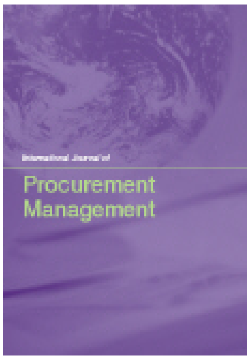

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Designing an innovative model of education management using fuzzy technique

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Designing an innovative model of education management using fuzzy technique

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Abstract: In this paper, we introduce the factors that can improve mathematical learning. The research methodology design, which was done in the period of one year from February 2019 to November 2020, is mixed or combined. In this research, with the help of 13 experts in teaching, learning, and math teaching, using the Delphi method, 17 factors affecting math learning in three Delphi repetitions were included. Content validity ratio (CVR) and content validity index (CVI) also confirm the validity. Then, using the comprehensive fuzzy interpretive structural modelling method, the factors are modelled at seven levels. The data of this method were collected using a researcher-made paired comparison questionnaire in which the incompatibility rate was 0.0024. At the highest level of this levelling, decision-making skills, the ability to understand a variety of knowledge and improve the speed of learning are observed.

Keywords: learning; teaching; comprehensive fuzzy interpretive structural modelling; learning quality.

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1 Introduction

The educational system has several issues that among them the issue of educational failure in various forms, including academic failure in mathematics, is one of the most important issues that causes bad mental effects for the students and their family every year plus wasting financial and human resources of society (Seif, 2011). In this case, there will be a possibility of aversion to mathematics for them, which is one of the biggest obstacles in learning mathematics. Findings show that one of the most important factors influencing students' viewpoints is to make them know what the use of mathematics is in real life. Numerous findings have shown that educational achievements in mathematics are not only influenced by knowledge structures and information processing processes but also are related to motivational factors such as beliefs, viewpoints, values, and anxiety. Seif (2011) found a strong relationship between high motivation, positive viewpoint, and low anxiety with mathematical performance. Therefore, feeling and emotion are very important subjects in mathematics education and can cause effects such as mathematical anxiety and fear, enjoyment of mathematics, mathematical confidence, success, and failure in mathematics (Saha, 2007).

Aiken (2007) also showed that the mathematical viewpoint predicts educational success in mathematics. The National Council of Math Teachers in the USA and Canada has emphasised that the best way to teach the students mathematics is when they construct the mathematical conceptions by themselves (Mann, 2009). Mathematics is not only an educational subject with limited objectives but it is the natural flow of human thought, and the children experience mathematical comprehensions by natural methods since their childhood. Due to the great importance of mathematics in different societies, it is the task of many experts and researchers to study how to achieve mathematical knowledge through learners (Varzdar, 2009). Due to the application of mathematics in various aspects of human life, proper learning of this science is essential to be able to achieve academic goals and make further progress in mathematics, learners need to make effective use of learning strategies. Teaching these strategies in class empowers students and enables them to increase learning by using the correct methods of study and monitoring their activities (Alamolhodaei, 2009). On the other hand, it can be emphasised that mental restraints can be taught and math teachers can teach these methods to students with proper planning so that they can increase their math skills and reduce their math anxiety, and consequently have better performance as well. Recent research has shown that an important part of student restraint can be taught. Research in the field of cognitive strategies has also shown that the use of these plans leads to increased learning for learners, this effect is especially significant for learners who somehow face learning difficulties (Beckman, 2002). In some sciences, such as mathematics, because of its abstraction and the imagination of not using it in everyday life, students become disinterested in it and this disinterest gradually becomes a hatred (Samadi, 2019). This phenomenon has bad effects on the core of the personality of students and their mental health in addition to the huge economic losses that are caused because of repetition of the lessons, (Alamolhodaei, 2009). The most important factors that can affect learning, self-concept, and anxiety are learning strategies relevant to learning levels to identify the factors affecting learning. Anxiety because of math lessons is a reaction by students to subject-related elements that include things like listening to a lecture, teaching math concepts, solving math problems in class, or a math test. This anxiety is caused by numerous factors and the most common one is the negative experiences in mathematics education. Students who struggle with math anxiety feel that they are the only ones suffering from it. By becoming familiar with learning levels, teachers can improve student performance and reduce this anxiety.

