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The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop higher-order thinking skills

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Abstract

This research aimed to identify the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop higher-order thinking skills (HOTS). To achieve the research objectives, a descriptive-analytical approach was adopted, and a questionnaire for teaching mathematics requirements needed to develop HOTS among intermediate school students was constructed. The questionnaire included 50 statements distributed into four dimensions: the requirements for teaching mathematics to develop: problem-solving skills, decision-making skills, critical thinking skills, and creative thinking skills. The questionnaire was administered to 136 intermediate school mathematics teachers. The results revealed that the level of fulfillment of mathematics teaching requirements to develop HOTS in general was moderate. The teaching requirements to develop problem-solving skills were ranked first, with a high level. The teaching requirements to develop creative thinking skills were ranked second, with a moderate level. The teaching requirements to develop critical thinking skills were ranked third, with a moderate level. The teaching requirements to develop decision-making skills were ranked fourth with a low level. The results also showed that there were statistically significant differences at ≤ 0.05) in the level of fulfillment of teaching requirements to develop HOTS due to qualification, years of experience, and training hours.

Keywords: teaching mathematics, problem-solving, decision-making, critical thinking, creative thinking, higher-order thinking skills, intermediate school

INTRODUCTION

Thinking is a characteristic that distinguishes humans from other beings. It is one of the basic factors that help them direct and advance life, solve problems, and avoid making mistakes. Al-Gharabiya (2012) stated that the secret of humans' superiority lies in the ability to think and plan, which helps achieve superiority and mastery. Burnett (2019) emphasized the correlation between positive thinking and happiness.

Developing the learners' thinking skills contributes to creating the spirit of creativity, coming up with everything new and innovative, understanding, analyzing, and interpreting situations, and using the information to solve life problems and make appropriate decisions. This requires non-traditional thinkers, but rather thinkers distinguished by higher-order thinking skills (HOTS). Because this era is considered the era of creativity, interest has recently increased in the necessity of developing HOTS among school students (Al-Kubaisi, 2014). Miterianifa et al. (2019) confirmed the importance of HOTS for students, especially when dealing with tests and answering questions that are difficult for them.

HOTS are highly required in the 21st century. The United Nations Educational, Scientific, and Cultural Organization emphasized the importance of developing 21st century competencies, which include HOTS like problem-solving, critical thinking, creativity, and decision-making skills, in educational systems in various countries (Kulnazarova & Ydesen, 2016). One of the most prominent goals of the Ministry of Education in the Kingdom of Saudi Arabia (KSA) is to raise the level of thinking among learners.

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Contribution to the literature

- This research can contribute to developing mathematics teaching in the intermediate school to develop HOTS.
- It can help developers of teacher preparation programs, training programs, and professional development programs for mathematics teachers in developing and adapting programs to develop HOTS.
- It can greatly help future researchers in developing mathematics teaching at the intermediate stage.

HOTS are important parts of teaching and learning, as students with HOTS can improve their performance and reduce their weaknesses (Yee et al., 2011). The development of students' HOTS is fundamental in teaching mathematics and one of the ingrained responsibilities in mathematics learning (Sa'dijah et al., 2021). Tanujaya et al. (2017) indicated a strong positive correlation between HOTS and academic achievement in mathematics. Oduro-Okyireh et al. (2024) showed that there is a partial mediation in the relationship between students' strength in mathematics and achievement in electrical and electronic engineering education by HOTS.

Mathematics is a fundamental subject that underpins many aspects of our lives and society. It is a discipline that involves the study of quantities, structures, space, and change, and is widely recognized as a critical component of a well-rounded education (Boaler, 2016). The teaching of mathematics, in particular, plays a crucial role in developing students' problem-solving abilities, critical thinking skills, and overall understanding of the world around them (Brookhart, 2021). However, the effective teaching of mathematics, especially in the intermediate stage, can be challenging, as it requires teachers to not only have a strong grasp of mathematical concepts but also the ability to foster HOTS in their students (Krupa et al., 2017).

Mathematics serves as the foundation for science, acting as a methodological framework. The principles, rules, implications, and applications that define mathematics underpin the fields of science and technology. At the core of science and technology lie the fundamental components of mathematics: arithmetic and logical reasoning (Nasution et al., 2020; Shone et al., 2024). According to Kurniawan et al. (2024), teaching mathematics contributes to developing crucial skills in students. These include the application of mathematical concepts in daily life, the cultivation of critical thinking abilities, and the preparation for success in a wide range of future endeavors. This aligns with the notion that mathematics is ubiquitous, serving as a mode of logical reasoning, and is a pivotal subject at all levels of education.

The currently implemented mathematics curricula in KSA contain a basic component at the end of each lesson HOTS problems that are presented differently and require using HOTS to solve them (Ministry of Education in KSA, 2022). Teaching HOTS in mathematical classrooms requires teachers to have an awareness of HOTS and how to teach mathematics to develop them. According to Eyal et al. (2023), the teacher's knowledge about HOTS and his training in teaching to develop them have an effective role in developing students' HOTS. Elfeky (2019) and Qaraan (2020) confirmed the role of the teacher and the classroom environment in developing thinking skills.

The National Council of Teachers of Mathematics (NCTM) in America has emphasized the importance of teachers using appropriate methods to develop students' HOTS (NCTM, 2009). Kojak (2015) confirmed that achieving the NCTM standards requires training and qualifying teachers to use appropriate strategies and approaches. The qualified teacher represents the most important elements for the success of teaching thinking, as his role is a trainer, observer, and advisor.

Teaching HOTS in mathematical classrooms includes applying mathematical principles, predicting impacts, resolving problems, making decisions, operating within one's expertise, experimenting with novel approaches, engaging in divergent thinking, and employing imaginative thinking (Tanujaya, 2016). The results of Eyal et al. (2023), Kadir and Rukman (2021), Riandari et al. (2018), Silitonga et al. (2020), Singh et al. (2020), and Suastra et al. (2019) revealed that the teacher's use of teaching strategies that enhance students' HOTS develops students' various abilities, develops their HOTS, and helps them solve the problems they face in life. Thomas (2011) stated that the teacher must encourage students to work in groups, act as a facilitator of the learning process, and involve students in solving problems instead of solving them. Polat (2020) emphasized the importance of the teacher's behavior, skills, and methods in helping students acquire thinking skills. Foong (2000) emphasized the importance of open-ended problems for developing HOTS in mathematical classrooms. Ghasempour et al. (2021) confirm that two problem posing strategies, namely "what ..., if not?" and "modifying given". Problem posing tasks for enhancing HOT skills among students.

THEORETICAL BACKGROUND

Higher-Order Thinking Skills

There is no specific definition in the educational literature for HOTS. Some defined HOTS as the ability to apply previous information and skills in new situations

(higher-order thinking as transfer). Others defined them as the ability to think critically (higher-order thinking as critical thinking), and some defined them as the ability to solve problems with higher-order (thinking as problem-solving) (Brookhart & ASCD, 2010).

Resnick (1987) defined HOTS as a mental activity that relies on careful judgment, analysis, and self-regulation. Newmann (1991) defined it as how an individual uses ideas to solve difficult and complex problems. Lewis and Smith (1993) defined it as the ability to interpret, analyze, organize, and apply the learned information and skills to new situations.

Others consider Bloom's cognitive levels (analysis, synthesis, and evaluation) higher-order thinking abilities, as they require complex thinking processes (Lee & Chae, 2021). Students need to reach Bloom's higher cognitive levels (analysis, synthesis, and evaluation) because meaningful learning experiences must include these levels (Garver & Roberts, 2013). According to Smith and Darvas (2017), one of the important activities that enhance these levels is self-evaluation or peer evaluation activities and teachers' use of HOTS during teaching increases students' ability to self-evaluate.

Critical thinking, creative thinking, and problem-solving are essential components of HOTS. These skills are mostly important in the teaching and learning of mathematics as they are needed for problem-solving, which is considered the core of mathematics (Aba-Oli et al., 2024). Developing students' HOTS helps them to use mathematics to understand the environment (Arnellis et al., 2020).

The current research is concerned with identifying the teaching performance requirements for developing HOTS among intermediate school students, recognizing the level of fulfillment for these requirements among mathematics teachers, and developing HOTS (problem-solving skills, decision making skills, critical thinking skills, and creative thinking skills).

Developing Problem-Solving Skills

Problem-solving cannot be separated from teaching and learning mathematics, it is a main goal of mathematics education and a means to achieve it. It is one of the main HOTS. There is a close relationship between thinking skills and problem-solving skills as problem-solving requires practicing thinking skills, especially HOTS, and for the student to solve the problem, inquiry skills must be used to discover the solution. Qutait (2011) pointed out that problem-solving is a process in which students use their previous knowledge, experiences, and skills to respond to the requirements of new situations that are unfamiliar to them. Problem-solving is an organized process that includes identifying a problem, examining the information provided, understanding what needs to be solved, suggesting solutions, evaluating the results, and critically evaluating the results (Alkhatib, 2019). According to Tolba (2017), problems represent opportunities to maximize learning and understanding, and thinking begins with the process of solving the problem in the context of the individual's interaction with the problem and then continues as a thinking process linked to general knowledge and accepted results and using the results to clarify many inferences through induction and deduction and arriving to the decision and evaluate it.

