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Digital integration in preschool math: Assessing the efficacy of a structured curriculum in classroom settings

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ABSTRACT

This study examined the impact of Collins Educative Solutions' mathematics curriculum, integrated with technological tools such as PhET simulations, on the mathematical skills of preschoolers in Jordan. The sample comprised 60 preschoolers from Irbid, Jordan, who were randomly assigned to either an experimental group or a control group. The experimental group was taught using the Collins Curriculum alongside animated digital manuals, while the control group received instruction through traditional teaching methods. The primary goal of the intervention was to foster the experimental group's logical reasoning and critical analytical thinking by incorporating visual aids with structured curriculum content. Post-test results showed that the experimental group significantly outperformed the control group across all assessed mathematical domains ($p \leq 0.05$), indicating the effectiveness of the enriched instructional approach. Further analysis by gender revealed no statistically significant differences ($p \geq 0.05$), suggesting that the Collins Curriculum supports equitable learning outcomes for both boys and girls. These findings underscore the value of integrating technology-enhanced curricula in early childhood education to strengthen foundational math skills. The findings also highlight the importance of providing targeted professional development to equip educators with effective strategies for implementing technology-based instruction. Overall, the study demonstrates the effectiveness of innovative teaching approaches preschoolers' mathematics achievement.

Keywords: early childhood education, educational technology, Collins curriculum, preschool learning

INTRODUCTION

In recent years, increasing attention has been given to the integration of technological tools in early childhood education, particularly as educators seek effective ways to support young children's cognitive development. Mathematics, a fundamental subject that plays a crucial role in fostering thinking and problem-solving skills, is often perceived as abstract and challenging by preschool-aged children. Traditional teaching methods, while valuable, often fail to fully address the developmental and learning needs of young children. This limitation has led educators to explore alternative strategies that foster engagement and promote deeper understanding (Duval, 1999). One such approach is the Collins Curriculum, which emphasizes developmentally appropriate practices, active learning, and conceptual understanding in mathematics instruction. When combined with educational technologies—such as PhET simulations and other interactive tools—this curriculum supports visual representations of mathematical concepts, facilitating children's mental construction of ideas (Scherer et al., 2019). These tools not only enhance comprehension but also promote the development of logical reasoning and critical thinking, skills essential for future academic success (Abd Algani, 2021).

In Jordan, the incorporation of educational technology into preschool classrooms is still a relatively recent endeavor. Despite existing research demonstrating the benefits of using digital technologies on learning outcomes (Papadakis et al., 2021; Spitzer & Musslick, 2021), there remains a gap in evaluating culturally relevant curricula and technologies in the context of Jordan. Furthermore, it is important to evaluate whether such interventions provide equitable learning opportunities across diverse student demographics. This study aims to evaluate the effectiveness of the Collins Curriculum, along with other technological aids, in improving preschoolers' understanding of mathematical concepts in Jordan. Specifically, it investigates whether the use of digital technologies enhances learning achievements compared to conventional teaching approaches and whether performance outcomes vary by gender (Lye & Koh, 2014). Through this inquiry, the research seeks to inform curriculum development, instructional design, and educational policy aimed at strengthening early childhood mathematics education (Al-Khateeb, 2018).

Study Significance

The research is of great importance as it offers practical recommendations for mitigating anxiety and improving the learning experience for children in Jordan by effectively implementing the Collins Mathematical Developmental Curriculum. The study seeks to broaden the scope of the existing curricula by integrating math concepts and process acquisition frameworks (Humaidat et al., 2021), hence making valuable contributions to early childhood education pedagogy (Duval, 2006).

Furthermore, the study presents a novel perspective on enhancing learning opportunities for children in the early stages of mathematical development. The findings are valuable for inspiring innovative solution designs aimed at educators seeking to move beyond traditional instructional methods. By creating engaging programs that integrate practical applications of mathematical concepts through e-learning technologies, educators can foster greater interactivity and efficiency in the learning process—making it more enjoyable and effective for young learners (Tuma, 2021).

Ultimately, this study's findings have the potential to significantly enhance the teaching and learning of mathematics for preschool children in Jordan. They provide a critical resource for educators aiming to modernize their instructional approaches, creating a more positive, dynamic, and effective educational experience for young learners.

Research Questions

This study seeks to answer the following three primary research questions:

RQ1 What is the impact of the Collins Curriculum on preschool children's performance across various mathematical sub-dimensions—such as balance law, arithmetic, integers, unit rate, number line, decimals, and equality—compared to traditional teaching methods?

RQ2 How do the mathematical sub-dimensions measured in this study differ among children, based on the average performances of both the experimental and control groups?

RQ3 Are there significant differences in children's performance between the experimental and control groups when considering demographic variables, such as gender?

