employ mathematical skills in solving problems in all branches of knowledge, increase opportunities for cooperation and communication, and develop students' self-learning skills. To achieve these goals, the Ministry of Education (MOE) focused on developing mathematics textbooks for all levels of education and made fundamental changes in the content of the books to keep pace with global developments and develop among students the required skills necessary to qualify them for the labor market. Given the previous and in-depth introduction, the related literature review is offered in the subsequent section.

Theoretical Foundations of 21st-Century Skills

Prominent international frameworks have shaped the understanding and classification of 21st-century skills. The P21 framework, for instance, emphasizes a blend of core academic content with essential skills for success in work and life (Partnership for 21st-Century Skills, 2015; Trilling & Fadel, 2009). It organizes these into three broad categories:

1. **Learning and innovation skills (often referred to as the "4Cs"):** Critical thinking and problem-solving, creativity and innovation, communication, and collaboration (cooperation and teamwork).
2. **Information, media, and technology skills:** Encompassing information literacy, media literacy, and ICT proficiency.
3. **Life and career skills:** Including flexibility, initiative and self-direction, social skills, productivity, and leadership.

Similar emphases appear in other works (e.g., Scott, 2015, highlighting the 4Cs; Zahran & Hamzeh, 2023, from the ATC21S project). Building on these foundations and analyses of various classifications (Al-Eid, 2019; Hajjah, 2018), the present study focuses on six key skills particularly relevant to mathematics education: critical thinking and problem-solving, creativity and innovation, communication, cooperation and teamwork, technical and information skills, and initiative and self-directed learning. Integrating these skills into curricula enables deep understanding, real-world application, and preparation for innovation and leadership in the 21st-century (Altarawneh & Al-Ghammaz, 2023).

This theoretical grounding underscores the need for explicit incorporation of such skills in school textbooks, particularly in subjects like mathematics that foster logical reasoning, problem-solving, and creative application.

LITERATURE REVIEW

Scholars have recorded the admission of 21st-century skills in the teaching of mathematics curricula and textbooks. Çekirdekci et al. (2023) analyzed activities in mathematics textbooks used in elementary schools in Turkey from the perspective of the 21st-century skills. The research method employed the descriptive survey technique. The outcome showed that acquiring and innovating skills are in the top tier, followed by life and work skills. The results also indicated that there were no activities related to the skills of know, media and technology in the mathematics textbooks.

Using a different approach, Sarigöz (2023) examined the secondary mathematics curriculum in Turkey within the context of 21st-century skills. The research methodology involves using the descriptive-analytical approach. The results indicated that critical thinking skills were 10.71% for the fifth grade, 6.78% for the sixth grade, 8.33% for the seventh grade, and 11.54% for the eighth grade. In terms of the activity book, critical thinking skills were 52.38% for the fifth grade and 64.00% for the seventh grade. As for creative thinking skills, it was 5.36% for the fifth grade, 3.39% for the sixth grade, 2.08% for the seventh grade, and 3.85% for the eighth grade. Concerning the activity book, creative thinking skills were 28.57% for the fifth grade, 10.52% for the sixth grade, 28.00% for the seventh grade, and 30.77% for the eighth grade. As for communication skills, they are not included in all educational levels. In the activity book, communication skills were 35.71% for the fifth grade, 5.26% for the sixth grade, 4.00% for the seventh grade, and 28.21% for the eighth grade. It was found that critical thinking and creative thinking and communication skills were included to a limited extent.

In a new context, Amrouni and Bragel (2023) identified the degree of inclusion of 21st-century skills in the content of the mathematics textbook for the fourth intermediate year in Algeria. The research methodology involves using the descriptive-analytical approach. The results showed that the degree of inclusion of 21st-century skills in the mathematics textbook for the fourth intermediate year was high, where the communication skill was ranked first with a high degree, while the self-learning skill was ranked second with a high degree. The results indicated that the critical thinking skill was ranked third with a medium degree, while the digital literacy skill was ranked last with a medium degree.

Al-Takhaina (2022) examined the Jordanian mathematics curriculum developed for seventh graders to measure the incorporation of 21st-century skills. This study used the descriptive analytical approach. The results of the study revealed that the text of the mathematics curriculum incorporated 21st-century skills to a moderate extent the average of 43 percent with skills such as critical thinking and problem-solving 21 percent, self-learning skills 7 percent, skills of creative thinking 6 percent, communication skills 6 percent, skills of the use of technology 2 percent, and cooperation and community participation skills 1 percent. Likewise, Al-Khatatneh (2022) examined the extent to which 21st-century skills were embedded in the mathematics

curriculum for 6th-graders in Jordan. This study also used the descriptive analytical approach. The results determined that the coverage of 21st-century skills was low in general with 28.55 percent, critical thinking and problem-solving skills was high with 47.86 percent, the skills of creativity and innovation was moderate with 52.99 percent, and the skills of information, communication and media literacy was low with 30.5 percent. Whereas, the skills of cooperation and teamwork, skills of computer and technology, skills of life and career, self-directed learning, and multicultural skills were low.