Problem-solving has a four-step technique:

(1) understanding the problem including reading the problem correctly, understanding the meanings and terminology included, determining the given information, distinguishing what is required, and determining the information needed for the solution,

(2) planning including choosing the appropriate arithmetic operations, translating the problem into another forms, linking the data to what is required within the framework of a concept, theory or previous experience, making drawings, using variables and giving names to variables or unknowns, and identifying one or more strategies for the solution then choose the most appropriate ones,

(3) executing the plan including performing calculations, arranging the steps of problem-solving according to the goal, and the correct writing of the problem's solution, and

(4) looking back including reviewing the steps for problem-solving, verifying the correctness of the calculations, writing the achieved solution, justifying the method of deducing the solution, and suggesting other solutions if possible (Pólya, 1965).

Al-Sawafta (2013) emphasized that students should rely on themselves in solving problems and the teacher's role should be limited to preparing and helping students if needed without solving problems directly. It is important to guide students to ask questions, solve complexities, search for relationships between parts of the problem, and build connections between parts of knowledge (Beser & Kissal, 2009). Cao (2024) emphasized the importance of students' collaborative problem-solving in mathematics classrooms. Zhang (2024) indicated that effective student interaction in peer collaborative problem-solving in mathematics needs to cultivate students' sense of collaboration, teachers should make appropriate interventions, and a collaboration group's organization should meet the reasonable matching mode.

The role of the teacher during problem-solving is a facilitator of the learning process and includes directing students to define the structure of the problem and the goals associated with it, motivating the strategies used in

solving problems among students, providing sufficient cognitive tools and supporting structures, directing students to think about their thinking, and providing immediate feedback (Lee & Cho, 2007; Troyer & Youngreen, 2009). Ovadiya (2023) believed that one of the important principles in teaching problem-solving is to promote active thinking and metacognitive thinking, provide guiding strategies for solving problems, and use worked examples.

Developing Decision-Making Skills

Decision-making skill is one of the most important skills as it is a highly specific process that affects the individual's present life and future. The individual makes decisions at almost every stage of life, and the individual's ability to make the right decision at the right time greatly affects his success socially, emotionally, and professionally (Ayyash & Ghareeb, 2018; Çoruh & Vural, 2019; Oguzhan, 2016). Global trends in teaching emphasize the importance of preparing the individual to be able to use scientific knowledge and skills in making wise decisions in life situations, issues, and events. Then they can engage in their society consciously and responsibly and adapt to the modern changes that occur in public life (Clegg & Kolodner, 2014). Decision making skills are important for teaching and learning mathematics, these skills can be refined by practice (Santagata & Yeh, 2016).

Decision-making is a mental process undertaken by the student when faces a problem that requires analysis and correct data, during practicing these processes, he practices the necessary mental skills–represented in identifying the problem, identifying alternatives, and deciding to issue a specific judgment about what the student should do in a particular situation (Al-Baali, 2014). Al-Tammam (2019) defined decision-making as a mental or intellectual activity carried out by an individual to compare available alternatives according to a scientific methodology to choose the best and most effective of these alternatives in achieving goals.

The decision-making process are similar to mathematics problem-solving in terms of steps. Whereas the decision-making process begins after encountering a situation that requires a decision, the decision-making process directs the individual on how to deal with this situation, the decision-making includes complex processes such as the processes involved in solving problems, where the individual determines the available alternatives and the best alternative to reach the desired goal should be chosen Ummet et al. (2019). The decision-making process begins with diagnosing and defining the problem, collecting and analyzing data and information to understand it, identifying and evaluating the available alternatives, choosing the best alternatives by comparing the available alternatives, and finally, the decision, where a solution plan is drawn up according to the chosen alternative, and this solution is evaluated (Al-Qaddafi, 2013; Ayyash & Gharib, 2018; Levinson et al., 2012).

The decision-making process is affected by the availability of supportive information and the cognitive style followed by the individual in processing information, supportive information must be presented and studied before starting educational tasks that require decision-making because supportive information has a high interaction with all elements. presenting it during implementing tasks will increase students' cognitive load, accordingly, they cannot make decisions wisely (Sweller et al., 2019). The decision-making process is affected by the psychological state of the individual, tendencies, beliefs, and personal characteristics, as well as the environmental conditions and various variables to which the individual is exposed when making the decision (Ayyash & Gharib, 2018).

Ramírez-Contreras et al. (2023) indicated the importance of studying probability and using it in decision making to develop students' decision-making skills. Hafni and Nurlaelah (2018) stated that developing the students' mathematical critical thinking skills can influence their decision-making style. Developing the learner's decision-making skills helps solve problems and reach appropriate decisions based on the scientific method (Gutierez, 2015). To develop students' decision-making skills, the teacher must choose appropriate strategies for the topic presented in the educational situation, help students generate ideas that help in making the appropriate decision for the given topic, evaluate these ideas, train them on how to collect and refine the information, present the largest possible number of ideas to reach the appropriate decision and train students to use the skills that help in decision-making, such as taking responsibility and discussion and constructive dialogue skills (Jarwan, 2015).

Williamson (2023) pointed out that developing students' decision-making skills occurs through the teacher practicing decision-making skills in dealing with some situations that appear during teaching, encouraging students to listen to each other's opinions and discussing these opinions constructively, directing students to benefit from their previous unsuccessful experiences in decision-making, enhancing students' mental alertness so that it helps them think rationally when making decisions, and finally, making the decision-making process fun by including games.

Bordia (2021) stressed the importance of constantly reminding students that it is a problem if a wrong decision is made, and they should learn from their previous experiences, as this enhances their decision-making ability.

Developing Critical Thinking Skills

Critical thinking is a relevant the 21st century skills. It is one of the types of thinking that the individual uses in most situations. There are many definitions of critical thinking from different perspectives:

(1) from the perspective of ability, critical thinking is defined as the ability to make a correct judgment about a specific topic based on sufficient reasons to make that judgment,

(2) from the perspective of being a cognitive strategy through which the individual analyzes ideas and decisions to reach a final decision,

(3) from a process perspective, where critical thinking is defined as a process through which an individual makes a judgment or decision, and

(4) from the perspective that it contains one or more other types of thinking, it is viewed as a pattern of complex thinking that contains a group of other thinking patterns such as (logical thinking, analogical thinking, and deductive and inductive thinking), working together when practicing critical thinking to reach a decision or judgment (Tolba, 2017).

Mulnix (2010) stated that critical thinking is an acquired skill for deducing, reasoning, generating information, and arriving at results and critical thinking is also a mental habit of using and accepting the results reached.

Facione (2011) categorized core critical thinking skills into

(1) interpretation, which includes the following sub-skills (categorize, decode significance, and clarify meaning),

(2) analysis, which includes the following sub-skills (examine ideas, identify arguments, and identify reasons and claims),

(3) inference, which includes the following sub-skills (query evidence, conjecture alternatives, and draw logically valid or justified conclusions),

(4) evaluation, which includes the following sub-skills (assess the credibility of claims and assess the quality of arguments that were made using inductive or deductive reasoning),

(5) explanation, which the following sub-skills (state results, justify procedures, and Present arguments), and

(6) self-regulation; includes the following sub-skills: (self-monitor and self-correct).

There is a relationship between critical thinking and mathematical literacy because justifying one's mathematical reasoning depends on critical thinking (Aubrey et al., 2012). critical thinking skills are considered a supporter for teaching and learning of mathematics, because teaching and learning of mathematics includes application of critical thinking skills like analyzing arguments, making inferential analysis either through inductive or deductive reasoning methods, performing assessments, and making accurate decisions from existing problems. The application of critical thinking skills makes the learning mathematics environment more meaningful (Aini et al., 2019; Ismail et al., 2019; Munawaroh et al., 2018). Naidoo et al. (2022) clarified that developing students' critical thinking skills contributes to achieving mathematical literacy, problem-solving, mental agility, lifelong learning, mathematical reasoning, problems-solving, understanding of concepts, distinguishing, and independent thinking.

According to Az-zahra et al. (2023) and Sutama and Anisti (2024), the implementation of problem-based learning in mathematics teaching modules has demonstrated effectiveness in enhancing students' critical thinking skills. The training of students in critical thinking helps them go beyond simply obtaining the final answers to problems. Instead, it enables them to provide detailed information and perform further analysis to arrive at the most appropriate solutions (Az-zahra et al., 2023). This indicates a reciprocal relationship between critical thinking and the ability to solve mathematical problems. The development of critical thinking skills directly supports students' problem-solving abilities in mathematics, while the process of solving mathematical problems also reinforces and strengthens their critical thinking faculties.

Al-Kubaisi (2014) emphasized that the teacher is considered one of the most important factors for the success of teaching critical thinking. Ismail et al. (2022) indicated that the practice of critical thinking skills in teaching mathematics needs a high teachers' awareness, perception and readiness about critical thinking skills. Al-Harthy (2009) indicated that open-ended questions are an important means of developing critical thinking skills, and the teacher must use various forms of these questions, such as

(1) questions that focus attention, such as What do you notice …?

(2) questions that lead to comparisons such as What is the difference …? What are the strengths ...?

(3) questions that aim to clarify such as What do you mean …? What is the explanation for this …?

(4) questions that raise questions such as What do you need to know about …? What would happen if …?

(5) questions that search for reasons such as Why did you think of this …?