2 The significance of learning math

Learning is a complex process in which many different factors and elements are involved in creating, facilitating, and accelerating it. Physical and mental development, prior preparation and knowledge, methods and strategies of learning, intelligence and memory of students all are factors that independently or in interaction with each other, affect the mental learning activities and consequently affect their educational performance. The world of education today has shifted its focus from teaching (knowledge transfer) to learning. This approach makes learning the basis of all education programs and policies. Achieving the goals of such an approach requires paying attention to the productivity of new and student-centred methods. Because mathematics requires the acquisition of many basic concepts and certain mental development, this factor plays an important role in the students' status in school mathematics. Examining the type and the amount of the basic and required preparation for learning mathematics at this time can help the teacher in choosing appropriate methods for teaching and preparing the appropriate educational activities and ultimately guide the child to understand the concepts of mathematics and learn its rules and principles. As Peterson (1992) says: "When a teacher is aware of how students think mathematically, it can facilitate the development of students' mathematical abilities with poor backgrounds" (Peterson, 1992). Some experts in the field of mathematics education believe that the requirement for life in today's complex and advanced world is to have a creative, dynamic, and productive mind, and effective learning of mathematical knowledge can help the formation and growth of this mind.

2.1 Math learning

Mathematics despite its importance as a basis for learning other sciences, has always been considered a difficult and frightening lesson for students, and the teaching and learning process encounters problems. As much as that sometimes students, instead of learning deeply, are content to only memorise it and are satisfied with just getting a score to pass this grade of the education. This is where the need to improve the teaching and learning process must be considered. Unfortunately, in math classes, the lecture method is mostly used plus sometimes the question and answer method. But the game can help training, end this repetitive process and improve training (Ayin, 2009). The process of teaching effective learning is the product of an accurate design and organisation plus attention to the diversity of teaching and learning strategies and the use of their most effective tools. The needs and interests of students are different from the previous generation so the way of teaching them has also changed (Ayin, 2009). Therefore, in the coming millennium, we cannot determine the strategy for the educational system by the legitimacy of the previous century, and it matters that we have not taken this period seriously (Wheeldon, 2008). New developments in mathematics learning focus on strengthening the learner's role in learning. This requires involving the student in activities that lead to effective learning because all learning begins with an experience. Feedback from information gained by experience is refined in the mind and leads to decisions about the information obtained plus the related beliefs and attitudes. Then the interface information is organised and stored in memory. New learning experiences (what is taken into the mind) use existing schemas (assimilation) and cause a change (called adaptation in psychology) in schemas. Mathematics should be related to other subjects and daily experiences of the child, thus the incarnate and objective tools and equipment should be related to visual symbols and finally to abstract symbols (Miri et al., 2012).

3 Bloom's modified classification

3.1 Classification of educational goals by Bloom's viewpoint

Bloom (1956) presented the most famous classification, which is generally divided into three domains: cognitive domain goals, emotional domain goals, psycho-motor domain goals, and each domain includes several subdomains.

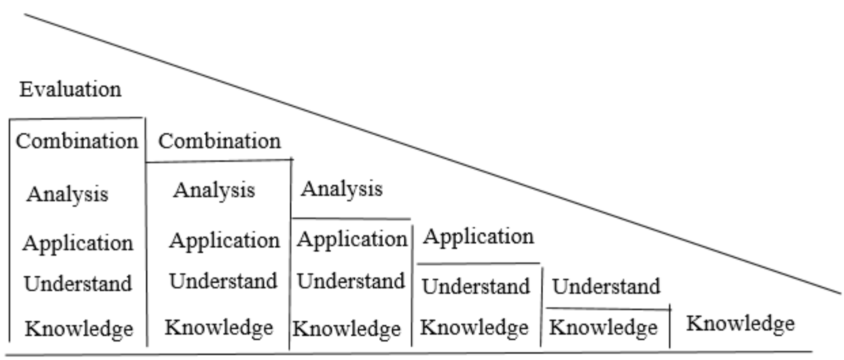
The cognitive domain includes knowledge, information, and mental abilities and skills.