Another key study conducted by Al-Zahrani (2021) determined the degree of availability of 21st-century skills in mathematics textbooks for the third intermediate grade in the Kingdom of Saudi Arabia. The research methodology involves using the descriptive-analytical approach. The findings indicated that the degree of availability of 21st-century skills in mathematics textbooks was very low with (13.2%), and with the critical thinking and problem-solving skills (43.5%) with a medium degree, creativity and innovation skills with (12.3%) with a low degree, the communication, information and media culture skills (9.8%) with a low degree, the profession and self-direction learning skills (8.9%) with a low degree, the cooperation, teamwork and leadership skills (8.7%) with a low degree, the culture of computing and information and communication technology skills (5.4%) with a low degree, and the skills of understanding multiple cultures (3.6%) in the last place with a low degree.

Furthermore, Al-Shehri (2021) revealed the level of inclusion of 21st-century skills in middle school textbooks in Saudi Arabia. The research methodology involves using the descriptive-analytical approach. The results showed that the percentage of skills included in all books was (50%) at a medium level, as follows: the critical thinking and problem-solving skills (50%), the communication, information and media skills (28%), the profession and self-direction learning skills (7%), the cooperation, teamwork, and leadership skills (6%), the computing and information technology skills (5%), the creativity and innovation skills (4%), and the skill of understanding multiple cultures (1%). With the previous and detailed literature review, the research problem is furnished in the following section.

RESEARCH PROBLEM

Education-based reform movements always call for the necessity of preparing students to face the requirements of the future and providing them with the skills that enable them to deal and interact with the skills of the 21st-century and adapt to their changes. Therefore, in the “education by 2030 report”, UNESCO (2016) indicated the need to provide students with the 21st-century skills and competencies necessary to keep pace with the modern era by developing their abilities and skills, employing communication skills to continue their self-learning, and building an identity based on openness to multiple cultures, respecting perspectives and achieving lifelong learning.

Various conference recommendations, such as the 36th International Arab Youth Conference, “skills for the 21st-century “ in 2017 and the International Conference, “skills for the future and their development and evaluation” in 2018 emphasized attention to 21st-century skills and their inclusion in the content of school curricula, focusing on the importance of integrating future skills into the general education curriculum. Despite the importance of including 21st-century skills in school curricula, several studies (see, for example, Al-Harbi, 2019; Al-Khuzaim & Al-Ghamdi, 2016; Al-Takhaina, 2022) showed that the level of representation of 21st-century skills in mathematics textbooks ranges from a medium level to wean one in most skills.

In the same context, much research work has recommended the importance of including 21st-century skills in school curricula. For example, Ahmed and Al-Maamari (2021) recommended the necessity of including 21st-century skills in mathematics textbooks for the basic stage and training curriculum planners on them. Also, Al-Harbi and Al-Harbi (2021) recommended attention to the skills of using technology, self-learning, cooperation, and community participation in mathematics textbooks. Moreover, Al-Zahrani (2021) recommended examining mathematics curricula in developed countries and the availability of 21st-century skills and utilizing them to include skills in the curricula, spreading the culture of the availability of 21st-century skills in the curricula of the various stages of education, and urging curriculum developers and designers to adopt these skills and know the extent of their importance for students in their future life. In a high-level effort by the researchers and academics and their keenness to enhance and develop students’ skills to keep pace with the skills of the 21st-century and meet the requirements of the labor market, the research problem is crystallized in answering the following main question: What is the degree of inclusion of 21st-century skills in the 9th-grade developed mathematics textbook in Jordan?

RESEARCH SIGNIFICANCE

The significance of the current study is drawn from the significance of the research problem and area which is reflected in the 21st-century skills, as they are a requirement to keep pace with modern global trends and meet the needs of students in the labor market. It is also a response to educational trends and researchers’ recommendations regarding the necessity of including 21st-century skills in mathematics textbooks at different educational levels. The practical significance of this study is also represented in drawing the attention of officials at the MOE and those responsible for planning and developing textbooks to the importance of including the necessary skills for students in the content of mathematics textbooks and providing them with a list of 21st-century skills that can be used as guidance when planning mathematics textbooks at different educational levels.

Likewise, it is hoped that the study will provide teachers with a list of the most important skills that students need to meet the requirements of the labor market in accordance with the skills of the 21st-century, and this in turn helps in improving teaching practices that benefit students and their level of achievement. The study is also expected to provide research tools that will benefit

researchers in various fields of science. More importantly, the significance of this study lies in being the first study conducted in Jordan due to the lack of studies and research conducted in this research area.

Research Boundaries and Limitations

This study is deliberately bounded (delimited) in scope to ensure focused and feasible analysis, while acknowledging certain limitations that readers should consider when interpreting the findings.

Objective boundaries

1. **Scope of the content:** The analysis is limited to the Jordanian MOE's 9th-grade mathematics textbook for the 2023/2024 school year which contains student book and exercise book for first and second semesters. Other associated books such as supplementary materials, teachers' books, and instructional digital materials for the textbook are excluded.
2. **Scope of the skills:** Only 6 21st-century skills which are adopted for the purposes of this research are included in the study: critical thinking problem-solving, innovation and creativity, communication, teamwork/cooperation, and technical/information skills, initiative and self-direction. Other 21st-century skills such as flexibility, leadership, productivity, multicultural understanding, and other skills are not included.
3. **Scope of place and context:** The research is placed in the context of the Jordanian educational system and the current curriculum. The results cannot be fully transferred to other grades, subjects, or countries without additional evidence.
4. **Scope of methodology:** The research employs content analysis where the researcher formulates an analysis card to be used in analyzing the text, activities, and exercises. No other data such as observations of classroom activities, teacher practices, and students' results are included.