According to Jarwan (2015), among the teacher's roles that help in developing students' critical thinking are the following; listening well to students, respecting diversity of opinions and openness, accepting and valuing students' roles and ideas, not being biased toward an idea, giving students sufficient opportunity to discuss and express their opinions, giving students

sufficient time to think, giving them positive feedback, developing their self-confidence and motivation, creating the appropriate classroom environment to develop critical thinking skills, and creating educational situations through which students' critical thinking skills can be developed.

Developing Creative Thinking Skills

Creative thinking is a purposeful mental activity, guided by a strong desire to search for solutions or reach original, previously unknown outcomes (Jarwan, 2015). According to Ritter et al. (2020), creative thinking is one of the most required skills for life and work in the 21st century. However, attention to, the provision and development of creative thinking is less than what is required. Training students to think creatively develops problem-solving skills, innovation, and self-satisfaction (Conklin & Manfro, 2012). Creative thinking skills are not innate and can be acquired by students through education and training, and creating exciting opportunities and situations for creative thinking, which require the student to use the mind to understand or solve them (Al-Subaie, 2011; Kleibeuker et al., 2016).

The learner who can think creatively is distinguished from his colleagues in many characteristics, including that he can find innovative, distinctive, and unusual solutions to the problems faces, whether in educational situations or his life in general, as well as, the breadth of scientific imagination and open-mindedness, the broad desire for knowledge, the ability to organize ideas and perception of relationships (Abu Hashem, 2014). Orakci (2023) found that academic motivation, self-efficacy, and problem-solving skills have a significant direct impact on creative thinking skills and creative thinking has a significant direct impact on critical thinking skills.

Ahmed (2010) pointed out that creative thinking in mathematics is the ability to come up with new, many and diverse original ideas for various mathematical activities, such as discovering new relationships and drawing new results, generalizations, or information from the ideas presented. Creative thinking is an essential cognitive process in the context of learning activities. Students' mathematical creativity is a crucial educational outcome, which can be fostered by engaging them in tasks that support multiple solution strategies, diverse reasoning approaches, and extended problem-solving in mathematics (Erdogan & Yildiz, 2021).

Given the importance of creative thinking in mathematics teaching, it can be argued that teachers are responsible for transforming their students into creative thinkers. According to the international standards for mathematics teacher preparation, developing creative thinking in students is one of the main roles of the mathematics teacher (Schmidt et al., 2013). Achkan (2022) concluded that one of the important skills for teachers to develop student's creative thinking skills is the ability to prepare open-ended tasks of varying difficulty and organize students' activity when implementing these tasks, as well as the ability to classify and prepare tasks according to different creative thinking skills.

Developing creative thinking among students requires the implementation of appropriate instructional methods and strategies. Olsson and Granberg (2024) as well as Pitta-Pantazi et al. (2022) have highlighted the importance of utilizing innovative educational technologies in nurturing students' creative thinking abilities in mathematics. Furthermore, Thahir et al. (2024) has indicated the effectiveness of teaching mathematics through project-based learning and problem-based learning in enhancing students' creative thinking abilities. Similarly, Samura et al. (2023) have demonstrated the efficacy of open-ended learning in developing the creative thinking skills of students in the domain of mathematics. Moreover, Levenson and Molad (2022) have found that the varying dynamics of collaborative student groups working on open-ended mathematics tasks can lead to different manifestations of mathematical creativity. When a group exhibits a higher level of collaboration, it can lead to an increase in their collective strategic flexibility. Conversely, when there is a mix of collaboration and individual contributions, it tends to promote collective fluency in mathematical creativity.

Research Problem and Questions

The mathematics teacher is an essential element in teaching and developing students' HOTS. The researcher has conducted interviews with seven mathematics supervisors about the extent of mathematics teachers' interest in developing HOTS among intermediate school students, and their efficiency in developing them among students, the results of the interviews indicated that 85% of them agreed that teachers were not interested in developing students' HOTS, and they all agreed that teacher's performance efficiency in developing HOTS among intermediate students is moderate. Despite that mathematics teachers are aware of the importance of developing students' HOTS by using appropriate teaching strategies, their knowledge about HOTS and how to develop and train students to use them in solving problems is still low (Retnawati et al., 2018). Sada (2019) showed that teachers' knowledge about HOTS and teaching according to them is moderate and Rianasari and Apriani (2019) found that the ability of pre-service mathematics teachers to design problems based on HOTS is very low. Alhassora (2017) and Seman (2017) indicated that mathematics teachers face challenges in teaching and learning for HOTS.

Studies have focused on the role of the teacher in developing thinking such as Al-Kassab (2014), Al-

Table 1. Descriptive statistics for teacher's demographic variables

Variable		N	Percentage	Mean	Standard deviation
Qualification	BA	112	82.4		
	MA	19	17.6		
Teaching experience (years)	≤ 5	20	14.7	10.11	4.08
	> 5 or ≤ 10	33	24.3		
	> 10 or ≤ 15	75	55.1		
	> 15	8	5.9		
Training hours	≤ 15	9	6.6	37.83	14.66
	> 15 or ≤ 30	36	26.5		
	> 30 or ≤ 45	34	25.0		
	> 45	57	41.9		

Khalidi et al. (2011), and Hussein (2014). Alhassora (2017) and Seman (2017) have focused the challenges mathematics teachers face teaching and learning for HOTS. Murray (2011) have focused on developing HOTS among mathematics teachers. There is not enough interest from researchers in the requirements of teaching mathematics to develop HOTS.

The existing literature has highlighted the importance of various instructional approaches, such as problem-based learning, project-based learning, and open-ended learning, in fostering critical thinking and creative thinking skills among students in the domain of mathematics. However, there is a need to further explore the extent to which mathematics teachers in the intermediate stage are able to fulfill the teaching requirements necessary to develop these HOTS in their students.

The problem of the current research is to identify mathematics teaching requirements to develop HOTS which includes problem-solving, critical thinking, creativity, and decision-making skills and identify the level of fulfillment of them among mathematics teachers in the intermediate stage; the research investigates the following questions:

1. What are the mathematics teaching requirements to develop HOTS among intermediate school students?
2. What is the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS?
3. To what extent does the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS vary according to qualification?
4. To what extent does the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS vary according to years of teaching experience?
5. To what extent does the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS vary according to the training hours?

METHOD

The research adopted the descriptive analytical approach to identify the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS and recognize the impact of qualifications, years of teaching experience, and training hours in the educational field on the level of fulfillment of these requirements.

The research population consists of all mathematics teachers at the government intermediate school in the Eastern Province of KSA. After obtaining official approvals, the respondents received their invitation to participate in the research via e-mail and text messages, where the questionnaire was converted into an electronic questionnaire based on Google Forms, and a link to the questionnaire was sent to all intermediate school mathematics teachers in the Eastern Province. The purpose of the research and how to participate were explained to the teachers before starting, and 136 of them completed the questionnaire. Most of the respondents to the questionnaire had moderate experience in teaching. The percentage of those with > 5 or ≤ 10 years of experience was 24.3%, and those with > 10 or ≤ 15 years of experience were 55.1%. Most of them hold a bachelor's degree with a percentage of (82.4%), and a reasonable percentage of them hold a master's degree (17.6%). All teachers have training courses. 93.4% of them hold more than 15 training hours. **Table 1** shows the demographic variables of the research sample.

Materials and Design

Questionnaire for identifying mathematics teaching requirements to develop higher-order thinking skills

After reviewing the literature related to mathematics teaching to develop HOTS, the objective of the questionnaire is to determine the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS. The initial form of the questionnaire was prepared and consisted of two parts. The first part included demographic data (qualification, years of experience, training hours). The second part included four sub-dimensions that represent the mathematics teaching requirements to develop

Table 2. Numerical estimate and mean of the level of fulfillment of mathematics teaching requirements among teachers to develop HOTS

Value	Level of fulfillment	Mean
5	Very high	≥ 4.2
4	High	> 3.4 or < 4.2
3	Moderate	> 2.6 or < 3.4
2	Low	> 1.8 or < 2.6
1	Very low	≤ 1.8

HOTS according to the limits of the research, which are mathematics teaching requirements to develop problem-solving skills (12 statements), mathematics teaching requirements to develop decision-making skills (11 statements), mathematics teaching requirements to develop critical thinking skills (13 statements), and mathematics teaching requirements to develop creative thinking skills (14 statements). Thus, the total number of statements (50 statements) expresses the teaching requirements for developing HOTS.

The statements in the second part were formulated according to a five-point Likert scale (1-5), and the level of teachers' fulfillment of mathematics teaching requirements for developing HOTS was numerically estimated in addition to the mean according to **Table 2**.

Face validity

The questionnaire was presented to a group of mathematics teachers with experience in teaching mathematics at the intermediate stage, as well as a group of educational supervisors in mathematics to evaluate the suitability of the tool for the objective, as well as the connection of the statements to the dimensions belonging to, and the clarity of its linguistic formulation. Some modifications were made according to their opinions. After that, it was presented to a group of curricula and methods of teaching mathematics staff members to evaluate it again, some modifications were also made, which were limited to rephrasing some statements, and the questionnaire was ready in its final form.

Internal consistency

To determine the internal consistency of the questionnaire, the questionnaire was administered to a pilot sample consisting of thirty-six intermediate school mathematics teachers. The Pearson correlation coefficient was calculated between the score of each statement and the total score of the dimension to which the statement belongs. The values of the correlation coefficients ranged between 0.335 and 0.919. The Pearson correlation coefficient was also calculated between each dimension of the questionnaire and the total score of the questionnaire, and the values of the correlation coefficients ranged between 0.640 and 0.874) which are high and moderate values, and all of them are positive, which means that there is a high degree of internal consistency that reflects a high degree of validity of the questionnaire.

