



The Level of Conceptual and Procedural Knowledge in Mathematics and Its Relationship to Creative Thinking among Gifted Students

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The present study aimed at measuring the levels of conceptual and procedural knowledge in mathematics among seventh grade gifted students in King Abdullah II schools for Excellence. In addition, this study aimed to investigate the association between the levels of conceptual and procedural knowledge on one hand and the level of students' creative thinking on the other hand. A sample of 224 seventh grade students were recruited in this study. To collect data, the researcher used a conceptual knowledge achievement test (20 items), a procedural knowledge skills test (20 items) and Torrance Creative Thinking Test (TCTT). The results revealed the seventh-grade gifted students had a moderate level of conceptual knowledge and a moderate level of procedural knowledge. In addition, it was found that there is a statistically significant positive correlation between conceptual knowledge and creative thinking and a statistically significant positive correlation between procedural knowledge and creative thinking. The study concluded that both conceptual and procedural knowledge are significantly and positively associated with gifted students' creative thinking. The study recommended adoption of more recent teaching strategies to improve the levels of both conceptual and procedural knowledge, in addition to the level of creative thinking among gifted students in Jordan.

Keywords: conceptual knowledge, procedural knowledge, creative thinking, gifted students, mathematics

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INTRODUCTION

Contemporary developments have imposed a change in the general perspective of mathematics education (Ernest et al., 2016). The goal of teaching mathematics is no longer merely developing the skills of performing arithmetic operations, or solving abstract problems that are not related to reality without links between them and this reality according to the traditional view (Kilpatrick, 2020; Al-Nofli, 2022). Rather, the goal of mathematics education has become to provide learners with thinking and correct understanding, including developing their abilities to solve the problems they face in their environment (Birgili, 2015; Wikanta & Susilo, 2022). The educational literature agrees on the importance of the teacher's role in teaching, and that it is the ruling factor in the success or failure of the teaching and learning processes (Lawrence & Tar, 2018), as the teacher's competence depends to a large extent on his knowledge and skills in teaching, and the question became: "What makes someone a good teacher?" Subject to discussion among those interested in teacher preparation and professional development (Bakhmat et al., 2019; Alarabi et al., 2022).

In this context, Lin et al (2018) assumed that a good teacher is an essential element in human success in any profession, and that automatic computers did not replace the teacher, and television systems were not able to reproduce teachers and distribute them to classes, and they will not be controlled by written lessons or control them, and no one could overtake them. Although researchers play a positive role in society, only teachers are responsible for making knowledge and skills accessible to others. to get the most out of the educational system (Van der Heijden et al., 2015); It takes a better job of preparing and evaluating the performance of teachers at all levels and giving them the recognition, they deserve (Niemi, 2016).

School mathematics curricula focus on the mathematical structure, and look at the mathematical content as a tightly interconnected and communicative building, and the basic unit of construction is the concepts (Jeannotte & Kieran, 2017; Kharisudin, 2022). Concepts are "the most important forms of mathematical knowledge and the basis upon which the rest of its forms depend on principles, laws and theories, which give them their flexibility and help organize and comprehend them" (Carrillo-Yañez et al., 2018). The concepts are more related to the student's life. If the student perceives the mathematical concepts and their meanings, the mathematics becomes more meaningful and clearer and more understandable (Gravemeijer et al., 2017).

The term Conceptual Knowledge is "one of the modern terms that appeared in education in the last decade of the twentieth century and the beginning of the twenty-first century, which came in line with the nature of this era - the era of the knowledge society - and more specifically the term appeared with the decline of the behavioral theory from the educational field" (Rittle-Johnson & Schneider, 2015); To be replaced by newer theories, and the subsequent departure from the framework of Bloom's Taxonomy, which resulted in the emergence of modern classifications of educational objectives such as Anderson and Krathwohl (2001), which classified knowledge into four categories: factual, conceptual, and procedural. Knowing what is beyond knowledge (Wilson, 2016).

Yurniwati & Soleh (2019) indicated that mathematical knowledge is classified into two types of knowledge: conceptual knowledge and procedural knowledge. Pre-existing, conceptual knowledge includes understanding mathematical ideas and procedures, and knowledge of basic facts in arithmetic. Rahman (2019) reported that students possess conceptual knowledge when they are able to define and apply principles, know and apply facts and terms, and are able to identify similarities and differences between different concepts.

Majeed et al (2010) considered that conceptual knowledge includes the relationships that make all parts of mathematical knowledge, including facts, generalizations, principles, laws and mathematical rules linked to each other by a network of close links, and conceptual knowledge includes the production of examples of mathematical concepts, and the use of shapes and graphics to express It also includes realizing the integration and interdependence between the main and sub concepts, defining the principles, laws and rules related to the mathematical concepts and explaining the relationship between them.