Limitations

1. **Generalization:** As the study analyzes a single textbook from one grade level in one country, the findings cannot be broadly generalized to other grades, subjects, educational systems, or cultural contexts. Results are specific to the Jordanian 9th-grade mathematics curriculum as implemented in 2023/2024.
2. **Instrument subjectivity:** Although the analysis card was developed based on established frameworks and literature, content analysis inherently involves researcher interpretation. Potential subjectivity in identifying and categorizing skill occurrences may influence the frequency counts, despite efforts to ensure reliability.
3. **Static nature of textbooks:** The analysis examines the textbook content as written, not how teachers actually use or adapt it in classrooms. Actual integration of 21st-century skills in teaching practice may differ from what the textbook affords.
4. **Temporal limitation:** The textbook analyzed reflects curriculum design decisions up to 2023/2024. Subsequent revisions or policy changes may alter the degree of skill integration in future editions.

These boundaries and limitations were intentionally set to maintain focus and depth, while the acknowledged constraints should be considered when interpreting and applying the results.

RESEARCH TERMS & DEFINITIONS

In this study, the terms "21st-century skills" and "9th-grade developed mathematics textbook" are mentioned, and their procedural definitions are as follows:

21st-century skills: The Partnership defines 21st-century skills as a set of skills that students need to succeed in school, work, and life. It includes three main areas: learning and innovation skills, information technology and media skills, and life and work skills (Partnership for 21st-Century Skills, 2015). Procedurally, 21st-century skills are defined as a set of skills and experiences necessary for students to keep pace with the requirements of the times and prepare for the labor market. They include the following skills: critical thinking and problem-solving, creativity and innovation, cooperation and teamwork, communication, technology, and informatics, initiative, and self-learning.

9th-grade developed mathematics textbook: It is one of the mathematics textbooks developed by the National Center for Curriculum Development, which is taught in schools in the Hashemite Kingdom of Jordan starting from the academic year (2023/2024). It includes two books "the student and the exercises" for the first and second semesters.

Conceptual Framework for the Study

The conceptual framework for this study is designed to explore the degree of inclusion of 21st-century skills in the 9th-grade developed mathematics textbook in Jordan. This framework is structured around several core components and research dimensions, all aimed at understanding and enhancing the integration of these essential skills within educational materials.

Core Components

The framework begins with a foundation in educational reform movements, emphasizing the necessity of preparing students for future challenges by equipping them with relevant skills. These movements are supported by the UNESCO (2016) "education by 2030 report," which highlights the importance of developing students' abilities, fostering communication for self-learning, and building an identity that respects diverse perspectives and promotes lifelong learning.

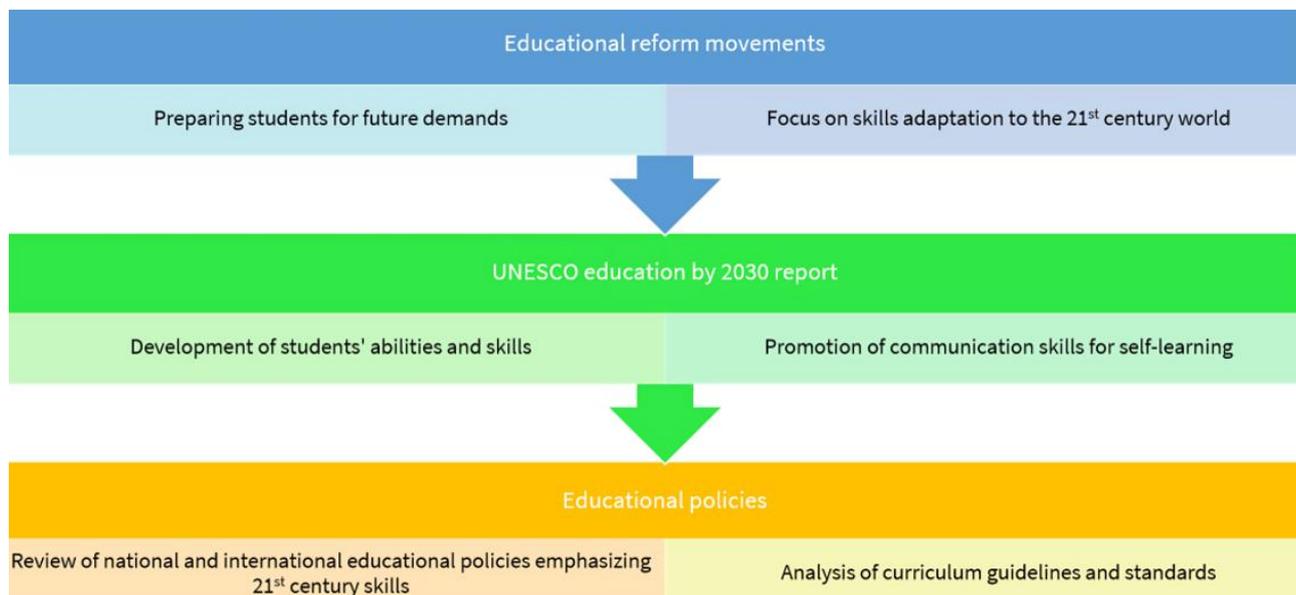


Figure 1. A conceptual framework to explore the degree of inclusion of 21st-century skills in the 9th-grade developed mathematics textbook in Jordan (Zahran & Hamzeh, 2023)

Conference recommendations further reinforce this foundation. Notable conferences, such as the 36th International Arab Youth Conference and the International Conference on “skills for the future and their development and evaluation,” have emphasized the critical need to incorporate 21st-century skills into school curricula. Despite this recognized importance, studies have shown varying levels of these skills’ inclusion in mathematics textbooks.