Reliability

The reliability coefficient for the questionnaire as a whole was determined using Cronbach's alpha, which reached 0.885. Reliability coefficients were also determined for the sub-dimensions of the questionnaire and were 0.766, 0.890, 0.540, and 0.774 respectively, which indicates that the tool has a high degree of reliability.

Thus, the final form of the questionnaire was reached, and the first research question was answered. **Table 3** shows the distribution of the questionnaire dimensions and the number of teaching performance indicators for each dimension.

FINDINGS

First: The Level of Fulfillment of Mathematics Teaching Requirements Among Teachers in the Intermediate Stage to Develop Higher-Order Thinking Skills

The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop higher-order thinking skills as a whole

Results showed that the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS as a whole was moderate (mean [M] = 3.03, standard deviation [SD] = 0.27). The teaching requirements for developing problem-solving skills were ranked first, with a high level of fulfillment (M = 3.50, SD = 0.38). The teaching requirements for developing creative thinking skills were ranked second, with a moderate level of fulfillment (M = 3.22, SD = 0.45). The teaching requirements for developing critical thinking skills were ranked third, with a moderate level of fulfillment (M = 2.86, SD = 0.37). Finally, the teaching requirements for developing decision-making skills were ranked fourth, with a low

Table 3. Distribution of the questionnaire dimensions, and number of teaching performance indicators for each dimension

Dimension	Teaching requirements number
Mathematics teaching requirements to develop problem-solving skills	12
Mathematics teaching requirements to develop decision-making skills	11
Mathematics teaching requirements to develop critical thinking skills	13
Mathematics teaching requirements to develop creative thinking skills	14
Total	50

Table 4. The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop HOTS as a whole

Dimension	M	SD	Rank	LoF
Mathematics teaching requirements to develop problem-solving skills	3.50	0.38	1	High
Mathematics teaching requirements to develop decision-making skills	2.48	0.45	4	Low
Mathematics teaching requirements to develop critical thinking skills	2.86	0.37	3	Moderate
Mathematics teaching requirements to develop creative thinking skills	3.22	0.39	2	Moderate
Mathematics teaching requirements to develop HOTS	3.03	0.27		Moderate

Note. LoF: Level of fulfillment

Table 5. The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop problem-solving skills

Mathematics teaching requirements to develop problem-solving skills	M	SD	Rank	LoF
Guiding students to read problem carefully and recognize new vocabulary in it	3.69	0.61	3	High
Discussing with students the unfamiliar data to help them organize it	3.42	0.76	8	High
Helping students interpret the symbols involved in the problem	3.85	0.40	1	High
Guiding students to reformulate the problem in other ways	3.65	0.63	4	High
Guiding students to identify what is required and its relationship to the data	3.27	0.80	11	Moderate
Discussing with students the processes and steps needed to solve the problem	3.32	0.80	9	Moderate
Encouraging students to make intelligent guesses about the solution, test it, and verify its validity	3.29	0.77	10	Moderate
Guiding students to write the steps to solve the problem in a sequential manner	3.55	0.65	6	High
Discussing with students the steps and procedures taken to reach the solution	3.73	0.52	2	High
Discussing with students the difficulties they encountered during the solution	3.18	1.08	12	Moderate
Encouraging students to suggest new problems that could be solved using the same strategy	3.58	0.68	5	High
Reinforcing students with original solutions	3.53	0.68	7	High
Mathematics teaching requirements to develop problem-solving skills	3.50	0.38		High

Note. LoF: Level of fulfillment

level of fulfillment (M = 2.48, SD = 0.39), as shown in **Table 4**.

The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop problem-solving skills

The results revealed that the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop problem-solving skills in general is high (M = 3.50, SD = 0.38). The most available teaching requirements are, as follows:

- The first rank: Helping students interpret the symbols involved in the problem (M = 3.85, SD = 0.40) with a high level.
- The second rank: Discussing with students the steps and procedures taken to reach the solution (M = 3.73, SD = 0.52) with a high level.
- The third rank: Guiding students to read the problem carefully and recognize new vocabulary in it (M = 3.69, SD = 0.61) with a high level.

The teaching requirements that ranked last were, as follows:

- Encouraging students to make intelligent guesses about the solution, test it, and verify its validity (M = 3.29, SD = 0.77) with a moderate level.
- Guiding students to identify what is required and its relationship to the data (M = 3.27, SD = 0.80) with a moderate level.
- Discussing with students the difficulties they encountered during the solution (M = 3.18, SD = 1.08) with a moderate level.

Table 5 shows the results in detail.

The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop decision-making skills

The results revealed that the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop decision-making skills in general is low (M = 2.48, SD = 0.45). The most available teaching requirements are, as follows:

- The first rank: Guiding students to identify possible mathematical alternatives in decision-making (M = 2.62, SD = 0.60) with a moderate level.
- The second rank: Helping students compare possible mathematical alternatives to determine the appropriate ones in decision-making (M = 2.59, SD = 0.51) with a low level.
- The third rank: Guiding students to arrange appropriate mathematical alternatives according to their importance in the mathematical problem (M = 2.57, SD = 0.51) with a low level.

Table 6. The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop decision-making skills

Mathematics teaching requirements to develop decision-making skills	M	SD	Rank	LoF
Guiding students to identify the expected pros and cons before deciding on a mathematical situation	2.54	0.53	4	Low
Discussing with students the mathematical information needed to decide	2.46	0.57	8	Low
Helping students determine the mathematical goal for decision-making	2.54	0.54	5	Low
Guiding students to identify possible mathematical alternatives in decision-making	2.62	0.60	1	Moderate
Guiding students to arrange appropriate mathematical alternatives according to their importance in the mathematical problem	2.57	0.51	3	Low
Helping students compare possible mathematical alternatives to determine the appropriate ones in decision-making	2.59	0.51	2	Low
Helping students choose best mathematical alternatives from suitable alternatives	2.49	0.63	6	Low
Guiding students to take an overview of the problem before implementing the decision related to the solution	2.35	0.71	9	Low
Encouraging students to exchange opinions with classmates about a difficult mathematical problem before deciding on a solution	2.31	0.77	11	Low
Guiding students to monitor the consequences of their decision regarding a mathematical situation	2.48	0.64	7	Low
Guiding students to rethink the mathematical situation to reach a better decision	2.34	0.87	10	Low
Mathematics teaching requirements to develop decision-making skills	2.48	0.45		Low

Note. LoF: Level of fulfillment

The teaching requirements that ranked last were, as follows:

- Guiding students to take an overview of the problem before implementing the decision related to the solution (M = 2.35, SD = 0.71) with a low level.
- Guiding students to rethink the mathematical situation to reach a better decision (M = 2.34, SD = 0.87) with a low level.
- Encouraging students to exchange opinions with classmates about a difficult mathematical problem before deciding on a solution (M = 2.31, SD = 0.77) with a low level.

Table 6 shows the results in detail.

The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop critical thinking skills

The results revealed that the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop decision-making skills in general is moderate (M = 2.86, SD = 0.37). The most available teaching requirements are, as follows:

- The first rank: Helping students find similarities and differences between mathematical problems (M = 3.59, SD = 0.58) with a high level.
- The second rank: Helping students distinguish between explicit and non-explicit data of a mathematical problem (M = 3.46, SD = 0.59) with a high level.
- The third rank: Encouraging students to discuss different solutions to the problem to determine which ones are correct and which are not (M = 3.09, SD = 0.86) with a moderate level.

The teaching requirements that ranked last were, as follows:

- Helping students make connections between mathematics and other sciences (M = 2.52, SD = 1.05) with a low level.
- Helping students reach a conclusion to solve the mathematical problem based on the data (M = 2.37, SD = 0.99) with a low level.
- Helping students identify cause and effect relationships when solving mathematical problems (M = 2.13, SD = 1.10) with a low level.

Table 7 shows the results in detail.

The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop creative thinking skills

The results revealed that the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop creative thinking skills is moderate (M = 3.22, SD = 0.39). The most available teaching requirements are, as follows:

- The first rank: Encouraging students to create new mathematical ideas based on their mathematical ideas (M = 3.87, SD = 0.36) with a high level.
- The second rank: Helping students formulate mathematical ideas creatively (M = 3.64, SD = 0.62) with a high level.
- The third rank: Helping students generate diverse ideas when responding to a mathematical situation (M = 3.49, SD = 0.79) with a high level.