Procedural knowledge expresses the skill to implement procedures in a flexible, accurate, effective, and appropriate manner (Rittle-Johnson & Schneider, 2015). Algorithms are used to express mathematical ideas and concepts, understand the relationships between written and mental performance, as well as link mathematical operations and procedures to life situations, and employ them in various fields of mathematics (López et al., 2022).

Those with the procedural behavioral attitude claim that thinking is a mental procedural process initiated by the individual, and he receives a response to it, or, an answer to a question that the individual was searching for (Watson, 2017). Through thinking, a person can learn new skills, experiences, and knowledge, in different ways. Among the patterns of higher thinking: creative thinking that requires highly efficient mental abilities, especially in finding unusual solutions and ideas (Ganiev & Tashev, 2021)

It can be said that creative thinking is a complex and purposeful mental activity, directed by a strong desire to search for previously unknown solutions and results (Lombardi et al., 2022). Looking at the familiar in an unfamiliar way, then developing it into an idea, then design, then creativity that can be applied and used (Al-Mahasneh, 2018). Sitorus (2016) indicated that it is a mental process that aims to collect facts, see materials, experiences, and information in new structures to illuminate the solution (Sitorus, 2016).

Research Questions

The present study sought to answer the following research questions

1. What is the level of conceptual knowledge and procedural knowledge among seventh grade gifted students in Abdullah II schools for Excellence in Jordan?
2. What is the level of creative thinking among seventh grade gifted students in Abdullah II schools for Excellence in Jordan?

3. Is there any statistically significant association between conceptual knowledge and procedural knowledge and creative thinking among seventh grade gifted students in Abdullah II schools for Excellence in Jordan?

Statement of Problem

The researcher has noticed that there is a great lack of studies that investigate the level of procedural and conceptual knowledge in mathematics and its relationship to the level of creative thinking among gifted students, as most of the available studies are a quantitative assessment process for the levels of conceptual and procedural knowledge only or an assessment of the level of creative thinking and its relationship with other variables. The problem of the study also lies in the importance of creative thinking for gifted students, as creative thinking plays an important role in the student's social, educational and personal life, as it is considered cognitive thinking that occurs within the student's cognitive system, and is directed to solving an educational or life problem, to reach a state of emotional and cognitive balance. Therefore, students, especially the gifted, must train and practice their skills to overcome the various educational and life problems that they may face. To sum up, there is a significant research gap represented by the absence of research studies investigating the association between conceptual and procedural knowledge and the level of creative thinking among gifted students in Jordan.

METHOD

Research Design

This study adopted the correlational cross-sectional research approach. This approach was chosen to suit the nature of the study problem that aim to quantitatively correlate the level of conceptual and procedural knowledge in mathematics to the level of creative thinking among gifted students (Pandey & Pandey, 2021).

Research population

The population of the present study was all seventh-grade gifted students from King Abdullah II schools for Excellence in Jordan. The establishment of schools for distinguished students came as a lofty royal initiative of His Majesty King Abdullah II bin Al Hussein in the various governorates of the Kingdom, to provide an enriching educational pattern in an educational environment to prepare promising leaders in various disciplines. The first school of King Abdullah II School for Excellence was opened at the beginning of the year 2001/2002 school year in Al-Zarqa Governorate, and the opening of these schools continues to include all governorates of the Kingdom. Objectives of establishing King Abdullah II Schools for Excellence were to provide the distinguished with a solid theoretical background in basic knowledge at its mastery and development level, to provide the distinguished students with beneficial life skills related to science and technology, to develop the talents and creativity of the distinguished and to invest their energies to a maximum extent, to develop the personality of the distinguished by enhancing their confidence in him/herself and their abilities, developing their vision of the future and planning for it, developing the

distinguished to face the challenges they face in an applied manner, developing higher-order thinking skills and scientific techniques for the distinguished, developing the sense of belonging, providing new educational opportunities in which the distinguished practice methods of learning and teaching that achieve their talent and creativity.

Research Sample

The study sample consisted of 224 gifted students who were selected purposefully from the gifted students enrolled in seventh grade in King Abdullah II schools for Excellence in Jordan during the second semester of the academic year 2021/2022. The school year is divided into two semesters in the selected schools.