Research Dimensions

To address this issue, the framework examines the inclusion of 21st-century skills across several dimensions within the 9th-grade mathematics textbook:

1. **Content analysis:** This involves a textual analysis to evaluate the presence and frequency of 21st-century skills in the textbook content and an activity analysis to assess exercises promoting these skills.
2. **Educational policies:** The framework reviews national and international educational policies, curriculum guidelines, and standards emphasizing 21st-century skills.
3. **Pedagogical approaches:** It identifies teaching methods and strategies in the textbook that foster these skills, evaluating instructional design alignment with modern educational practices.
4. **Learning outcomes:** The framework assesses intended learning outcomes related to 21st-century skills and measures skills development through textbook content.

Expected Outcomes

The expected outcomes include a detailed understanding of how 21st-century skills are incorporated into the 9th-grade mathematics textbook, insights into areas needing improvement, and recommendations for curriculum developers and educators on enhancing the integration of these skills. This study aims to draw attention to the importance of including necessary skills in mathematics textbooks, providing guidance for future curriculum planning, and improving teaching practices to benefit student achievement.

This conceptual framework ensures a comprehensive approach to evaluating the integration of 21st-century skills in mathematics textbooks, aligning with educational reforms, policies, and the UNESCO (2016) 2030 agenda (**Figure 1**).

METHODOLOGY

Research Approach

To achieve the research objective and answer its question, the descriptive-analytical approach was used, based on the method of analyzing the content of the mathematics textbook developed for the ninth grade in light of 21st-century skills suitable for this type of study.

Population and Sample

The research population and sample consists of the 9th-grade developed mathematics textbook, “Student book and exercise book,” for the first and second semesters approved by the MOE in Jordan as of the academic year (2023/2024). The textbook cover,

introduction, and list of contents were excluded from the analysis. The percentage of content analyzed in the student book is (97.23%), while the exercise book is 90.38% of the total book content.

Instrument

In light of the variations in 21st-century skills highlighted in previous studies, it became evident that there is considerable diversity in how these skills are defined and emphasized. To address this, a comparative analysis of previous studies was conducted to identify the 21st-century skills most commonly agreed upon. Following this analysis, skills directly related to the topics covered in the mathematics curriculum and appropriate for the students' age group were identified. Based on these findings, a content analysis card was developed, tailored to the specific context of the study. This card included six main skills and 40 sub-skills, ensuring a comprehensive evaluation of the textbook content. This approach aligns with the ongoing research efforts to understand the role of computer data analysis in education, reflecting a commitment to integrating modern educational practices into the curriculum.

Instrument Validity

To check the validity of the content analysis card, it was reviewed in its initial form by a group of validators with experience and expertise in curricula and mathematics teaching methods to ensure the importance of the items, their degree of clarity, and their suitability for ninth grade students. Some validators indicated that some important amendments shall be made to some items, alongside the addition of some items related to the research study subject. Given the proposed amendments, the analysis card consists of six main skills, which are divided into 33 sub-skills instead of 40 sub-skills, as follows:

1. First: Critical thinking and problem-solving skills with 8 sub-skills.
2. Second: Creativity and innovation skills with 6 sub-skills.
3. Third: Cooperation and teamwork skills with 3 sub-skills.
4. Fourth: Communication skills with 5 sub-skills.
5. Fifth: Technical and information skills with 6 sub-skills.
6. Sixth: Initiative and self-direction learning skills 5 sub-skills.

The following units of analysis, "ideas and shapes," were identified to determine the basic 21st-century skills included in the 9th-grade mathematics textbook.

Instrument Reliability

The reliability of the analysis card over time was calculated by selecting a random lesson from the ninth grade mathematics textbook, "student book," for the first semester, entitled "analyzing graphs of a relation" in unit two. After completing the analysis process and its results, the lesson was re-analyzed again after two weeks using the Cooper equation, as indicated by Al-Assaf (2014). The value of the reliability coefficient over time is 91.6%, which indicates that the reliability coefficient was high, as it is considered an acceptable and appropriate value if the percentage is 80.0% or higher (Attia, 2009). Therefore, it can be adopted and used to conduct this study.

Data Analysis Procedures

In a structured manner, with precision and uniformity, content analysis was done, consisting of these steps:

1. **Primary analyst:** The lead researcher, whose body of work includes specialization in Curriculum and Instruction and Mathematics Education, undertook a thorough analysis of the content of the entire textbook (Student book and exercise book). The researcher painstakingly examined the content and, by turning the pages, detected the presence of the 21st-century skills imbued in the content using the validated analysis card.
2. **Units of recording:** Each instance was documented according to the outlines of the units of analysis, "ideas" for the text, and "shapes" for the visuals and activities. Only instances where one or more of the 33 sub-skills were promoted, whether explicitly or implicitly, were counted. To prevent over-counting, when one instance demonstrated multiple sub-skills, only the primary skill was counted, although the total frequency number accounted for all sub-skills corresponding with the instance.
3. **Independent coding for reliability:** To validate the analysis and minimize researcher bias, an independent coder collaborated. This coder was another analyst with a PhD in mathematics education and content expertise, who examined 20.0% of the textbook content (distributed across units of both semesters and across both books) that was randomly chosen.
4. **Agreement procedure:** The output of the principal researcher and independent coder was taken and compared item by item.