Table 7. The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop critical thinking skills

Mathematics teaching requirements to develop critical thinking skills	M	SD	Rank	LoF
Encouraging students to provide clear justifications for their answers and conclusions when solving a mathematical problem	2.69	1.09	10	Moderate
Helping students make connections between mathematics and other sciences	2.52	1.05	11	Low
Helping students find similarities & differences between mathematical problems	3.59	0.58	1	High
Helping students prioritize the steps to solve a mathematical problem	2.96	0.83	5	Moderate
Helping students identify cause and effect relationships when solving mathematical problems	2.13	1.10	13	Low
Listening to students' ideas, accept their opinions, and encourage them to discuss and respect their points of view	2.90	0.99	7	Moderate
Using open-ended questions to get students thinking	2.94	0.84	6	Moderate
Helping students reach a conclusion to solve mathematical problem on data	2.37	0.99	12	Low
Encouraging students to derive generalizations and mathematical rules and verify their validity	2.99	0.80	4	Moderate
Helping students make a decision in the light of the findings	2.73	0.98	9	Moderate
Helping students distinguish between explicit and non-explicit data of a mathematical problem	3.46	0.59	2	High
Helping students distinguish between the given data and the required mathematical problem	2.89	0.92	8	Moderate
Encouraging students to discuss different solutions to the problem to determine which ones are correct and which are not	3.09	0.86	3	Moderate
Mathematics teaching requirements to develop critical thinking skills	2.86	0.37		Moderate

Note. LoF: Level of fulfillment

Table 8. The level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop creative thinking skills

Mathematics teaching requirements to develop creative thinking skills	M	SD	Rank	LoF
Encouraging students to raise thought-provoking questions	3.06	1.02	11	Moderate
Helping students come up with multiple ideas about a mathematical situation	3.40	0.80	6	Low
Guiding students to provide multiple solutions to the mathematical problem	2.68	0.97	13	Moderate
Helping students generate diverse ideas when responding to a mathematical situation	3.49	0.79	3	High
Helping students diversify their ways of thinking in solving mathematical problems	2.85	0.85	12	Moderate
Guiding students to verify the correctness of solving mathematical problems in various ways	3.45	0.77	4	High
Helping students come up with appropriate alternatives to clarify difficult mathematical ideas and concepts	3.21	0.82	8	Moderate
Helping students apply mathematical concepts and generalizations to unfamiliar situations	3.29	0.74	7	Moderate
Encouraging students to create new mathematical ideas on their mathematical ideas	3.87	0.36	1	High
Helping students formulate mathematical ideas creatively	3.64	0.62	2	High
Encouraging students to derive unprecedented solutions to a math problem	3.09	0.99	10	Moderate
Discussing with students the common errors to be expected when solving a mathematical problem	3.10	0.80	9	Moderate
Encouraging students to add new ideas to mathematical concepts or generalizations to reach new concepts or generalizations	2.53	1.03	14	Low
Guiding students to use solution of a math problem to solve a new problem	3.44	0.80	5	High
Mathematics teaching requirements to develop creative thinking skills	3.22	0.39		Moderate

Note. LoF: Level of fulfillment

The teaching requirements that ranked last were, as follows:

- Helping students diversify their ways of thinking in solving mathematical problems (M = 2.85, SD = 0.85) with a moderate level.
- Guiding students to provide multiple solutions to the mathematical problem (M = 2.68, SD = 0.97) with a moderate level.
- Encouraging students to add new ideas to mathematical concepts or generalizations to reach new concepts or generalizations (M = 2.53, SD = 1.03) with a low level. **Table 8** shows results.

Table 9. Differences in the level of fulfillment of teaching requirements according to qualification

Qualification	M	SD	n	t (df)	p
Master	3.193	0.122	24	3.281 (134)	0.001
Bachelor	2.993	0.282	112		

Second: The Level of Fulfillment of Mathematics Teaching Requirements Among Teachers in the Intermediate Stage to Develop Higher-Order Thinking Skills According to Qualification

Using the independent samples t-test to clarify the significance of the statistical differences, the results showed that there were statistically significant differences at ≤ 0.05 in the level of teaching performance of mathematics teachers in the primary stage for developing HOTS according to qualification favoring teachers who hold a master's degree, as t = 3.281, p = 0.001. **Table 9** shows the results.

Third: The Level of Fulfillment of Mathematics Teaching Requirements Among Teachers in the Intermediate Stage to Develop Higher-Order Thinking Skills According to Years of Teaching Experience

Using the one-way ANOVA test to clarify the differences in statistical significance, the results showed that there were statistically significant differences at ≤ 0.05 in the level of fulfillment of teaching performance requirements among intermediate school mathematics teachers to develop HOTS according to years of teaching experience, as F = 18.329, p = 0.000.

To determine the source of these differences, the Scheffe test for multiple comparisons was used. The results showed that there were statistically significant differences at ≤ 0.05 in the level of fulfillment of teaching performance requirements for intermediate school mathematics teachers to develop HOTS according to years of teaching experience favoring teachers with experience greater than > 10 or ≤ 15 years compared to the rest of the teachers.

Fourth: The Level of Fulfillment of Mathematics Teaching Requirements Among Teachers in the Intermediate Stage to Develop Higher-Order Thinking Skills According to Training Hours

Using the one-way ANOVA test to clarify the differences in statistical significance, the results showed that there were statistically significant differences at≤ 0.05 in the level of fulfillment of teaching performance requirements among intermediate school mathematics teachers to develop HOTS according to the training hours, as it was F = 5.034, p = 0.002.

To determine the source of these differences, the Scheffe test for multiple comparisons was used. The results showed that there were statistically significant differences at ≤ 0.05 in the level of fulfillment of teaching performance requirements for intermediate school mathematics teachers to develop HOTS according to training hours favoring teachers who obtained training hours greater than 45 hours.

DISCUSSION AND CONCLUSION

The current research aims at determining the level of fulfillment of mathematics teaching requirements among teachers in the intermediate stage to develop students' HOTS**.** The results of the second question showed that the level of fulfillment of teaching requirements for developing problem-solving skills was high. This can be explained as developing problem-solving skills is one of the widely spread topics, both in pre-service mathematics teacher preparation programs, as well as in in-service training programs. **Table 1** shows that 93.4% of the research sample holds more than 15 hours of training. Likewise, problem-solving skills are included in the mathematics content of the intermediate school textbooks (Ministry of Education in KSA, 2022). The results revealed that the level of fulfillment of teaching requirements for developing creative and critical thinking skills was moderate.

This can be explained as developing critical thinking and creative thinking skills requires using appropriate teaching strategies, as well as using modern teaching techniques (Wijnen et al, 2023). Most teachers have limited use of modern technologies to support student learning (Fraillon et al. 2018; Ottenbreit-Leftwich et al. 2018). This can also be explained in light of the results of Jailani et al. (2023) who found that pre-service mathematics teachers face difficulties in developing mathematical problems that require HOTS and the importance of including educational experiences about developing HOTS in teacher preparation programs. Christodoulou and Papanikolaou (2023) indicated that it is necessary to include topics on critical thinking and thinking skills in teacher preparation programs and train student teachers in them.

The results also revealed that the level of fulfillment of teaching requirements for developing decision-making skills was low. This can be due to insufficient attention to decision-making skills in teacher preparation programs or in-service training programs for teachers. This may be due to teachers' low level of knowledge about HOTS, as well as their weak practice of them (Abdullah et al., 2017) and teachers' focus on using teaching strategies that measure knowledge (Al-Shudifat, 2018).

These results are consistent with Al-Sabil and Al-Muatham (2017), who found that intermediate school mathematics teachers' use of HOTS problems was low, Retnawati et al. (2018) found that mathematics teachers' knowledge about HOTS and their ability to develop them among students are still weak, Al-Hindal and Al-Dhafiri (2022) found that the degree to which science

teachers practice methods for developing critical thinking skills is low and the level of fulfillment of teaching requirements for developing HOTS, from teachers' point of view, may differ from the level of their actual teaching performance. Al-Ruwais et al. (2016) found that mathematics teachers' implementation of HOTS problems, from their point of view, ranged between moderate to high, while the study found that the reality of their implementation of HOTS problems ranged between weak to high, and Acharya (2021) found that teachers have clarity about the meaning of HOTS, but they rarely apply them.

The research also aimed to identify the significance of the differences in the level of fulfillment of teaching requirements for developing HOTS according to qualification, teaching experience, and training hours. The results showed that there are statistically significant differences in the level of fulfillment of teaching requirements for developing critical thinking skills due to qualifications, teaching experience, and training courses.

The results of the third question showed that the differences are favoring teachers who hold a master's degree. This can be explained as a master's degree increases and expands teachers' knowledge about many educational topics, including thinking skills and this is reflected in their performance and skills. This result is consistent with Abdullah et al. (2017) who found a link between teachers' knowledge about HOTS and their practice and Hamadneh and Alshawahin (2017) who showed that there is a strong correlation between teachers' knowledge and critical thinking skills and the degree to which they practice them.

The results of the fourth question showed that the differences are favoring teachers with teaching experience > 10 or ≤ 15 years compared to the rest of the teachers, including teachers with more than 15 years of teaching experience. This can be explained, as the accumulation of experiences is an important factor in developing teaching practices.

This can be attributed to the diversity and quality of courses offered to mathematics teachers in KSA. **Table 1** shows that 93.4% of teachers have received more than 15 training hours, which has provided them with the skills they need to teach. The superiority of teachers with > 10 or ≤ 15 years of experience over teachers with more than 15 years can be due to their small number in the sample, as they represent only 5.9%, while teachers with > 10 or ≤ 15 years of experience represent 55.1%.

The results of the fifth question showed that the differences are favoring teachers who have more than 45 hours of training, and this result is consistent with Alomari (2019) who indicated that increasing training courses effectively contributes to increasing the teachers' ability to apply critical thinking skills as these courses increase their ability and experience to apply these skills within the classroom.