LITERATURE REVIEW

Learning institutions all over the world are adapting to a more advanced technological framework. For example, Jordan is working to reform its educational framework to align with international standards while also advancing its national educational goals. Similarly, other developing countries are revising their educational policies to keep pace with global developments and avoid falling behind more developed nations. Jordan, as part of these efforts, is working with international partners such as UNESCO, UNICEF, and USAID to advance its educational practices.

The Fourth National Conference for the Development of Education marked a pivotal milestone in Jordan's educational reform efforts, emphasizing the importance of modernizing the curriculum and developing new textbooks. It called for more creativity in curriculum development through international benchmarking from the USA, UK, South Korea, Indonesia, and other countries. The objective of these recommendations was to incorporate the most effective strategies that have been successfully developed elsewhere and tailor them to fit Jordan's context (as cited in Jordanian Ministry of Education, 2020).

The National Curriculum Development Center in Jordan City was assigned the task of preparing and developing teaching and learning guides for preschool and elementary level science and mathematics for the year 2019. This project integrated the guidelines from the Collins Curriculum, which began operating in the 2019-2020 academic year. The Collins Curriculum is based in part on Marva Collins' philosophy of education, which postulates that children do not fail on their own. Rather, failure is rooted in the teaching system's incompetence. This philosophy calls for the provision of appropriate materials that emanate high-quality to aid in stimulating and developing mental powers (Collins & Tamarkin, 1990; Hollins,1982).

Arithmetic and mathematics instruction in the Collins Curriculum focuses on the development of logical thinking and involves children's mental activities through numbers, shapes, and symbols. The curriculum applies the Socratic Method in teaching to enhance reasoning as students are invited to look at problems from several angles. This method is considered very useful for the development of reasoning skills in young learners (Arab Organization for Education and Science, 2014).

As in other subjects, the teaching of science has advanced from low-order rote memorization to high-order critical thinking and problem-solving. Contemporary science curricula emphasize activities and approaches that are participatory and that capture children's interest. The Collins Curriculum endorses these modern educational philosophies by fostering participation and reflection while limiting homework and emphasizing learning through doing (Collins & Tamarkin, 1990).

Nonetheless, Collins Curriculum has faced some criticism, with some sidelining the theories as unworkable in Jordanian kindergartens. These critics argue that the curriculum lacks alignment with Jordan's educational philosophy, cultural values, and broader social studies context, including Islamic principles. Furthermore, critics contend that there is a lack of national research on the curriculum, an absence of a clear reform agenda, and insufficient evaluation of the relevance of curricular materials used in Jordanian textbooks. Moreover, critics argue that the curriculum may not effectively meet the needs of Jordanian children and falls short in incorporating global best practices in education.

Regardless of the criticism, the Collins Curriculum's core principles of nurturing and refining critical and logical reasoning skills, supporting active participation, engagement, and critique, are applicable in this study. This research aims to tailor these core principles to the Jordanian context by developing educational software specifically designed to teach mathematics at the middle school level in Jordan. In conclusion, the Collins Curriculum and other recent educational reforms have been recognized in the literature for supporting the global movement toward enhanced student engagement and learning. However, it is essential to consider the local context—particularly socio-cultural values and the educational ethos—when adopting and implementing such curricula and strategies.

Problem Statement

The curricula of Jordan once held unrivalled importance in the Arab world during the 20th century, and several countries viewed Jordan as a model for curriculum development (Al-Na'was, 2010). The country's ability to develop new solutions to address emerging educational issues has, however, been hampered by a lack of coherent teaching policies and an overly reductionist approach to complex subjects, especially those demanding higher-order thinking skills. These challenges have hindered the introduction of essential concepts, such as the early teaching of advanced mathematical ideas to preschoolers.

The implementation of innovative curricula like the Collins Curriculum has encountered challenges within the Jordanian educational system due to a lack of coherence in educational policies and insufficient teacher preparedness. These challenges, which were made more challenging during the Covid-19 pandemic, have hindered the effective integration of such curricula into the education system. This study seeks to fill those gaps by investigating how the Collins Curriculum impacts the teaching of mathematics to young learners in Jordan.

The Collins curriculum is rooted in the Structural Learning Theory (SLT), which argues that knowledge is gained through hierarchical levels. SLT promotes systematic reasoning and problem-solving, facilitating the development of complex mathematical concepts in a structured manner (Barber, 2012). This approach supports the design of progressively scaffolded learning activities that are tailored to the learner's level of understanding, particularly during the foundational stages of mathematical development (Shute et al., 2017).

Mathematical Concepts in Early Education

Learning math concepts in early childhood enhances children's chances of success in future levels of education and in understanding more advanced mathematics. According to Alkouri (2022a), these early concepts are foundational for higher-level mathematical understanding; however, teaching them can be quite challenging. It is therefore essential to employ effective strategies or methods that support children's comprehension of these ideas and facilitate the development of more advanced strategies as their mathematical thinking matures (Lindquist & Gates, 1994).