The following equation (Al-Assaf, 2014) was used to compute agreement: $\text{level of agreement} = (\text{number of agreements} / (\text{number of agreements} + \text{number of disagreements})) * 100$. As the inter-rater reliability coefficient was 88.4%, this implied that there was consistently high reliability (acceptable value $\geq 80.0\%$; Attia, 2009). The disagreements were minor, mainly relating to borderline. As these were explained, and consensus was reached, it was noted for transparency that the initial coefficient was kept.

Table 1. Criterion for finding out the degree of inclusion of skills in the 9th-grade mathematics textbook

Percentage (%)		Degree of inclusion
0.25	11.71	Low
11.72	23.18	Medium
23.19	34.65	High

Table 2. Frequencies, percentages, and degrees for the 21st-century skills included in the 9th-grade mathematics textbook arranged in descending order

	21st-century skills	Frequency			Percentage (%)			Degree of inclusion
		Part one	Part two	Total	Part one	Part two	Total	
1	Critical thinking and problem-solving	1,029	1,014	2,043	35.41	33.86	34.62	High
2	Initiative and self-direction learning	871	938	1,809	29.97	31.32	30.66	High
3	Communication	707	709	1,416	24.33	23.67	24.00	High
4	Creativity and innovation	272	297	569	9.36	09.92	09.64	Low
5	Technical and information	17	32	49	0.58	1.07	0.83	Low
6	Cooperation and teamwork	10	5	15	0.34	0.17	0.25	Low
	Overall	2,906	2,995	5,901	100	100	100	

5. **Final data consolidation:** The principal researcher's coding (only edited where consensus had been reached for the purpose of clarity enhancement) was used to arrive at the final frequencies (which summed to 5,901). From that, proportions were determined and corresponding to the total occurrences, the skills were ranked.

The findings' reliability and the potential subjectivity of qualitative content analysis are both countered by this two-analyst method and the high inter-rater agreement.

Statistical analysis

The following statistical methods are used to answer the research questions and process the data statistically.

1. Frequencies, percentages, and ranks were used to answer the main research question, and the Cooper equation was also used to ensure the reliability of the analysis card.
2. The statistical scale dividing the total percentage into three levels "high, medium, low" was adopted using the length of the category according to an equation to determine the content analysis of the 9th-grade developed mathematics textbook (Abu Ghalioun, 2016). The degree is also determined by applying the following equation: $\text{Category length} = (\text{highest percentage obtained by the skill} - \text{lowest percentage obtained by the skill}) / 3$. $\text{Category length} = (34.62 - 0.25) / 3 = 11.46\%$.

Table 1 includes an explanation of the percentages for mathematics textbooks.

RESULTS & DISCUSSION

The main research question addressed the degree of inclusion of 21st-century skills in the Jordanian 9th-grade mathematics textbook (Student book and exercise book, 2023/2024 edition). A total of 5,901 occurrences were identified across the six skills.

Table 2 presents the frequencies, percentages, ranks, and degrees of inclusion.

As shown in **Table 2**, the degree of inclusion of 21st-century skills in the 9th-grade mathematics textbook reached 5,901 frequencies for the two parts. Critical thinking and problem-solving skills were ranked first, with a total of 2,043 frequencies, at a rate of 34.62%, with a high degree. This result is attributed to the ability of this skill to activate the largest number of mental processes, senses, and imagination, which are considered part of the nature of mathematics based on thinking processes, and the ability to excite students, develop their ability to solve problems, and use new methods of thinking by presenting situations, activities, and applications that develop the ability to deduce and make decisions. This result was consistent with the studies of Al-Takhaina (2022) and Al-Zahrani (2021), where critical thinking and problem-solving skills were ranked in the first place, and the study of Al-Khatatneh (2022), where critical thinking and problem-solving skills were in a high degree. However, the result differed from the results of the study of Sarıgöz (2023), where critical thinking and problem-solving skills were ranked in at a low degree, and the study of Amrouni and Bragel (2023), where critical thinking and problem-solving skills were in a medium degree.

Moreover, initiative and self-direction learning skills were ranked in the second place, with a total of 1,809 frequencies at a rate of 30.66%, with a high degree. This is due to the fact that the mathematics subject contains various activities and situations that enhance the role of students and develop their sense of responsibility by relying on themselves and paying attention to solving the problems and exercises assigned to the students. The result agreed with the study of Amrouni and Bragel (2023), where initiative skills and self-direction learning were highly ranked. However, this result differed from the study of Al-Khatatneh (2022), where life and vocational skills and self-direction learning were in a very low degree, and the study of Al-Zahrani (2021), where initiative and self-direction learning were ranked in fourth place.