Implications and Limitations

The current research focused on a very vital element of the educational process, which is the teacher, and investigated an essential aspect, which is the teaching requirements for developing HOTS. The results of the research showed that the level of fulfillment of these requirements among mathematics teachers in the intermediate stage, in general, is moderate, and that the level of fulfillment of these requirements for developing Problem-solving skills, critical thinking, and creative thinking skills is moderate, and for developing decision-making skills is low.

Mathematics teachers, researchers, and policymakers can benefit from the research results in developing HOTS in teaching. Developers of teacher preparation programs can develop these programs in light of the requirements for developing HOTS, and those responsible for teachers' professional development can benefit from the results to help in-service teachers develop HOTS.

The current research revealed statistically significant differences in the level of fulfillment of teaching requirements for developing HOTS according to qualification, years of teaching experience, and training hours favoring higher qualifications, more years of experience, as well as more training hours. These results demonstrate to mathematics teachers, researchers, and policymakers the importance of continuing professional development for the teacher and its impact on his teaching practices, and the importance of guiding teachers to take advantage of all professional development opportunities.

One of the limitations of the current research is the small sample size, which was not randomly selected. All participants were government intermediate schoolteachers, and their views and responses can differ from other teachers who work in private or international schools. However, the research attempted to overcome this limitation and reach the largest number of mathematics teachers by sending the study instrument electronically to the largest number of mathematics teachers.

Another limitation is that the research adopted a quantitative tool to collect data, and it is limited to teaching performance requirements for developing problem-solving, decision-making, critical thinking, and creative thinking skills. The research attempted to overcome this limit by preparing the tool in light of reviewing educational literature and then it was reviewed by a group of specialists. The validity and reliability of the tool were verified before application.

The research recommends that future research should consider the use of qualitative tools to collect data

on teaching requirements for developing HOTS at different academic levels. Furthermore, it is important to prepare a comprehensive guide to HOTS with multiple examples for each course. The research also suggests constructing training programs to develop mathematics teachers' performance to develop HOTS and measure their effectiveness.

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REFERENCES

Aba-Oli, Z., Koyas, K., & Husen, A. (2024). Higher-order thinking skills-oriented problem-based learning interventions in mathematics: A systematic literature review. *School Science and Mathematics*. https://doi.org/10.1111/ssm.12676

Abdullah, A. H., Mokhtar, M., Abd-Halim, N. D., Ali, D. F., Tahir, L. M., & Abdul- Kohar, U. H. (2017). Mathematics teachers' level of knowledge and practice on the implementation of higher-order thinking skills. *EURASIA Journal of Mathematics, Science and Technology Education, 13*(1), 3-17. https://doi.org/10.12973/eurasia.2017.00601a

Abu Hashem, R. (2014). *The effectiveness of using the cognitive conflict strategy in teaching physics for developing innovative thinking and achievement among first-year students from industrial technical institutes.* [Unpublished master thesis]. Zagazig University.

Acharya, N. (2021). Mathematics teachers' perceptions on higher order thinking skills. *International Journal of Multidisciplinary Perspectives in Higher Education, 6*(2), 105-125.

Achkan, V. V., Vlasenko, K. V., Chumak, O. O., Sitak, I. V., & Kovalenko, D. A. (2022). A model of learning the online course "creative thinking through learning elementary maths". *Journal of Physics. Conference Series, 2288*, Article 012020. https://doi.org/10.1088/1742-6596/2288/1/012020

Ahmed, S. (2010). The effectiveness of the integrated teaching system based on (discussion method–computer-assisted learning approach–guided discovery method) in developing achievement and innovative thinking in mathematics and attitude towards the subject matter among intermediate school students. *Faculty of Education Journal, Port Said University, 4*(8), 135-163.

Aini, N. R., Syafril, S., Netriwati, N., Pahrudin, A., Rahayu, T., & Puspasari, V. (2019). Problem-based learning for critical thinking skills in mathematics. *Journal of Physics: Conference Series, 1155*, Article 012026. https://doi.org/10.1088/1742-6596/1155/1/012026

Al-Baali, I. A. (2014). The effectiveness of using the Needham constructivist model for developing decision-making skills and academic achievement in science among sixth-grade primary school students in the Kingdom of Saudi Arabia. *Arab Studies in Education and Psychology, 47*(3), 13-36.

Al-Gharabiya, S. A. (2012). *Thinking skills and learning styles*. Dar Al-Zahra.

Al-Harthy, I. A. (2009). *Teaching thinking*. International Links for Publishing and Distribution.

Alhassora, N. S. A., Abu, M. S., & Abdullah, A. H. (2017). Inculcating higher-order thinking skills in mathematics: Why is it so hard. *Man in India, 97*(13), 51-62.

Al-Hindal, D., & Al-Dhafiri, N. (2022). The extent to which science teachers practice methods of developing critical thinking skills in teaching in intermediate school in Kuwait. *Educational Sciences Journal, 30*(2), 163-198.

Al-Kassab, A. A. (2014). The role of social education teachers in developing creative thinking skills among high school students (literary) in the Saudi Qunfudhah Governorate schools from the point of view of teachers and students. *International Journal of Excellence Development, 5*(8), 111-139.

Al-Khalidi, J., Al-Kilani, A., & Al-Awamra, M. (2011). The degree to which Islamic education teachers practice higher-order thinking skills from the point of view of secondary school students in Jordan. *Al-Quds Open University Journal for Research and Studies, 23*, 47-74.

Alkhatib, O. J. (2019). A framework for implementing higher-order thinking skills (problem-solving, critical thinking, creative thinking, and decision-making) in engineering & humanities. In *Proceedings of the Advances in Science and Engineering Technology International Conferences* (pp. 1-8). IEEE. https://doi.org/10.1109/ICASET.2019.8714232

Al-Kubaisi, A. H. (2014). *Developing thinking in interesting ways*. Debono Printing, Publishing, and Distribution.

Alomari, H. (2019). The degree of the application of critical thinking skills by science teachers for middle school students in the Province Mikhwah. *Journal of the Faculty of Education, University of Asyut, 34*(3).

Al-Qaddafi, M. (2013). *The effectiveness of an enrichment program based on self-concept in the psychology curriculum in developing decision-making skills for high*

school students [Unpublished doctoral dissertation]. Cairo University.

Al-Ruwais A., Al-Shalhoub, S., Abdel Hamid, A., & Al-Badour, A. (2016) The reality of elementary mathematics teachers' implementation of higher order thinking skills problems. *International Journal of Educational Research in the Emirates, 40*(1), 29-57.

Al-Sabil, F., & Al-Muatham, K. (2017). The reality of middle school mathematics teachers' performance of higher order thinking skills problems included in the McGrohl curriculum series. *Faculty of Education Journal, Menoufia University, 1*(4) 192-227.

Al-Sawafta, M. A. (2013). *The effect of a training program based on educational games in developing higher-order thinking skills among upper basic stage students* [Unpublished doctoral dissertation]. Amman Arab University.

Al-Shudifat, K. A. (2018). Obstacles of critical thinking as perceived by faculty members at Najran University. *Route Educational and Social Science Journal, 5*(6), 608-636. https://doi.org/10.17121/ressjournal.1208

Al-Subaie, M. (2011). *Higher-order thinking skills (creative and critical thinking)*. Dar Al-Masila for Publishing and Distribution.

Al-Tammam, A. (2019). The extent to which students at the Islamic University of Medina practice decision-making skills and its relationship to organizational citizenship behavior from their point of view. *Scientific Research in Education Journal, 20*(9), 61-118.

Arnellis, A., Fauzan, A., Arnawa, I. M., & Yerizon, Y. (2020). The effect of realistic mathematics education approach oriented higher order thinking skills to achievements' calculus. *Journal of Physics. Conference Series, 1554*, Article 012033. https://doi.org/10.1088/1742-6596/1554/1/012033

Aubrey, C., Ghent, K., & Kanira, E. (2012). Enhancing thinking skills in early childhood. *International Journal of Early Years Education, 20*(4), 332-348. https://doi.org/10.1080/09669760.2012.743102

Ayyash, L. M., & Ghareb, S. A. (2018). Decision making among postgraduate students at Baghdad University. *Lark Journal of Philosophy, Linguistics and Social Sciences, 28*, 178-196.

Az-zahra, F. A., Lukman, H. S., & Balkist, P. S. (2023). Development of PBL-based mathematics teaching modules to improve the mathematical critical thinking skills of elementary school students. *Inovasi Matematika, 5*(2), 131-150. https://doi.org/10.35438/inomatika.v5i2.392

Beser, A., & Kıssal, A. (2009). Critical thinking dispositions and problem solving skills among nursing students. *DEUHYO ED, 2*, 88-94.

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey-Bass/Wiley.

Bordia, *D. (2021). How to help your students with decision making*. https://blog.teachmint.com/decision-making-skills/

Brookhart, S. M. (2021). *How to assess higher-order thinking skills in your classroom*. ASCD.

Brookhart, S. M., & ASCD. (2010). *How to assess higher-order thinking skills in your classroom*. ASCD.

Burnett, D. (2019). *The happy brain, the science of where happiness comes from, and why*. Guardian Faber Publishing.