Alkouri (2022b) also notes that some children struggle with the developmental skills of imatination and problem-solving, which are crucial to understanding mathematics. This supports the argument for promoting an engineering mindset and nurturing an early interest in mathematics to foster innovation and creativity in learning (Banks & Barlex, 2020). Integrating these elements can lay a strong foundation for mathematical learning and problem-solving (Laurent et al., 2022).

Teachers' Motivation and Role in Mathematics Acquisition

Mathematics instruction is most effective when it is integrated with other curriculum areas rather than taught in isolation, as emphasized by Kuennen et al. (2020). This interdisciplinary approach fosters an understanding of how to draw connections between concepts and combine them to generate innovative solutions to problems (Scherer, 2016).

Teachers who have this ability can approach problem-solving in creative and original ways, which in turn increases students' motivation and enjoyment of mathematics (Fuchs et al., 2003).

Besides teaching mathematical concepts, teachers also play a vital role in supporting students' self-esteem and perseverance. They help learners reframe their understanding of failure, celebrate progress and effort, and value the learning process rather than focusing solely on outcomes. Encouraging cooperation over competition is crucial and foundational to young learners' success..

Benefits of the Collins's Curriculum

The Collins's Curriculum incorporates new approaches that will improve critical thinking and logical reasoning—skills that are increasingly valuable in the 21st century. By connecting mathematical concepts to children's everyday experiences, the curriculum increases both the relevance of learning and student engagement (Collins & Tamarkin, 1990). One major change in the Jordanian context is the use of Arabic numerals instead of Indian ones, which facilitates the teaching of mathematics concepts to young learners (Ministry of Education, 2020).

The curriculum is also based on Structural Learning Theory (SLT), which proposes that learning is achieved through the building up of concepts. This theory encourages teachers to scaffold children's learning by gradually introducing more advanced concepts and building on what the learners already know (Barber, 2012). Such an approach permits establishing skills with arithmetic and number lines before addressing more complex concepts like unit rates and equality (Calao et al., 2015).

The application of the SLT can further be illustrated in the curriculum's application of Socratic questioning, which helps children consider different angles and further deepens their understanding of mathematical concepts. This is meant to enhance reasoning and promote logical thinking, which are crucial for success in future academic work (Drot-Delange et al., 2019).

The development of the Collins Curriculum was initiated in response to global assessment data revealing a concerning decline in academic performance in Jordan, particularly in mathematics and science (Spitzer & Musslick, 2021). Based on these results, the Ministry of Education (2020) attempted to reform the educational system by adopting a curriculum that focuses on critical thinking and problem solving. HarperCollins was later awarded the project in a competitive tendering process to design a curriculum informed by the educational philosophy of Marva Collins, aimed at strengthening the foundations of mathematics education in early childhood (Ghanbari & Shariatmadari, 2011). **Figure 1** depicts key systemic issues, such as policy

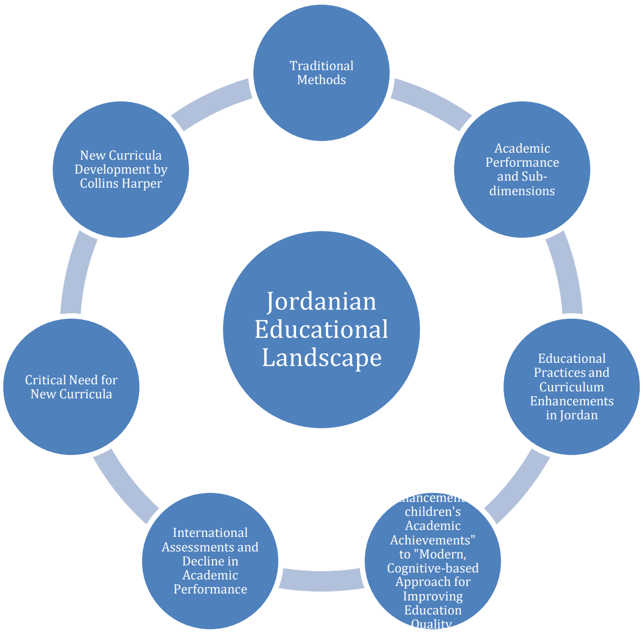

Figure 1. Challenges in the Jordanian Educational Landscape (Source: Authors' own elaboration)

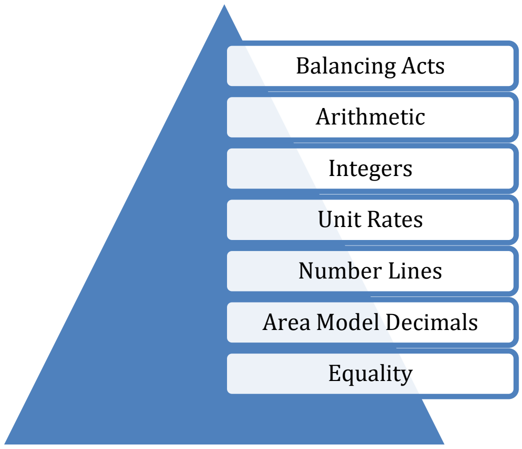

Figure 2. Hierarchical structure of mathematical sub-dimensions in the Collins Curriculum (Source: Authors' own elaboration)

inconsistencies and curriculum gaps, that necessitated the adoption of the Collins Curriculum to address educational challenges in Jordan.