- Emotional domain: Deals with interest, motivation, viewpoint or appreciation, and valuation.
- Psychomotor domain: It is related to activities that are mostly physical.

3.2 Primary domain of cognitive domain goals

The goals of the cognitive domain are related to knowledge and information and are related to the currents that deal with human mental and intellectual activities. According to this, this domain is the most important domain of learning because most of the educational activities in schools, and most of the subjects and educational goals are related to this domain. In 1956, Benjamin Bloom and his colleagues classified cognitive goals into six domains. Each of these domains describes a type of cognitive process. These six domains include knowledge, perception, application, analysis, synthesis, and evaluation, which are arranged hierarchically from objective and simple to abstract and complex.

Figure 1 Classification of educational objectives (cognitive domain)



This classification is designed to categorise educational objectives, to help teachers, researchers, and curriculum planners for better understand in curricula and educational problems. Bloom considered the primary classification to be more than a measurement tool. He believed that this classification could be as:

- A common language was developed to present the goals of learning, teaching, and curriculum to facilitate communication between individuals on topics and at different levels.
- A basis for identifying a specific topic or curriculum.
- A tool to determine the proportion between educational goals, activities, and assessment in a unit, course, or curriculum.
- A perspective to show the different teaching methods that can be adopted due to the breadth and depth of a particular subject or curriculum (Amer, 2006).

3.3 Weaknesses of Bloom's primary classification

There are weaknesses and limitations seen in Bloom's primary classification. A notable weakness is that cognitive processes are arranged on a one-dimensional basis from simple to complex behaviours (Karampour et al., 2011); another weakness of this classification is that some parts of knowledge are much more complex than the analysis and evaluation parts. Also, evaluation is less complex than com Also, in cumulative hierarchy, it is assumed that there is no commonality between the groups. As Anderson et al. (2005) suggested, "If cumulative hierarchy is considered in such a way that dominating a complex group requires dominating previous groups with less complexity", it will be a difficult standard.

According to Bloom Taxonomy, the knowledge group includes aspects of noun and verb for each purpose simultaneously. The broad subgroups of knowledge refer to the noun aspect and the verb aspect is included in the definition of knowledge that students should have ability to remember or recognise information. But this has been eliminated irregularly in Revised Bloom Taxonomy. Therefore, the noun and verb aspects are placed in different dimensions, the noun aspect is placed in the knowledge dimension, and the other one is placed in the cognitive processes dimension.

3.4 Revised Bloom Taxonomy

After Bloom Taxonomy was published in 1956, educational and psychological researchers faced the introduction of various theories for learning that gave students more responsibilities for their own learning and thinking (e.g., constructivism, information processing, metacognition and self-regulatory learning. Revised Bloom Taxonomy used these theories and revised the initial classification according to the theories mentioned and expressed to eliminate the shortcomings (Radmehr and Alamolhodaei, 2010). Revised Bloom Taxonomy includes two dimensions: knowledge dimension, cognitive process dimension. The modified Bloom classification structure is presented in Table 1.