Cao, Y. (2024). Research on collaborative problem solving teaching in a secondary school mathematics classroom. In Y. Cao (Ed.), *Students' collaborative problem solving in mathematics classrooms: Perspectives on rethinking and reforming education*. Springer. https://doi.org/10.1007/978-981-99-7386-6_1

Christodoulou, P., & Papanikolaou, A. (2023). Examining pre-service teachers' critical thinking competences within the framework of education for sustainable development: A qualitative analysis. *Education Sciences, 13*(12), Article 1187. https://doi.org/10.3390/educsci13121187

Clegg, T., & Kolodner, J. (2014). Scientizing and cooking: Helping middle-school learners develop scientific dispositions. *Science Education, 98*(1), 36-63. https://doi.org/10.1002/sce.21083

Conklin, W., & Manfro, J. (2012). *Strategies for developing higher-order thinking skills grade K-2*. Shell Education.

Çoruh, Y., & Vural, M. (2019). Study on high school teachers' self-esteem in decision making and decision making styles. *Asian Journal of Education and Training, 5*(2), 362-368. https://doi.org/10.20448/journal.522.2019.52.362.368

Elfeky, A. I. (2019) The effect of personal learning environments on participants' higher order thinking skills and satisfaction. *Innovations in Education and Teaching International, 56*(4), 505-516. https://doi.org/10.1080/14703297.2018.1534601

Erdogan, F., & Yildiz, F. (2021). Investigation of pre-service mathematics teachers' creative thinking tendencies. *International Online Journal of Education & Teaching, 8*(4), 2297-2316.

Eyal, L., Rabin, E., & Meirovitz, T. (2023). Pre-service teachers' attitudes toward integrating digital games in learning as cognitive tools for developing higher-order thinking and lifelong learning. *Education Sciences, 13*(12), Article 1165. https://doi.org/10.3390/educsci13121165

Facione, P. A. (2011). Critical thinking: What it is and why it counts. *Insight Assessment, 1*(1), 1-23.

Foong, P. Y. (2000). Open-ended problems for higher order thinking in mathematics. *Teaching and Learning, 20*(2), 49-57.

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2018). *Preparing for life in a digital world: IEA international computer and information literacy study 2018 international report*. The International Association for the Evaluation of Educational Achievement.

Garver, M. S., & Roberts, B. A. (2013). Flipping & clicking your way to higher-order learning. *Marketing Education Review, 23*(1) 17-21. https://doi.org/10.2753/MER1052-8008230103

Ghasempour, Z., Kashefi, H., Bakar, M. N., & Miri, S. A. (2021). Higher-order thinking via mathematical problem posing tasks among engineering students. *Asean Journal of Engineering Education, 1*(1).

Gutierez, S. (2015). Integrating socio-scientific issues to enhance the bioethical decision-making skills of high school students. *Canadian Center of Science and Education International Education Studies, 8*(1), 142-151. https://doi.org/10.5539/ies.v8n1p142

Hamadneh, A., & Alshawahin, S. (2017). The degree of thinking skills acquired by higher elementary school Arabic teachers in Bani Kinana and how often practiced. *Journal for Education and Psychology, Association of Arab Universities, 16*(2).

Hussein, J. H. (2014). The effectiveness of a developed program for developing thinking skills in mathematics and its impact on achievement, intelligence, and psychological attitudes towards the subject among fifth-grade students in the Kingdom of Bahrain. *International Journal for Developing Excellence, University of Science and Technology, Yemen, 5*(8), 79-110.

Ismail, S. N., Muhammad, S., Kanesan, A. G., & Ali, R. M. (2019). The influence of teachers' perception and readiness towards the implementation of critical thinking skills (CTS) practice in mathematics. *International Journal of Instruction, 12*(2), 337-352. https://doi.org/10.29333/iji.2019.12222a

Ismail, S. N., Muhammad, S., Omar, M. N., Shanmugam, S. K. S., & Rajoo, M. (2022). The practice of critical thinking skills in teaching mathematics: Teachers' perception and readiness. *Malaysian Journal of Learning and Instruction, 19*(1), 1-30. https://doi.org/10.32890/mjli2022.19.1

Jailani, J., Retnawati, H., Rafi, I., Mahmudi, A., Arliani, E., Zulnaidi, H., Abd Hamid, H. S., & Prayitno, H. J. (2023). A phenomenological study of challenges that prospective mathematics teachers face in developing mathematical problems that require higher-order thinking skills. *EURASIA Journal of Mathematics, Science and Technology Education, 19*(10), Article em2339. https://doi.org/10.29333/ejmste/13631

Jarwan, F. A. (2015). *Teaching thinking: Concepts and applications*. Dar Al-Fikr.

Kadir, K., & Rukman, D. F. (2021). Improving students' higher order mathematical thinking skills in accelerated classes through Purdue learning model. *Journal of Physics: Conference Series, 1836*, Article 012072. https://doi.org/10.1088/1742-6596/1836/1/012072

Kleibeuker, S. W., De Dreu, Carsten K. W., & Crone, E. A. (2016). Creativity development in adolescence: Insight from behavior, brain, and training studies: Creativity development in adolescence. *New Directions for Child and Adolescent Development, 151*, 73-84. https://doi.org/10.1002/cad.20148

Kojak, L. (2015). Linking mathematical, scientific and engineering practices. In *Proceedings of the 1st Conference on Excellence in Science and Mathematics Teaching and Learning: STEM Orientation*.

Krupa, E. E., Huey, M., Lesseig, K., Casey, S., & Monson, D. (2017). Investigating secondary mathematics teachers' conceptions of mathematical modeling. *International Journal of Education in Mathematics, Science and Technology, 5*(2), 92-108.

Kulnazarova, A., & Ydesen, C. (2016). *UNESCO without borders: Educational campaigns for international understanding*. Routledge. https://doi.org/10.4324/9781315641966

Kurniawan, H., Purwoko, R. Y., & Setiana, D. S. (2024). Integrating cultural artifacts and tradition from remote regions in developing mathematics lesson plans to enhance mathematical literacy. *Journal of Pedagogical Research, 8*(1), Article 61. https://doi.org/10.33902/JPR.202423016

Lee, H., & Cho, Y. (2007). Factors affecting problem finding depending on degree of structure of problem situation. *The Journal of Educational Research, 101*(2), 113-124. https://doi.org/10.3200/JOER.101.2.113-125

Lee, M., & Chae, S. E. (2021). Development of the higher-order thinking skill scale for Korean university students (HOTUS). *Journal of College Student Development, 62*(4), 469-487. https://doi.org/10.1353/csd.2021.0048

Levenson, E. S., & Molad, O. (2022). Analyzing collective mathematical creativity among post high-school students working in small groups. *ZDM, 54*(1), 193-209. https://doi.org/10.1007/s11858-021-01321-7

Levinson, R., Kent. P., Pratt, D., Kapadia, R., & Yogui. C. (2012). Risk-based decision making in a scientific issue: A study of teachers discussing a dilemma through a micro world. *Science Education, 96*(2), 212-233. https://doi.org/10.1002/sce.21003

Lewis, A., & Smith, D. (1993). Defining higher-order thinking. *Theory Into Practice, 32*(3), 131-137. https://doi.org/10.1080/00405849309543588

Ministry of Education in KSA. (2022). *Mathematics for the second intermediate grade, first semester, teacher's guide*. Obeikan Education Company.

Miterianifa, Trisnayanti Y., Khoiri, A., & Ayu, H. D. (2019). Meta-analysis: The effect of problem-based learning on students' critical thinking skills. *AIP Conference Proceedings, 2194*, Article 020064. https://doi.org/10.1063/1.5139796

Mulnix, J. W. (2010). Thinking critically about critical thinking. *Education Philosophy and Theory, 44*, 464-479. https://doi.org/10.1111/j.1469-5812.2010.00673.x

Munawaroh, H., Sudiyanto, & Riyadi. (2018). Teachers' perceptions of innovative learning model toward critical thinking ability. *International Journal of Educational Methodology, 4*(3), 153-160. https://doi.org/10.12973/ijem.4.3.153

Murray, E. C. (2011). *Implementing higher-order thinking in middle school mathematics classrooms* [Doctoral dissertation, University of Georgia].

Naidoo, J., & Makonye, L. (2022). Exploring the need to develop critical thinking skills with young (3-8-year-old) mathematics learners. *Journal of African Education, 3*(2), 15-43. https://doi.org/10.31920/2633-2930/2022/v3n2a1

Nasution, M. K. M., Salim Sitompul, O., Nasution, S., Aulia, I., & Elveny, M. (2020). Mathematic. *Journal of Physics: Conference Series, 1566*, Article 012030. https://doi.org/10.1088/1742-6596/1566/1/012030

NCTM. (2009). *Focus in high school mathematics: Reasoning and sense making*. National Council of Teachers of Mathematics.

Newmann, F. M. (1991). Promoting higher order thinking in social studies: Overview of a study of sixteen high school departments. *Theory and Research in Social Education, 19*(4), 325-326. https://doi.org/10.1080/00933104.1991.10505645

Oduro-Okyireh, T., Mulyanti, B., Rohendi, D., Oduro-Okyireh, G., Mensah, A. C., & Acheampong, K. (2024). The mediating role of higher-order thinking skill in the relationship between mathematics strength and achievement in electrical and electronic engineering education. *Nurture, 18*(1), 73-90. https://doi.org/10.55951/nurture.v18i1.544

Oguzhan, C. (2016). The effect of decision-making skill training programs on self-esteem and decision-making styles. *Eurasian Journal of Educational Research,* (65), 259-276.