Study Focus and Research Aims

This study explored two key aspects:

1. **Statistical differences in academic performance**: The first aim was to determine whether there were statistically significant differences (at a significance level of $\alpha \leq 0.05$) between the performance of the experimental group, which used the Collins Curriculum, and their peers who followed traditional teaching methods. These differences were analyzed across various academic performance dimensions, with a particular focus on mathematical sub-dimensions such as *Balancing Acts*, *Arithmetic*, *Integers*, *Unit Rates*, *Number Lines*, *Area Model Decimals*, and *Equality*.
2. **Variations in mathematical sub-dimensions**: The second aim was to examine whether there were significant disparities in children's performance in the mathematical sub-dimensions described above, following a post-assessment at the preschool level.

These research aims form the foundational framework for this study, offering valuable insights into the effectiveness of the newly developed curriculum compared to traditional teaching methods. The findings have the potential to inform and enhance educational practices in Jordan, particularly in the context of preschool mathematics education (Grover & Pea, 2013).

The mathematical sub-dimensions described above (e.g., Balancing Acts, Arithmetic) reflect the hierarchical approach of the Collins Curriculum, which aligns with Structural Learning Theory (Barber, 2012). For instance, foundational concepts like *Arithmetic* provide the base for more complex concepts such as *Equality*, ensuring a scaffolded progression of learning. **Figure 2** illustrates this sequential learning structure, which emphasizes building knowledge from simple to more advanced concepts.

Table 1. Demographic characteristics of the study sample (N = 60)

Variable	Category	Frequency	Percentage
Group	Experimental	30	50%
	Control	30	50&
Gender	Male	26	43.3%
	Female	34	56.7%

Table 2. Comparison of major curricular themes of PhET simulations and collins curriculum

Curricular Theme	PhET Simulations	Collins Curriculum	Rationale for Integration
Critical Thinking	Encourages exploration and hypothesis testing (e.g., adjusting variables in "Balancing Act").	Promotes Socratic questioning to challenge assumptions and deepen understanding.	PhET's interactive exploration complements Collins' questioning to enhance analytical skills.
Logical Reasoning	Provides visual feedback to deduce relationships (e.g., number lines for integer operations).	Emphasizes logical problem-solving through structured dialogue and reflection.	PhET's feedback reinforces Collins' focus on logical deduction in real-time problem-solving.
Active Engagement	Requires student interaction with simulations to manipulate and observe outcomes.	Focuses on active student participation rather than passive learning.	PhET's hands-on activities align with Collins' active learning philosophy.
Conceptual Understanding	Offers dynamic representations of abstract concepts (e.g., unit rates via simulations).	Builds knowledge hierarchically using scaffolding and real-world applications.	PhET's visual tools support Collins' scaffolding approach to master complex concepts.
Problem-Solving	Challenges students to solve problems through trial and error (e.g., balancing equations).	Encourages students to tackle problems from multiple perspectives.	PhET's trial-and-error environment mirrors Collins' multi-perspective problem-solving.

In **Figure 2** and **Table 2**, the pyramid illustrates the scaffolded progression of mathematical concepts evaluated in the study, starting with foundational skills (e.g., Arithmetic) and advancing to higher-order concepts (e.g., Equality), consistent with Structural Learning Theory.

METHODOLOGY

This kindergarten-based study was conducted in a preschool located in the Irbid Governorate, which was deemed an optimal setting for achieving the study's objectives. The research design encompassed all relevant aspects of early childhood education to provide a comprehensive understanding of the issue under investigation. To minimize potential teacher-related bias, the influence of the teacher was controlled during the formation of the experimental and control groups.

In the experimental group, children were taught using educational assistive technologies, while the control group received instruction through traditional teaching methods. From the preschool population, 60 children were randomly selected and evenly distributed between the two groups. The sample included slightly more females (53.4%) than males (46.6%), ensuring gender representation and supporting the validity of the findings across both genders. **Table 1** presents the demographic information of the participants, including sex, group assignment, and membership in either the experimental or control group.

Variable Analysis

Irbid Governorate was selected as the site of the study because of the researcher's understanding of the culture, economics, society, and context of this area. Such understanding helped the researcher to manage multiple environmental and demographic variables. The researcher made sure that the content was similar for both the experimental and control groups, and both groups were given the same number of activities.