Table 1 Revised Bloom Taxonomy

	Remember	*Understand*	*Use to*	*Analyse*	*Evaluate*	*Produce*
Basic knowledge						
Conceptual knowledge						
Executive knowledge						
Metacognitive knowledge						

4 Knowledge dimension

According to Anderson et al. (2005), knowledge dimension in Revised Bloom Taxonomy is introduced into the following four categories, each of which will be expressed with an example:

- *Factual knowledge*: Basic information that students need to know to be able to solve the problem in a specific discipline or topic that includes two sub-sections:
    1. *Knowledge of terminology*: Vocabulary terms, mathematical symbols, musical notes, letters of the alphabet.
    2. *Knowledge of specific details and elements*: Components of the food pyramid, the names of government ministers.
- *Conceptual knowledge*: It refers to the relationship between factual knowledge and its relationship to the broader structures which makes them work together, which includes three subsections:
    1. *Knowledge of classifications and categories*: Types of animals, types of reasoning, geology courses.
    2. *Knowledge of principles and generalisations*: The laws of democracy, the laws of Newton, the laws of probability, Euclid's principles.
    3. *Knowledge of theories, models, and structures*: Theory of gradual evolution, economic theories, structure of DNA models.
- *Procedural knowledge*: It refers to the method of doing the work, the research method, the criteria and how to use the skills, algorithms, techniques and methods, which includes three sections:
    1. *Knowledge of subject specific skills and algorithms*: It refers to the methods to solve quadratic equations, essential watercolour techniques and skills in painting, division algorithm for integers.
    2. *Knowledge of subject specific techniques and method*: Methods to solve mathematical problems, interview techniques to data collection.
    3. *Knowledge of criteria for determining when to use appropriate procedure*: It refers to suitable methods to perform various experiments, appropriate time for using the fractional method in integration, suitable time for using Newton's second law in physics problems.
- *Metacognitive knowledge*: It refers to the knowledge of cognition in general and in addition to knowledge of ourselves (thinking about thinking) which consists of three sections which are expressed below with an example.
    1. *Strategic knowledge*: This type of knowledge refers to ways of memorising facts, conceptual comprehension strategies, methods of designing a web page, knowledge of using exploratory discussions.
    2. *Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge*: Differences between the needs of readers of textbooks and story books, the difference between an e-mail and a business letter.
    3. *Self-knowledge*: The need for a chart or table to understand complex processes in a better way, the need for sharing ideas with others before writing an article, the knowledge to critique an article written by yourself in terms of the strengths or weaknesses of the article (Miller, 2004).

5 Cognitive processes dimension

The cognitive processes dimension in the revised taxonomy consists of 6 sections. Its number is equal to the original taxonomy, but the names of some sections have been changed, and the place of evaluation and generation have been replaced with each other. Also, all cognitive processes have changed from noun to verb aspect to adapt to the way used to define goals according to this taxonomy. The hierarchy between cognitive processes is the same as Bloom's original taxonomy in the revised taxonomy, in this way that it has begun with a reminder with less complex, and ended with a generation that is more complex than cognitive processes (Radmehr and Alamolhodaei, 2010). Each of these cognitive processes is expressed with an example in the following:

- *Remember*: Recovering long term memories, which consists of two sections:
  1. *Recognition*: Finding amphibians from photos of animals, finding equilateral triangles from given triangles, answering questions, correct/wrong.
  2. *Summon*: Writing a table of multiplication of one-digit, Name three poets of the 17th century?
- *Understand*: Ask them to identify the meaning of an educational statement, whether oral, written or visual, which consists of seven sections.
  1. Interpret: Ask them to turn a verbal problem into an algebraic equation, to draw a diagram of the body's digestive system.
  2. To cite an example: Ask them to draw a parallelogram, to name the domestic animals that live in your living area.
  3. Grouping: Ask them to classify numbers into two categories: prime numbers and compound numbers, to make a list of domestic and wild animals in two different columns.
  4. Summarise: Ask them to summarise a story.
  5. Inference: Ask them to guess the next number after looking at a sequence of numbers, listen to a piece of conversation between two characters and conclude about their previous relationship.
  6. Compare: Ask them to explain how the heart works like a pump, show even and odd functions using a graph.
  7. Explain: Ask them to explain how bank interest rates affect the economy, explain how atmospheric pressure affects the climate by drawing a diagram.
- *Apply*: Performing or using an algorithm in a given situation.
- *Execute*: Ask them to read a piece of text in a foreign language, multiply two two-digit numbers.
- *Implement*: Ask them to design an experiment to see the growth of plants in different soils.
- *Analyse*: Breaking down an article into its constituent parts and identifying how the relationship between the components of the article has been able to form the purpose or structure, which consists of the following three sections:

1. Distinguish: Ask them to make a list of important information in a mathematical verbal problem and remove trivial information trivial information.
2. Organise: Ask them to organise school library books in an appropriate way.
3. Attribute: Ask them to determine the motivation of the characters in a novel or short story.