Research Instrument

After reviewing the previous studies and available literature related to assessing the levels of conceptual and procedural knowledge and assessing the level of creative thinking, the researcher prepared the following data collection instruments:

- A content analysis card that was used to analyze the content of the seventh-grade mathematics curriculum. The card was presented to a number of referees and experts in mathematics curriculum design and development in order to ensure its validity. The purpose of using this card was identifying the availability of the procedural knowledge and conceptual knowledge concepts in the seventh-grade mathematics curriculum.
- An achievement test to identify and assess the level of conceptual knowledge in mathematics among gifted students in the seventh grade.
- Skills test to identify and assess to how extent the seventh graders gifted students possess the procedural knowledge in mathematics.

Both tests used in this study were built based on the analysis of the mathematics curriculum designed for the gifted students in the seventh grade. The researcher determined the ratio of the conceptual knowledge and the procedural knowledge and determined the number of questions for each unit in the curriculum.

To ensure the validity of the achievement test and the skills test for the conceptual knowledge and the procedural knowledge, respectively, the researcher presented the test in its primary form to a number of referees and experts in mathematics education for intermediate stage. The final form of the knowledge test (both conceptual and procedural) consisted of 40 items distributed equally over the conceptual knowledge domain and the procedural knowledge domain.

The researcher used the pilot sample to determine the test time. A sample of 20 students were used as a pilot sample. The mean time between delivering the first test paper and the time of getting back the last test paper was calculated and found to be 120 minutes. To determine the level of both conceptual and procedural knowledge, a scale was used as following: Low (Less than 33%), moderate (33% to less than 66%) and high (66% or higher).

To ensure the reliability of the conceptual and procedural test, the researcher used the Pearson's correlation coefficient in order to check the internal consistency of the test items. It was found that all correlation coefficients, either between the items or between

the items and the total score, were statistically significant at 0.05. In addition, the researcher used the Kuder and Richardson equation to analyze the variance and it was found that the reliability coefficients for the conceptual knowledge test was 0.78, for the procedural knowledge was 0.74, and for the whole test was 0.79.

Creative thinking scale

To assess and measure the level of creative thinking among gifted students, the researcher used the Torrance Test of Creative Thinking (TTCT). A TTCT comprises of several simple sub-tests or tasks, which make up the overall test. The test material comprised of a verbal and non-verbal (figural) section. In the verbal section, there are generally seven verbal activities, as follows: Asking, guessing causes, guessing consequences, product improvement, unusual uses, and unusual questions and just suppose. These are scored on three metrics; fluency, flexibility and originality. On the other hand, the figural section focuses on a figural or nonverbal, also sometimes called pictorial, activities. There are three main figural activities, as follows: picture construction, picture completion, and lines/circles.

During these activities, the examinees will generally be provided with sheets of paper, which contain some form of abstract or incomplete symbols or shapes. The examinee will then be asked to make amendments or addition to the symbols or shapes in order to create something meaningful. These activities are scored on five metrics, as follows: fluency, flexibility, elaboration, abstractness of titles, and resistance to premature closure.

In this study, the Arabic version of the TTCT was used and it was validated in different studies and ensured for reliability in this study through administering the test to a pilot sample consisted of 20 students who were excluded from the study sample. The test-retest method was used in this study to ensure the TTCT reliability. A high reliability coefficient (0.81) was found for the TTCT in this study.

Data Analysis

The researcher the Statistical Package of Social Sciences (SPSS) (v. 26, IBM Corp, Chicago, IL, USA) to analyze the study results. The descriptive statistics such as frequencies, percentages, means and standard deviations were used to analyze the participants' scores in the conceptual and procedural knowledge tests. In addition, descriptive statistics were used to analyze the participants' responses to the creative thinking scale used in this study. Moreover, Pearson's correlation coefficient was used to assess the correlation between the level of procedural knowledge conceptual knowledge in mathematics and the level of creative thinking among enrolled seventh grade gifted students. A statistical significance threshold of ($\alpha \leq 0.05$) was used in this study.

FINDINGS

The results presented in table 1 show the conceptual knowledge scores of the study participants using the conceptual knowledge test that consisted of 20 questions. The

results showed that the enrolled students had a moderate level of conceptual level (59.3%). The results showed that the students had a moderate conceptual knowledge in unit rate lesson (65.1%), proportion lesson (61.9%), direct variation lesson (57.1%), inverse variation lesson (44.1%), and proportional division lesson (43.8%). However, a high level of conceptual knowledge was found to be in proportional relationships lesson (69.9%).