Study participants were aged 4 to 6 years, so that they met the criteria as well as reducing age bias. Moreover, participants' social and economic status was also tracked to prevent confounding variables, thereby ensuring that the groups were comparable. Data collection and analysis commenced in the first academic term of the 2021-2022 academic year, which was also the official start of the research process.

Research Instruments

In this study, two sets of lesson plans were prepared based on the Collins Curriculum and developed according to the Structural Learning Theory (SLT). SLT focuses on how knowledge is built in a hierarchy, and this was particularly evident in the arrangement of mathematical concepts. The lesson plans started from the lower-level sub-dimensions of Arithmetic (addition and subtraction), progressing to more advanced constructs such as Unit Rates and Equality.

This approach helped children grasp the basic concepts first before going on to the more advanced ones, which was in line with SLT's scaffolding principles (Barber, 2012).

As a part of supporting the sequential development of concepts, PhET simulations were employed. These simulations helped students interact with mathematical concepts in a fun, engaging, and controlled environment. For instance, "Balancing Act" helped students learn the concept of Equality by having them balance a seesaw, which reinforced the concept of equilibrium in

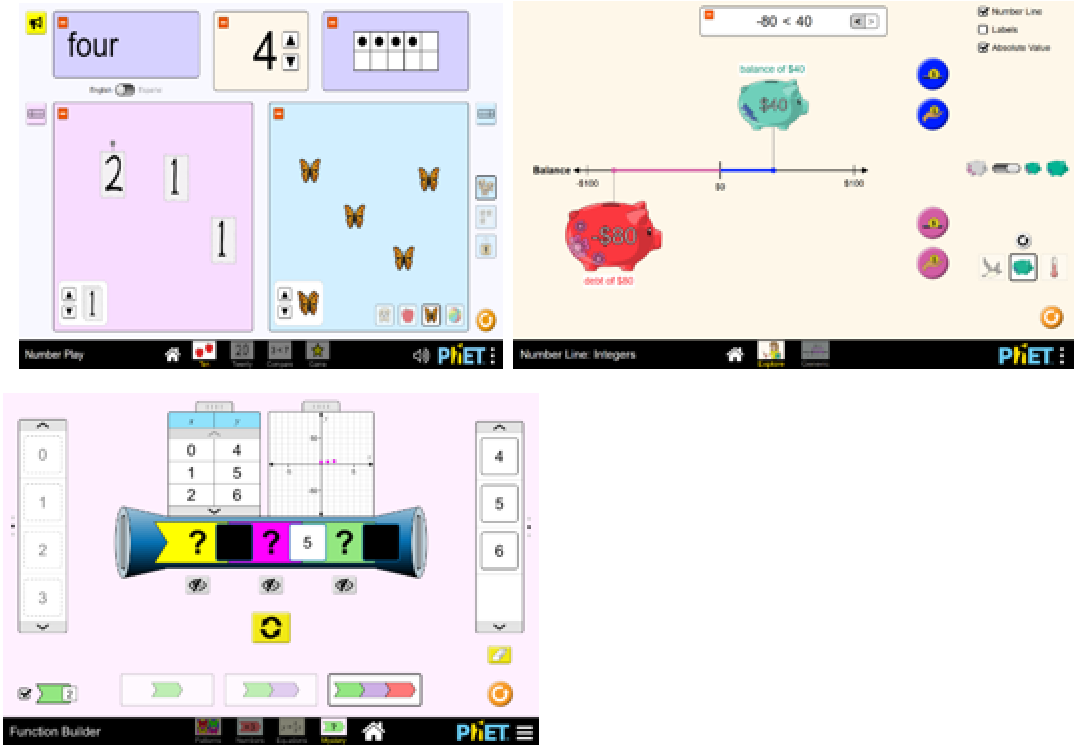

Figure 3. Interactive simulations: Number play, number line: Integers, and function builder (Source: Authors' own elaboration)

equations. Also, the "Number Line: Integers" simulation helped children learn about integers by having them plot numbers on a number line, which follows SLT's scaffolding principle.

The use of PhET simulations is aligned with the Collins Curriculum's focus on developing reasoning, higher-order thinking, and problem-solving skills. These simulations enabled students to test hypotheses, observe their outcomes, and strengthen learning through trial, error, and feedback which was provided instantly. The use of these tools helped increase students' understanding of the subject matter while also ensuring compliance with SLT's sequential principles of learning.

Evaluation and Assessment

The evaluation was designed to assess children's comprehension of the mathematical concepts taught through the Collins Curriculum. To ensure developmental appropriateness, photographs directly related to mathematical ideas were incorporated into the assessment tools. These visual aids supported a more conceptual evaluation of children's problem-solving abilities. Additionally, PhET simulations were used to provide interactive and visually rich representations, promoting deeper engagement with the content.