Besides, communication skills were ranked in third place, with a total of 1,416 frequencies, representing 24.00% and a high degree. This is attributed to the awareness of those responsible for preparing and developing curricula of the importance of communication skills in building students' personalities and the ability to change students' behavior. Al-Harbi and Al-Harbi (2021)

Table 3. Frequencies and percentages for the critical thinking and problem-solving skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
1	The content encourages the learner to solve mathematical problems individually or collectively.	283	101	317	97	600	198	37.59	44.30
2	The content helps explain and clarify ideas.	172	1	172	1	344	2	21.55	0.45
3	The content guides the learner to interpret mathematical ideas.	119	35	89	22	208	57	13.03	12.75
4	The content provides mathematical problems related to the learner's life.	48	12	56	18	104	30	6.52	6.71
5	The content encourages the learner to apply facts and evidence to new situations.	45	28	54	27	99	55	6.20	12.30
6	The content enables the learner to use different types of thinking "inductive, deductive" to suit the educational situation.	42	22	41	23	83	45	5.20	10.07
7	The content presents different types of mathematical problems and unfamiliar situations.	42	19	39	24	81	43	5.08	9.62
8	The content includes mathematical situations that develop decision-making skills.	47	13	30	4	77	17	4.82	3.80
Overall		798	231	798	216	1,596	447	100	100

mentioned that mathematical communication is one of the standards of the mathematical content. The National Council of Teachers of Mathematics has indicated that what students acquire through mathematics contributes to enriching their linguistic knowledge and giving them the ability to communicate and understand the environment in which they live.

Additionally, the creativity and innovation skills were ranked in the fourth place with total of 569 frequencies at a rate of 9.64% and a low degree. This is due to the lack of diversity in the methods of solving mathematical problems, the absence of adding activities that contribute to adding new ideas, the lack of exercises that require different solutions in a non-routine manner, and the absence of using advanced methods of creativity and integrating them into mathematical content. The study results agreed with Al-Shehri's (2021) study, as creativity and innovation skills were at a low level. However, the study results differed from the study of Al-Khatatneh (2022), as creativity and innovation skills were in a medium degree.

Likewise, technical and information skills were ranked in fifth place with total of 49 frequencies, at a rate of 0.83%, with a low degree. This is due to the lack of benefit from the recommendations of experts in curricula and teaching methods. The reason may also be due to the focus on learning mathematical concepts more than digital culture, as this percentage is insufficient for its availability in the content due to the importance of technical and information skills in the current era, which is witnessing a massive knowledge and technological explosion. Accordingly, the skill of digitalization has become an essential feature that distinguishes the current era. The result agreed with the study of Al-Khatatneh (2022), as the information, communication and media literacy skills were at a low level. The results of the study differed from the study of Amrouni and Bragel (2023), as digital culture skills and computing culture skills and information and communication technology were ranked in last place.

Similarly, the cooperation and teamwork skills were ranked in the last place with total of 15 frequencies at a rate of 0.25%, and with a low degree. This is due to the lack of interest in the content and its failure to address situations and activities that support cooperation and teamwork skills working in a team, and projects, such as group competitions and cooperation with others. Through the cooperation and teamwork skills, students can learn faster and achieve in academic subjects and develops confidence among students while working in groups. The study results agreed with the study of Al-Khatatneh (2022), as cooperation and teamwork skills were very low. However, the study results differed from the study of Al-Zahrani (2021), as cooperation and teamwork skills in the leadership team were ranked in the fifth place. With that being given, a review of the main 21st-century skills included in the mathematics textbook is detailed as follows:

Critical Thinking and Problem-Solving Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 3** illustrates those results.

This skill recorded the highest inclusion (2,043 occurrences, 34.62%). The sub-skill "encourages the learner to solve mathematical problems individually or collectively" dominated (798 occurrences across both books), reflecting mathematics' focus on activating mental processes, deduction, and decision-making through diverse activities and real-life applications. The lowest sub-skill was decision-making situations (4.82% in student book), possibly due to emphasis on procedural over open-ended tasks.

These patterns support prior Jordanian findings (Al-Khatatneh, 2022; Al-Takhaina, 2022) but contrast with lower rates reported by Sarıgöz (2023) in Turkey.

Creativity and Innovation Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 4** illustrates those results.

Table 4. Frequencies and percentages for the creativity and innovation skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
		1	The content introduces the ideas, concepts, terms and laws contained in the mathematics textbook to learner.	81	0	54	0	135	0
2	The content develops the skill of creative mathematical imagination “fluency, flexibility, and originality.”	42	18	40	21	82	39	20.05	24.38
3	The content encourages the learner to give creative interpretations of mathematical data and outcomes.	26	24	35	19	61	43	14.91	26.88
4	The content encourages the learner to create diverse alternatives and solutions to solve unfamiliar mathematical problems.	18	13	36	20	54	33	13.20	20.63
5	The content provides open-ended, non-routine mathematical problems solved in multiple ways.	21	14	32	19	53	33	12.96	20.63
6	The content encourages the transformation of mathematical ideas in an innovative, tangible and realistic way.	4	11	20	1	24	12	5.87	7.50
Overall		192	80	217	80	409	160	100	100