Table 1
Level of conceptual level among seventh grade gifted students (n=224)

Lesson	Number of basic mathematical concepts	Number of test items	Correct answers	% of correct answers	Incorrect answers	% of incorrect answers	Degree
Unit rate	6	4	583	65.1%	313	34.9%	Moderate
Proportion	4	3	416	61.9%	256	38.9%	Moderate
Proportional relationships	9	5	783	69.9%	337	30.1%	High
Direct variation	5	3	384	57.1%	288	42.9%	Moderate
Inverse variation	4	3	296	44.1%	376	55.9%	Moderate
Proportional division	6	2	196	43.8%	252	56.3%	Moderate
Total	34	20	2658	59.3%	1822	40.7%	Moderate

The results presented in table 2 show the procedural knowledge scores of the study participants using the procedural knowledge test used in this study. The results showed that the enrolled seventh grade gifted students had a moderate level of procedural knowledge (62.7%). The results showed that the participating students had a moderate level of knowledge in unit rate lesson (63.7%), proportion lesson (53.9%), proportional relationships lesson (65.6%), direct variation lesson (59.2%), and inverse variation lesson (60.4%). However, a high level of knowledge was found to be in proportional division lesson (75.7%).

Table 2
Level of Procedural Knowledge among seventh grade gifted students (n=224)

Lesson	Procedural knowledge items	Number of test items	Correct answers	% of correct answers	Incorrect answers	% of incorrect answers	Degree
Unit rate	6	4	571	63.7%	325	36.3%	Moderate
Proportion	5	4	483	53.9%	413	46.1%	Moderate
Proportional relationships	4	3	441	65.6%	231	34.4%	Moderate
Direct variation	5	3	398	59.2%	274	40.8%	Moderate
Inverse variation	2	3	406	60.4%	266	39.6%	Moderate
Proportional division	4	3	509	75.7%	163	24.3%	High
Total	26	20	2808	62.7%	1672	37.3%	Moderate

The results presented in table 3 showed the level of creative thinking among the enrolled seventh grade gifted students. The results showed that the participants had a mean score of (46.25 ± 7.38) on fluency domain, a mean score of (27.61 ± 4.22) on flexibility domain, a mean score of (20.41 ± 4.38) on originality domain and a total mean score of creative thinking (94.27 ± 9.86) .

Table 3
Level of creative thinking among seventh grade gifted students (n=224)

Skill	N	M±SD	Rank
Fluency	224	46.25±7.38	1
Flexibility	224	27.61±4.22	2
Originality	224	20.41±4.38	3
Total	224	94.27±9.86	

The results presented in table 4 show the Pearson's correlation coefficient between the enrolled seventh grade gifted students' scores of conceptual and procedural knowledges, and their scores on creative thinking scale. The results showed that conceptual knowledge was significantly associated with fluency ($r=0.351$, $p=0.000$), flexibility ($r=0.408$, $p=0.036$), originality ($r=0.226$, $p=0.000$) and with creative thinking as a whole ($r=0.398$, $p=0.000$).

In addition, it was found that the procedural knowledge was significantly associated with fluency ($r=0.218$, $p=0.029$), flexibility ($r=0.168$, $p=0.000$), originality ($r=0.430$, $p=0.000$) and creative thinking as a whole ($r=0.416$, $p=0.001$).

Table 4
Pearson's correlation coefficient between procedural and conceptual knowledge and creative thinking among seventh grade gifted children (n=224)

Variable	Fluency	Flexibility	Originality	Creative Thinking
Conceptual knowledge	$r=0.351^*$	$r=0.408^*$	$r=0.226^*$	$r=0.398^*$
	$P=0.000$	$P=0.036$	$P=0.000$	$P=0.000$
Procedural knowledge	$r=0.218^*$	$r=0.168^*$	$r=0.430^*$	$r=0.416^*$
	$P=0.029$	$P=0.000$	$P=0.000$	$P=0.001$

*Statistically significant at significance level ($\alpha \leq 0.05$)

DISCUSSION

The present study sought to assess the levels of both conceptual knowledge and procedural knowledge among seventh grade gifted students and identify its association to the level of creative thinking. The findings of the present study revealed that seventh grade gifted students had a moderate level of both conceptual and procedural knowledge. This result might be referred to the tendency of many mathematics teachers to use traditional teaching methods that focus only on procedures, and neglect to teach concepts; this creates difficulty for students when facing problems that require thinking skills, and weakens their positive attitude towards learning mathematics, and weakens the participation of these students in teaching and learning activities. The reason for focusing on the procedural aspect without concentrating on the conceptual structure may be due to the teacher, who often directs the focus of his students to perform arithmetic operations without focusing on understanding, and this in turn leads to an imbalance between procedures and concepts on which mathematics education is supposed to be built. This may be attributed to the failure of mathematics teachers and their students to have sufficient understanding of the nature and structure of mathematical knowledge, and this was confirmed by the results of research and studies conducted in this regard. It

means that schoolchildren reach the university level with mathematical experiences centered on procedural knowledge and little conceptual experience.