This evaluation approach aligned with the active, student-centered teaching methods advocated by Collins, fostering a more engaging and effective learning environment for preschoolers. **Figure 3** displays one of the PhET simulations that was central to the study's methodology. These simulations played a key role in enhancing preschool children's understanding of mathematical concepts by offering dynamic, hands-on learning experiences consistent with both Structural Learning Theory and the pedagogical foundations of the Collins Curriculum.

Pilot Study

The pilot study involved interviews with 15 kindergarteners, selected to represent both genders and include children with varying levels of familiarity with the subject matter. The goal was to test the tools and determine how long it would take the children to complete the tasks.

The timing of the tasks revealed that the first participant completed the tasks in 28 minutes, while the last completed them in 32 minutes, resulting in an average completion time of approximately 30 minutes. This helped establish a reasonable estimate for the time required for the full assessment during the actual study.

Validity and Reliability

To ensure the validity of the tools, a team of 12 expert evaluators with backgrounds in preschool education, teaching methodologies, educational technology, and curriculum design was assembled. These evaluators were well-versed in the Collins Curriculum and tasked with reviewing the principles of the test and the educational software in relation to the mathematical concepts being assessed. Based on their feedback, the researcher made necessary modifications to the evaluation tools to ensure alignment with the objectives of the study.

For the reliability assessment, the same group of 15 preschool children (ensuring both genders were represented) was reassessed using the newly developed questionnaire and software. The reliability of the questionnaire was evaluated using

Table 3. Mean and standard deviations for each concept in Collins' math curriculum

Dimensions	Groups	Mean	Standard Deviation	Standard Error
Balancing Act	Experimental	2.83	0.343	0.165
	Control	1.59	0.379	0.157
Arithmetic	Experimental	3.15	0.732	0.151
	Control	1.47	0.921	0.152
Integers	Experimental	2.81	0.779	0.183
	Control	1.70	1.142	0.184
Unite Rates	Experimental	3.08	1.169	0.262
	Control	1.19	0.839	0.263
Number Line	Experimental	2.37	0.741	0.151
	Control	1.46	0.893	0.152
Area Model Decimals	Experimental	3.31	0.887	0.169
	Control	1.59	1.012	0.182
Equality	Experimental	2.86	0.742	0.178
	Control	1.48	0.912	0.177
Total	Experimental	20.39	2.589	0.511
	Control	10.57	3.103	0.513

Cronbach's alpha, which is a measure of internal consistency. The resulting Cronbach's alpha value for the questionnaire was 0.88, indicating high reliability (values above 0.85 are considered excellent). Similarly, the reliability of the educational software was tested, yielding a coefficient of 0.82, which falls within the acceptable range (greater than 0.7).

These findings confirm that both the questionnaire and the software are reliable tools for assessing preschool children's understanding of the mathematical concepts embedded in the Collins Curriculum, ensuring consistency and effectiveness in evaluating the targeted learning outcomes is provided in **Table 3**.

RESULTS AND DISCUSSION

Results of the First Question

The analysis related to the first research question aimed to determine whether statistically significant differences existed in children's performance across selected mathematical sub-dimensions—specifically those represented by diagrams of towers, pyramid patterns, and step patterns. The results revealed the following:

There were no statistically significant differences ($p \geq 0.05$) between the mean scores of the experimental group, which used educational software, and the control group, which received traditional instruction. This finding held across multiple sub-dimensions, including Balancing Act, Arithmetic, Integers, Unit Rate, Number Line, Area Model, Decimals, and Equality.

A comprehensive evaluation of the post-assessment data—including means, adjusted means, standard deviations, achievement levels, and results from the Collins Developmental Mathematical Concepts Test—reinforced these findings.

In summary, the data indicate no meaningful performance differences between the two groups. This suggests that the educational software used in the experimental group did not result in significantly greater improvements in mathematical understanding compared to traditional teaching methods.

These results show differences in mean performance across the sub-dimensions and overall scores of the Collins developmental mathematics curriculum between the experimental and control groups, with the experimental group showing marginally higher performance.

To assess the statistical significance of these differences at the predetermined significance level ($\alpha \leq 0.05$), the researcher utilized Multivariate Analysis of Covariance (MANCOVA), accounting for participants' initial scores before the program commenced. The results are summarized in **Table 4**.

The analysis of the average performance for both the control and experimental groups indicated statistically significant differences at the set significance level ($\alpha \leq 0.05$) for every dimension and overall task score. These findings suggest that the Collins preschool curriculum had a noticeable positive impact, especially when delivered through educational software, on the teaching and learning of mathematical concepts. The performance of the experimental group, which used educational software, was significantly higher than that of the control group in all the tests of mathematical concepts.