- *Evaluate*: Judging by rules and standards, which consists of the following two sections:
  1. Check: Ask them to listen to a political speech and make a list of the contradictions in the speech.
  2. Criticise: Ask them to choose the best way to solve a complex math problem, to check the correctness or incorrectness of the solution given by a classmate to a math problem.
- *Create*: Putting elements together to form a cohesive article or create a new intellectual product, which consists of the following three parts:
- *Generating*: Ask them to make some scientific hypotheses to explain why plants need sunlight.

  Position because composition…

  - *Infer*: After looking at a sequence of numbers, guess the next number, listen to a piece of conversation between the two characters, and draw conclusions about their previous relationship.
  - *Compare*: Explain how the heart works as a pump. Show even and odd functions using a graph.
  - *Explain*: Explain how bank interest rates affect the economy, draw a diagram of how atmospheric pressure affects the climate.
    1. Apply: Perform or use an algorithm in a given situation.
       - *Perform*: Read a piece of text in a foreign language, multiply two two-digit numbers.
       - *Implement*: Design an experiment to see the growth of plants in different soils.
    2. Analyse: Analyse an article into its constituent parts and identify how the components of the article relate to each other that have been able to form the purpose or structure, which includes the following three sections:
       - *Distinguish*: List important information in a mathematical verbal problem and write down unimportant information.
       - *Organising*: Organise school library books appropriately.
       - *Attribution*: Determine the motivation of the characters in a novel or short story.
    3. Evaluate: Judging by rules and standards, which includes the following two parts:

- Examination: Listen to a political speech and make a list of the contradictions in it.
- Criticise: Choose the best way to solve a difficult math problem, check the correctness or incorrectness of the solution presented by a classmate for a math problem.

4 Create: Putting elements together to form a cohesive story or create a new intellectual product that consists of the following three parts:

- Generating: Make some scientific hypotheses to explain why plants need sunlight.
- Planning: Plan a scientific study to test the effect of music on plant growth.
- Producing: Make a container for birds' water.

6 Learning management system

In today's world, learning can be done for everyone in all places and at all times. With the use of the Internet and extranets, e-learning (e-learning) has become an integral part of teaching and learning. Piner (2015) reports that higher education ranks first in the list of top industries using e-learning. Research on theories and methods of learning in cyberspace has been conducted and concluded that its significant benefits and contribution make it important and fundamental for learners. Therefore, more educational institutions are taking steps to use this technology and are preparing to improve the way they provide guidelines and regulations and the performance of their class (Anderson et al., 2005). These activities to create educational and training materials in the classroom in a new environment and space, the era of virtual learning environments, distance learning, learning management systems (LMS), content management systems and content management systems. It creates a competitive advantage. But we need to know that LMS are the best way to respond to education in university higher education institutions (Zimmerman and Pons, 1986). Zimmerman and Pons stated that LMS has great potential for demand in all developed or developing countries as an alternative learning path both in the field of education and industry. These are now becoming one of the most important tools and measures in enhancing the teaching and learning process. The most important task and user code of the LMS is to develop, store, store and distribute and manage learning objects, such as student activities, reading materials, portfolios and assessment records.