Table 5. Frequencies and percentages for the cooperation and teamwork skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
		1	The content presents mathematical situations that contribute to solving societal problems.	6	0	3	0	9	0
2	The content includes mathematical tasks, activities and projects that require teamwork.	2	0	1	0	3	0	20.00	0.00
3	The content promotes positive attitudes toward cooperative work.	2	0	1	0	3	0	20.00	0.00
Overall		10	0	5	0	15	0	100	100

As indicated in **Table 4**, the inclusion of the critical thinking and problem-solving skills in the content of the 9th-grade mathematics textbook were in varying proportions. The skill stipulating “the content introduces the ideas, concepts, terms and laws contained in the mathematics textbook to the learner” is ranked first with a total of 135 frequencies and a rate of 33.01%. This result may be attributed to the importance of including concepts, terminology, generalizations, and mathematical facts in the content because they help the student understand the lesson, know its requirements, and represent the basic building block from which mathematics education begins. In the exercise book, the skill that states “the content encourages the learner to give creative interpretations of mathematical data and outcomes” is ranked third with a total of 43 frequencies and a rate of 26.88%. This may be due to the importance of activating students’ minds to solve questions and exercises in many ways, which leads to developing creativity, confronting unfamiliar questions in a correct way, and unleashing students to solve mathematical problems in different ways and think outside the box.

Moreover, in last place in the student book is the skill that states, “the content encourages the transformation of mathematical ideas in an innovative, tangible and realistic way” with a total of 24 frequencies and a rate of 5.87%. In the exercise book, the skill that states “the content introduces the ideas, concepts, terms and laws contained in the mathematics textbook to the learner” is ranked first a total of 0 frequencies and a percentage of 0.00%. This result may be attributed to the focus of the exercise book on solving routine and non-routine mathematical problems and training the student on the steps to solve the problem rather than its focus on putting concepts, terminology and ideas in the exercise book designated for the student.

Cooperation and Teamwork Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 5** illustrates those results.

As indicated in **Table 5**, the inclusion of the critical thinking and problem-solving skills in the content of the 9th-grade mathematics textbook were in varying proportions. The skill stipulating “the content presents mathematical situations that contribute to solving societal problems” is ranked first with a total of 135 frequencies and a rate of 33.01%. This may be due to the importance of presenting exercises and mathematical problems that are related to the student’s life and highlighting the nature of the problems facing society and how students can contribute to solving these problems. However, in last place in the student book are the two skills that state, “the content includes mathematical tasks, activities and projects that require teamwork” and “the content promotes positive attitudes toward cooperative work,” with a total of 3 frequencies and a percentage of 20.00%. This result may be due to students focusing on themselves, not being distracted, or the lack of time in mathematics class. In the exercise book, cooperation and teamwork skills were not included. This may be due to their lack of focus on cooperation skills or for students to solve exercises and mathematical problems themselves and take enough time to think and reach the correct and sound solution.

Table 6. Frequencies and percentages for the communication skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
1	The content encourages the written expression of mathematical ideas in a variety of formats.	292	110	312	97	604	207	56.24	60.53
2	The content provides mathematical situations that develop oral communication skills.	186	40	171	43	357	83	33.24	24.27
3	The content presents mathematical situations related to positive behaviors related to life.	25	13	35	3	60	16	5.56	4.68
4	The content encourages the learner to express his ideas effectively.	20	17	25	19	45	36	4.19	10.53
5	The content provides an opportunity for the learner to listen and share mathematical ideas in common language.	4	0	4	0	8	0	0.74	0.00
Overall		527	180	547	162	1,074	342	100	100

Table 7. Frequencies and percentages for the technical and information skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
1	The content encourages the learner to use computers and digital technologies while learning.	6	0	10	0	16	0	32.65	0.00
2	The content develops positive attitudes towards the use of digital technology.	6	0	10	0	16	0	32.65	0.00
3	The content urges the learner to follow scientific and ethical foundations when using the Internet and social media networks.	2	0	9	0	11	0	22.45	0.00
4	The content provides links and websites to access information.	1	0	2	0	3	0	6.12	0.00
5	The content provides mathematical activities that require collecting information from its original sources.	2	0	1	0	3	0	6.12	0.00
6	The content supports the use of multimedia tools and media in the field of mathematics.	0	0	0	0	0	0	0.00	0.00
Overall		17	0	32	0	49	0	100	100

Communication Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 6** illustrates those results.

As indicated in **Table 6**, the inclusion of the critical thinking and problem-solving skills in the content of the 9th-grade mathematics textbook were in varying proportions. The skill stipulating “the content encourages the written expression of mathematical ideas in a variety of formats” is ranked first in both books with total of 604 frequencies at a rate of 56.24% in the student book, and with total of 207 frequencies at a rate of 60.33% in the exercise book. This may be due to the nature of mathematics content, which requires the student to practice writing and make multiple attempts to reach solutions to problems, use geometric tools in the drawing process, write down the data available in the problems, provide the necessary evidence for proof, and train the student to interpret the problem and rewrite it in a special form and the ability to express about it in its own sense.

Moreover, in the last place in both books is the skill that states, “the content provides an opportunity for the learner to listen and share mathematical ideas in common language” with a total of 8 frequencies at a rate of 0.74% in the student book, and with a total of 0 frequencies, at a rate of 0.00%, in the exercise book. This result may be attributed to the fact that the nature of mathematics subjects tends to work and think individually in order to accustom the student to dealing with mathematical situations and problems and how to develop a solution plan to deal with problems and exercises, as well as providing the opportunity to reach unfamiliar and multiple solutions when facing life problems.