These findings support the conclusions of Spitzer and Musslick (2021), who reported that educational software dramatically improves children's cognitive understanding of mathematical concepts. Educational software aids in forming accurate mental images of mathematical concepts and supports the shift from conventional to constructivist teaching approaches, which may improve motivation and interest among learners (Nelson, 2009).

As Ghasem and Sleymani (2016) noted, the development of mathematical concepts depends on the environment and mental imagery. Additionally, Papadakis et al. (2021) and Ghose and Kundu (2016) highlighted that educational software captures children's attention with audiovisual elements, which enhance learning motivation and enjoyment.

Table 4. MANCOVA analysis of the Collins developmental mathematics curriculum between experimental and control groups

Post Variable	Source of the Variable	Sum of the Squares	Freedom Degrees	Means of the Squares	(F) Statistical Value	Sig Value	Effect of R^2 Value
Balancing Act	Pre-variable	0.001	1	0.019	0.001	0.973	
	The group	16.020	1	16.022	22.965	0.000	0.273
	The error	41.802	62	0.623			
	Total	450.0	72				
Arithmetic	Pre-variable	0.027	1	0.027	0.042	0.839	
	The group	39.380	1	32.381	51.789	0.000	0.461
	The error	38.071	62	0.628			
	Total	448.0	72				
Integers	Pre-variable	0.018	1	0.16	0.020	0.889	
	The group	0.329	1	8.328	9.321	0.002	0.134
	The error	59.508	62	0.893			
	Total	429.0	72				
Unite Rate	Pre-variable	0.390	1	0.389	0.203	0.653	
	The group	50.749	1	50.748	26.390	0.000	0.303
	The error	117.294	62	1.924			
	Total	429.0	72				
Number Line	Pre-variable	5.470	1	3.471	5.392	0.052	
	The group	6.143	1	6.142	3.545	0.003	0.136
	The error	39.256	4	0.648			
	Total		733400				
Area Model Decimal	Pre-variable	0.142	1	0.139	0.160	0.691	
	The group	46.784	1	47.784	55.491	0.000	0.477
	The error	51.538	62	0.859			
	Total	539.0	72				
Equality	Pre-variable	0.061	1	0.059	0.063	0.804	
	The group	88.467	1	28.449	29.681	0.000	0.328
	Total	443.0	72				
Total Degree of the Test	Pre-variable	16.713	1	16.724	2.262	0.139	
	The group	438.242	1	1185.253	160.441	0.000	0.726
	The error	452.632	63	7.386			
	Total	19118.0	72				

Results of the Second Question

The analysis of the second research question found no relevant differences between the experimental group using educational software and the control group taught using conventional methods. This finding holds for both the overall score and individual scores across all sub-dimensions of mathematics, including Balancing Act, Arithmetic, Integers, Unit Rate, Number Line, Area Model, Decimals, and Equality, tested at $\alpha \leq 0.05$.

A summary of the means and standard deviations for the post-assessment scores across each mathematical dimension, as well as the total score, is provided in **Table 5**.

Result of the Third Question

The analysis of the third research question reveals noticeable differences between male and female participants in their mean scores across the sub-dimensions and overall proficiency in the mathematical concept test, as shown in **Table 5**. However, Multivariate Analysis of Covariance (MANCOVA) results indicated that gender did not significantly influence the achievement of mathematical skills.

The analysis presented in **Table 6** indicates that gender did not play a significant role in differentiating any of the sub-dimensions or the total score on the overall post-test results. This conclusion is supported by the Wilks' Lambda value of 0.753 and a significance level (σ) of 0.462, which exceeds the threshold of $p > 0.05$, indicating non-significance according to the criteria of the MANCOVA test.

These findings appear to be reasonable, as both male and female participants were taught under identical and consistent educational conditions throughout the study. The two kindergarten groups were also comparable in terms of initial abilities and developmental levels, as all participants were between five and six years old. Therefore, any observed differences in performance are likely attributable to factors other than gender.

The textbooks and instructional materials used in the study were developed based on principles that accounted for the developmental needs of all children, regardless of gender. The educational software sessions were also designed to be gender-neutral, which supports the absence of statistically significant differences in mean scores between male and female participants.

Similar outcomes have been reported in earlier research by Swearing (2011) and Papadakis (2021), both of whom found no gender-based differences in educational achievement. However, the results of the present study differ from those of Kappers (2009), who did report gender-related disparities in academic performance.