The previous finding is supported by the findings reported by Mutambara & Tsakeni (2022) who found that The knowledge of the student-teachers about mathematical concepts is very weak, and the student-teachers find great difficulties in understanding and comprehending concepts in the topics of numbers and operations such as the concept of fractions, as well as the concept of operations on them; As the concept of the process of dividing fractions and the concept of the process of multiplying them. However, Khan et al (2017) pointed that the evaluation strategies used in university education played a prominent and clear role in the conceptual weakness of student teachers; the strategies used in assessment place learners in a narrow circle of prepared situations for the procedural processes that they have learned and memorized. In addition, Hulse et al (2019) reported that students cannot deal with the mathematical problem when changing the wording of the question or idea or rearranging the phrases; Because understanding here fails them; Enhancing conceptual knowledge requires presenting learners with mathematical situations within new and diverse contexts, and using different images of mathematical concepts to deepen their understanding of these concepts, present them with unconventional issues, and help them solve these issues in creative and innovative ways. The enhancement of conceptual knowledge also makes it imperative for the assessment methods used to reflect this interest so that the student feels that without deep conceptual knowledge he will not obtain a high score on tests that reflect his academic achievement (Pitt & Norton, 2017).

Our findings suggested that both conceptual knowledge and procedural knowledge are significantly and positively associated to the level of creative thinking among the studied gifted students. This results might be referred to that conceptual knowledge contribute to the creation of learning for the learner, through the ability to link new information with the previous one to form concepts, and then conclude the rest of the components of generalizations, principles and laws, and employ them in new situations that help the learner's strength mathematically.

Modern educational theories such as Ozebl's theory emphasized the need for the student to be able to build primary and secondary mathematical concepts. The teaching of the new concept was associated with the student; by linking it to the previous concepts present in the cognitive structures in his mind, and working to rebuild and develop them during his growth.

Which contributes to its continuous rearrangement and organization according to new educational situations, and this helps to replace misconceptions with correct ones. Which is acquired in a cooperative and social environment through discussions and dialogues that take place between the teacher and the student on the one hand, and the student with his peers in the classroom in small working groups on the other.

The results of the current study are also attributed to the fact that the learner's acquisition of conceptual knowledge contributes to his ability to link between

mathematical concepts and ideas, and the acquisition of conceptual knowledge contributes greatly to the acquisition of procedural knowledge, as conceptual knowledge helps learners and facilitates the acquisition of algorithms, and works to guide learners to the correct methods in solving mathematical problems and problems, in addition to developing their abilities to invent new ways of solving. This result is confirmed by the findings reported by Levin (2018) who confirmed that the relationship between conceptual knowledge and procedural knowledge is bidirectional, meaning that each affects the other, so there must be a balance in the organization of conceptual and procedural knowledge.

Despite the significant findings reported in this study, still there are a number of limitations that might prevent the generalization of the study findings. A significant limitation is the sample of the study, as this study was performed over a sample of gifted students who might have a higher level of thinking skills. Therefore, the findings of the study might not be generalized over ordinary students with normal thinking skills. In addition, the psychometric properties of the data collection tools might vary among different settings due to difference in population characteristics.

CONCLUSION

The study concluded that seventh grade students in King Abdullah II schools for Excellence in Jordan had a moderate level of conceptual knowledge and the highest level of conceptual knowledge was in the domain of the proportional relationships whereas the lowest was in the proportional division domain. In addition, the study concluded that the students had a moderate level in the procedural knowledge and the highest level of procedural knowledge was in the proportional division domain whereas the lowest was in the proportion domain. Moreover, the study concluded that there was a significant association between the levels of students' conceptual and procedural knowledge and their level of creative thinking as the highest was between the procedural knowledge and the originality domain and the lowest was between the procedural knowledge and the flexibility domain.

RECOMMENDATIONS

Based on the findings of the study, the study recommends the policy makers and administrative authorities in Jordanian ministry of education to enhance the use and adoption of more recent educational strategies and means in order to improve the level of procedural and conceptual knowledge and the level of creative thinking among gifted students. In addition, the study recommends the curricula developers and designers to revise and improve the content of the mathematics curricula for the gifted students throughout adding a content that improves students' conceptual and procedural knowledge levels and exercises that improve their level of creative thinking.

CONFLICT OF INTEREST

No conflict of interest

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