Technical and Information Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 7** illustrates those results.

As indicated in **Table 7**, the inclusion of the critical thinking and problem-solving skills in the content of the 9th-grade mathematics textbook were in varying proportions. The two skills stipulating “the content encourages the learner to use computers and digital technologies while learning” and “the content develops positive attitudes towards the use of digital technology” are ranked first in the student book with total of 16 frequencies and a percentage of 32.65%. This may be due to the importance of applying mathematics in different ways by using the computer so that students do not get bored with the class, or

Table 8. Frequencies and percentages for the initiative and self-direction learning skills included in the 9th-grade mathematics textbook

No	Sub-skills text of item	First part frequencies		Second part frequencies		Total frequencies for both parts		Percentage (%)	
		Student book	Exercise book	Student book	Exercise book	Student book	Exercise book	Student book	Exercise book
1	The content establishes in the learner the principle of self-monitoring and completing mathematical tasks without direct supervision.	274	109	312	97	586	206	44.60	41.62
2	The content develops in the learner a sense of responsibility and bearing results while performing mathematical tasks.	273	109	312	97	585	206	44.52	41.62
3	The content includes educational situations that develop the learner's self-initiative.	22	16	34	21	56	37	4.26	7.47
4	The content presents mathematical activities and problems that suit different learning styles.	26	19	25	18	51	37	3.88	7.47
5	The content allows the use of various educational tools and resources that support self-learning.	19	4	17	5	36	9	2.74	1.82
Overall		614	257	700	238	1,314	495	100	100

highlighting the students who possess computer skills, which makes them enjoy the class more, as well as the teachers' awareness of the importance of using technology in teaching mathematics and benefiting from it, including mathematical drawings, geometric shapes, and ease of dealing with them and making the related required modifications. In the last place in the student book is the skill that states, "the content supports the use of multimedia tools and media in the field of mathematics" with a total of 0 frequencies and a percentage of 0.00%. However, in the exercise book, technical and information skills are not included.

Initiative and Self-Direction Learning Skills

To explain this, frequencies and percentages for the 21st-century skills included in the 9th-grade developed mathematics textbook were calculated. **Table 8** illustrates those results.

As indicated in **Table 8**, the inclusion of the critical thinking and problem-solving skills in the content of the 9th-grade mathematics textbook were in varying proportions. The skill stipulating "the content establishes in the learner the principle of self-monitoring and completing mathematical tasks without direct supervision" is ranked first in the two books with total of 586 frequencies at a rate of 44.60% in the student book and total of 206 frequencies at a rate of 41.62%, in the exercise book. This result may be attributed to the students' sense of the value of the responsibility that falls on them in solving mathematical problems, following the strategy of trial and error, and providing the student with the opportunity to review his solution more than once and benefit from self-feedback so that he can practice solving routine and non-routine problems and increase his ability to think about various alternatives to deal with mathematical situations inside and outside the classroom.

Likewise, in the exercise book, the skill that states "the content develops in the learner a sense of responsibility and bearing results while performing mathematical tasks" is ranked first with total of 206 frequencies and a rate of 41.62%. This may be attributed to their feeling that completing tasks on their own makes them able to take responsibility and how to manage time, love mathematics more, and feel pleasure and enthusiasm when completing mathematical tasks successfully. However, in both books, the skill that states "the content allows the use of various educational tools and resources that support self-learning" is ranked last with total of 36 frequencies and a rate of 2.74% in the student book and total of 9 frequencies and a rate of 1.82% in the exercise book. This result may be due to the fact that students do not rely on sources that might make them sluggish in their performance of mathematics, or it may be more suitable for students in the upper grades than for students in the ninth grade or because there is no possibility of obtaining these sources that may be important for students who need more clarification of the lesson.

CONCLUSION

Among the key results concluded in this article is that 21st-century skills were included in 9th-grade developed mathematics textbooks. It was also found that critical thinking and problem-solving skills, initiative, and self-direction learning skills, and communication skills had a high degree of inclusion. However, creativity and innovation skills, technical and information skills, and cooperation and teamwork skills were ranked low in the textbook because these results shed light on the directions through which officials and curriculum planners are focusing on the necessity of preparing students for the labor market and empowering them with the skills necessary for them in the future.

Of the important results is that although some skills were ranked low, this opens the way for further analytical studies to reveal the inclusion of 21st-century skills in mathematics textbooks in other stages and grades and provide suggestions for surveying mathematics teachers' opinions about the extent to which they focus on 21st-century skills during their teaching. It is also hoped that this study will contribute to advancing academic knowledge and providing new insights that can benefit researchers, experts, and everyone related to educational affairs in this field.

Recommendations

Given the said results and discussion, the current article recommends raising the level of including digital culture skills in mathematics textbooks due to their importance in the age of technology and including the content of the ninth-grade mathematics textbook with activities and life situations that encourage creative thinking and teamwork. Other key recommendations are reflected in implementing training courses that help mathematics teachers integrate 21st-century skills in implementing lessons and classroom activities in mathematics classes and conducting comparative studies between the content of mathematics textbooks for the basic stage in Jordan with developed countries in the Arab World in mathematics education to determine the availability of 21st-century skills in those textbooks.

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