Table 5. Mean and standard deviation of post-achievement test scores for Collins' curriculum

Dimension	Gender	Mean	Standard Deviation
Balancing Act	Males	2.23	1.057
	Females	2.29	1.211
Arithmetic	Males	2.41	1.22
	Females	2.10	1.12
Integers	Males	2.51	1.163
	Females	1.94	1.132
Unite Rate	Males	2.26	1.170
	Females	0.04	1.113
Number Line	Males	2.07	0.715
	Females	1.88	1.021
Area Model Decimals	Males	2.32	1.252
	Females	2.53	1.271
Equality	Males	2.19	1.247
	Females	2.28	1.123
Total	Males	16.06	5.124
	Females	15.04	6.178

Table 6. Results of the multivariate analysis of covariance (MANCOVA)

Variable	Welex Lambda Value	F Value	Significance
Gender	0.753	1.243	0.462

CONCLUSION

This study aimed to evaluate the effectiveness of educational software, based on Collins' developmental mathematics curriculum, in enhancing Jordanian preschool children's understanding of mathematical concepts. The findings demonstrated statistically significant differences between the experimental and control groups across all sub-dimensions of mathematical proficiency, with the experimental group—who engaged with the educational software—consistently outperforming their peers. These results add to the growing body of evidence supporting the positive impact of technology-assisted learning on young children's cognitive and academic development, particularly in mathematics (Hsiao & Su, 2021).

While initial descriptive statistics suggested only marginal differences between the groups, multivariate analysis (MANCOVA) confirmed these differences to be statistically significant ($\alpha \leq 0.05$). The use of educational software appears to enhance conceptual understanding by offering interactive and visual representations that help children form accurate mental models of mathematical concepts. These findings are consistent with previous research (Papadakis et al., 2021; Spitzer & Musslick, 2021), which highlights the role of digital tools in fostering cognitive engagement and improving learning outcomes in early childhood education.

The study further found that the Collins Curriculum supports equitable learning outcomes across genders, as no significant differences in mathematical performance were observed between male and female participants. This supports earlier findings (Papadakis, 2021; Swearing, 2011), though it contrasts with Kappers (2009), who reported gender-based disparities in academic achievement. These divergent findings underscore the need for continued investigation into the socio-contextual and methodological factors that influence learning (Perkins & Salomon, 1992).

In conclusion, this research demonstrates the potential of educational software to strengthen mathematical skills in preschool-aged children. Integrating technology thoughtfully into early childhood education enhances engagement, conceptual understanding, and academic success. While the results are promising, longitudinal studies are needed to explore the long-term impact of technology-based instruction and how interactive elements shape learning trajectories.

IMPLICATIONS AND RECOMMENDATIONS

The implications of this study are particularly relevant for educators in Jordan and internationally. It emphasizes the importance of incorporating educational technologies—such as PhET simulations—into early mathematics instruction, providing young learners with abstract yet accessible representations that support deeper understanding.

In light of the findings, it is imperative that Jordanian educators work toward integrating educational technologies into foundational curricula, particularly in mathematics. The rapid advancement of technology in education has become a critical component of contemporary early childhood learning frameworks, and policymakers should recognize it as such.

Moreover, the absence of sociocultural performance gaps within the Collins Curriculum suggests that it promotes equitable learning opportunities, laying a strong foundation for inclusive education from early childhood. This is especially valuable for initiatives aimed at bridging demographic disparities in educational achievement and access.

Accordingly, the Jordanian Ministry of Education and other relevant stakeholders are encouraged to:

- Prioritize the integration of educational technology within preschool mathematics curricula.
- Design and implement comprehensive professional development programs for early childhood educators that focus on the effective use of technology.
- Provide teachers with the technical and instructional skills necessary to effectively transform traditional lessons into interactive, digitally-enhanced learning experiences.

A sustained investment in teachers' digital competencies will not only promote innovative teaching practices but also foster engaging and effective learning environments that can better prepare children for future academic success

Future Research Directions

While this study offers valuable insights into the integration of technology in early childhood education, it also identifies several promising areas for future inquiry.

Future research should investigate the application of the Collins Curriculum and similar educational software across a broader range of subjects, such as science and literacy, to evaluate their adaptability and effectiveness beyond mathematics. Additionally, expanding the scope of studies to include diverse cultural and socio-economic contexts, particularly in regions outside Jordan, would strengthen the generalizability of the findings and reveal contextual factors that influence the implementation and outcomes of technology-enhanced curricula.

Longitudinal studies are particularly needed to assess the long-term effects of technology-integrated curricula like Collins on children's academic achievement, engagement, and sustained interest in learning. Such research could provide critical insights into the long-term benefits and potential limitations of early exposure to educational technology.

Future studies could also explore specific design features of educational software—such as levels of interactivity, feedback mechanisms, personalization— to identify which elements most effectively support early learning. These insights could inform the development and refinement of digital tools to better meet the needs of young learners.

In conclusion, this study highlights the promise of integrating the Collins Curriculum with educational technologies, such as PhET simulations, to enhance mathematical learning outcomes among preschool children in Jordan. However, ongoing and diversified research is essential to fully understand, optimize, and scale its impact across varyious educational contexts and learner populations.

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