Olsson, J., & Granberg, C. (2024). Teacher-student interaction supporting students' creative mathematical reasoning during problem solving using scratch. *Mathematical Thinking and Learning, 26*(3), 278-305. https://doi.org/10.1080/10986065.2022.2105567

Orakci, Ş. (2023). Structural relationship among academic motivation, academic self-efficacy, problem solving skills, creative thinking skills, and critical thinking skills. *Psychology in the Schools, 60*(7), 2173-2194. https://doi.org/10.1002/pits.22851

Ottenbreit-Leftwich, A.T., Kopcha, T. J., Ertmer, P. A. (2018). Information and communication technology dispositional factors and relationship to information and communication technology practices. In J. Voogt, G. Knezek, R. Christensen, and K. W. Lai (Eds.), *Second handbook of information technology in primary and secondary education*. Springer. https://doi.org/10.1007/978-3-319-53803-7_27-1

Ovadiya, T. (2023). Implementing theoretical intervention principles in teaching mathematics to struggling students to promote problem-solving skills. *International Journal of Mathematical Education in Science and Technology, 54*(1), 4-28. https://doi.org/10.1080/0020739X.2021.1944682

Pitta-Pantazi, D., Christou, C., Demosthenous, E., Pittalis, M., & Chimoni, M. (2022). Nurturing mathematical creativity for the concept of arithmetic mean in a technologically enhanced 'personalised mathematics and mathematics inquiry' learning environment. *ZDM, 54*(1), 51-66. https://doi.org/10.1007/s11858-021-01308-4

Polat, S. (2020). Multidimensional analysis of the teaching process of the critical thinking skills. *Research in Social Sciences and Technology, 5*(2), 134-157. https://doi.org/10.46303/ressat.05.02.8

Pólya, G. (1965). *Searching for the solution*. Franklin Printing and Publishing Corporation.

Qaraan, M. E. (2020). *Critical thinking: Importance and applications*. https://www.new-educ.com/author/medqoranedtech

Qutait, G. Y. (2011). *Solve problems creatively*. House of Culture.

Ramírez-Contreras, A., Zúñiga-Silva, L., & Ojeda-Gómez, E. (2023). A study on mathematics students' probabilistic intuition for decision-making in high school. *International Electronic Journal of Mathematics Education, 18*(4), Article em0749. https://doi.org/10.29333/iejme/13586

Resnick, L. B. (1987). *Education and learning to think*. National Academies.

Retnawati, H., Djidu, H., Kartianom, K., Apino, E., & Anazifa, R. D. (2018). teachers' knowledge about higher-order thinking skills and its learning strategy. *Problems of Education in the 21st Century,*

76(2), 215-230. https://doi.org/10.33225/pec/18.76.215

Rianasari, V. F., & Apriani, M. S. (2019). Pre-service mathematics teachers' knowledge about higher-order thinking skills. *Journal of Physics: Conference Series, 1366*, Article 012083. https://doi.org/10.1088/1742-6596/1366/1/012083

Riandari, F., Susanti, R., & Suratmi. (2018). The influence of discovery learning model application to the higher order thinking skills student of Srijaya Negara Senior High School Palembang on the animal kingdom subject matter. *Journal of Physics: Conference Series, 1022*, Article 012055. https://doi.org/10.1088/1742-6596/1022/1/012055

Ritter, S. M., Gu, X., Crijns, M., & Biekens, P. (2020). Fostering students' creative thinking skills by means of a one-year creativity training program. *PLoS ONE, 15*(3), Article e0229773. https://doi.org/10.1371/journal.pone.0229773

Sa'dijah, C., Murtafiah, W., Anwar, L., Nurhakiki, R., & Cahyowati, E. T. D. (2021). teaching higher order thinking skills in mathematics classrooms: Gender differences. *IndoMS-Journal on Mathematics Education, 12*(1), 159-180. https://doi.org/10.22342/jme.12.1.13087.159-180

Sada, C. (2019). Exploring teaching learning process in developing higher order thinking skill (HOTS) to higher secondary school (SMA) students in Pontianak. *Journal of Education, Teaching, and Learning, 4*(1), 228-232. https://doi.org/10.26737/jetl.v4i1.1020

Samura, A. O., Darhim, Juandi, D., Said, A. M., Alfian, & Tamur, M. (2023). Application of open-ended learning towards mathematics creative thinking ability of junior high school students. *AIP Conference Proceedings, 2734*(1), Article 090007. https://doi.org/10.1063/5.0155361

Santagata, R., & Yeh, C. (2016). The role of perception, interpretation, and decision making in the development of beginning teachers' competence. *ZDM, 48*(1-2), 153-165. https://doi.org/10.1007/s11858-015-0737-9

Schmidt, W., Burroughs, N., & Cogan, L. (2013). *World class standards for preparing teachers of mathematics*. https://eric.ed.gov/?id=ED558128

Seman, S. C., Yusoff, W. M. W., & Embong, R. (2017). Teachers challenges in teaching and learning for higher order thinking skills (HOTS) in primary school. *International Journal of Asian Social Science, 7*(7), 534-545. https://doi.org/10.18488/journal.1.2017.77.534.545

Shone, E. T., Weldemeskel, F. M., & Worku, B. N. (2024). The role of students' mathematics perception and self-efficacy toward their mathematics achievement. *Psychology in the Schools, 61*(1), 103-122. https://doi.org/10.1002/pits.23033

Silitonga, H. T. M., Panjaitan, M., & Supriyati, Y. (2020). Problem solving based physics learning strategy to enhance students' higher order thinking skills. *Journal of Physics: Conference Series, 1567*(4), Article 042104. https://doi.org/10.1088/1742-6596/1567/4/042104

Singh, C. K. S., Gopal, R., Tek, O. E., Masa Singh, T. S., Mostafa, N. A., & Ambar Singh, R. K. (2020). ESL teachers' strategies to foster higher-order thinking skills to teach writing. *Malaysian Journal of Learning and Instruction, 17*(2), 195-226. https://doi.org/10.32890/mjli2020.17.2.7

Smith, V. D., & Darvas, J. W. (2017). Encouraging student autonomy through higher order thinking skills. *Journal of Instructional Research, 6*, 29-34. https://doi.org/10.9743/JIR.2017.5

Suastra, I. W., Suarni, N. K., & Dharma, K. S. (2019). The effect of problem based learning (PBL) model on elementary school students' science higher order thinking skill and learning autonomy. *Journal of Physics: Conference Series, 1318*, Article 012084. https://doi.org/10.1088/1742-6596/1318/1/012084

Sutama, S., & Anisti, A. (2024). Problem based learning mathematics teaching module: Improving critical thinking skills for vocational high school students. *AIP Conference Proceedings, 2926*(1), Article 020041. https://doi.org/10.1063/5.0182852

Sweller, J., van Merriënboer, J. J. G., & Paas, F. (2019). Cognitive architecture and instructional design: 20 years later. *Educational Psychology Review, 31*(2), 261-292. https://doi.org/10.1007/s10648-019-09465-5

Tanujaya, B. (2016). Development of an instrument to measure higher order thinking skills in senior high school mathematics instruction. *Journal of Education and Practice, 7*(21), 144-148. https://doi.org/10.21009/JISAE.011.05

Tanujaya, B., Mumu, J., & Margono, G. (2017). The relationship between higher order thinking skills and academic performance of student in mathematics instruction. *International Education Studies, 10*(11), 78-85. https://doi.org/10.5539/ies.v10n11p78

Thahir, A., Safitri, M., Wahyuni, C., & Rahmawaty. (2024). How ability to think creative mathematics? using project-based learning and problem-based learning. *AIP Conference Proceedings, 3058*(1), Article 060015. https://doi.org/10.1063/5.0200965

Thomas, T. (2011). Developing first year students critical thinking skills. *Asian Social Science, 7*(4), 25-36. https://doi.org/10.5539/ass.v7n4p26

Tolba, I. G. (2017). *Dispositional theory of thinking and teaching strategies and models*. Al-Mutanabbi Library.

Troyer, L., & Youngreen, R. (2009). Conflict and creativity in groups. *Journal of Social Issues, 65*(2), 409-427. https://doi.org/10.1111/j.1540-4560.2009.01606.x

Ummet, D., Eksi, H., & Erdogan, A. (2019). Predictive role of narcissism and family relations on decision-making characteristics of secondary school students. *Eurasian Journal of Educational Research, 79*, 21-38.

Wijnen, F., van der Molen, J. W., & Voogt, J. (2023). Primary teachers' attitudes towards using new technology and stimulating higher-order thinking in students: A profile analysis. *Education and Information Technologies, 28*(6), 6347-6372. https://doi.org/10.1007/s10639-022-11413-w

Williamson, B. (2023). *Teaching responsible decision making skills*. https://everfi.com/blog/k-12/responsible-decision-making/

Yee, M. H., Othman, W., Yunos, J., Tee, T. K., Hassan, R., & Mohammad, M. M. (2011). The level of Marzano higher order thinking skills among technical education students. *International Journal of Social Science and Humanity, 1*(2), 121-125. https://doi.org/10.7763/IJSSH.2011.V1.20

Zhang, Z. (2024). Research on student interaction in peer collaborative problem solving in mathematics. In Y. Cao (Ed.), *Students' collaborative problem solving in mathematics classrooms: Perspectives on rethinking and reforming education*. Springer. https://doi.org/10.1007/978-981-99-7386-6_8