7 Creative thinking learning management model

Sanders (1966) concluded in his research that the creative and innovative human being has a "question-mind-sensitive mind and environment" and Newell, Shaw, and Simon (1962) concluded that creativity is a type of problem-solving behaviour. And accountability is individual or group, and problem solving is an important part of learning management, especially in mathematics. Guilford (1950) described the creative paradigm as manifest in creative behaviour, including behaviours such as invention, innovation, design, production, composition, and planning. Around different issues, ideological mastery, set flexibility, idea novelty, ability combining and sharing, reorganising or redefining ability such as Gestalt psychology, scope of thought structure such as complexity of individual conceptual structure and evaluation of ability beyond this, Feldhusen and Kolloff (1986). The relevant factors in the creativity model are presented as follows:

1 metacognitive processing a set of metacognitive strategies or skills for processing information and acquired knowledge and using the knowledge base

2 knowledge base, large and fluent knowledge base to develop and improve skills in a specific field

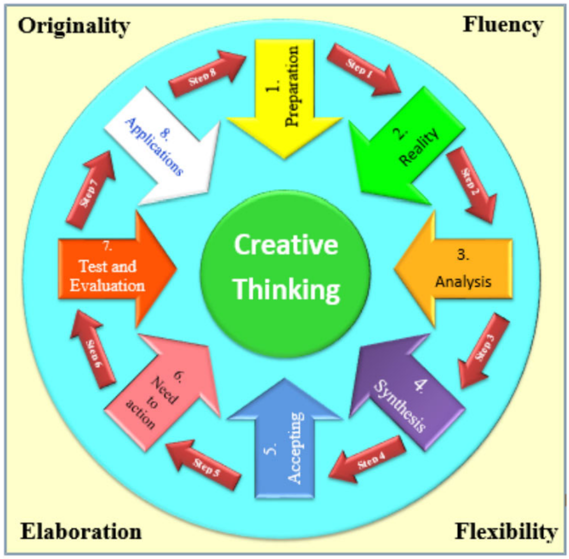
3 personality includes the attitudes, values, attitudes, motivations of individuals, and personal experiences that make the learner inclined to seek alternatives, new settings, or unique solutions.

Table 2 The creative thinking learning management model eight steps

	Step	*Meaning*	*Activities*	*Output*
1	Preparation	Prepare to face the situation.	Creative situation brainstorming	Knowledge of the situation
2	Reality	Understanding the truth of the problem.	Discussion, focus group, and brainstorming	Understand the importance
3	Analysis	Analytical thinking by distinguishing the various parts of the problem.	Mind map, concept map, diagram, and flowchart	Have a clear understanding.
4	Synthesis	The synthesis of the solution and priorities	Classification, priorities	Solutions
5	Accepting	Is the decision to exit the right approach?	Discussion focus group, brainstorming.	Have a choice. The right approach.
6	Need for action	Follow the alternative and accept the result.	Practice and preparation	Follow the choice/accept the consequences
7	Test and evaluation	Check the results	Presentation, model, and testing	The results of the practice.
8	Applications	Using creativity to create new things.	Productivity	New work/new method

So, we can say that problem solving is a complex and difficult process that involves different types of knowledge, information and individual and group skills. For this purpose, Atai et al. (2015) has presented a model of eight stages of creative thinking, which includes the following stages.

Figure 2 Creative thinking learning management model (see online version for colours)



Source: Atai et al. (2015)

8 UAcD model: learning management model

The learning management model to increase creativity and production in this research was the 'UAcD' model, which used the beginning of the learning process in the model (Ac stand for access). The components were content, micro and macro goals, learning process and stages, media and learning resources, and thought and knowledge feedback. The essence of each component is described below:

1 Theme: Creativity and innovation skills are important skills for competition. Learning management must improve the learner to develop creative and innovative skills in order to have a competitive advantage in the future.

2 Purpose: To improve the power of creativity and innovation and thought and skills in the knowledge force.

3 Learning processes: The learning process of the learning management model to improve the abilities of creativity and innovation and creation consisted of 3 stages, the complexity of which is explained based on the learner:

Phase 1 Understanding. Comprehensive encouragement to look at the barriers that exist at the individual, classroom and school level, whether there is a problem with homework, classroom, use of resources in the classroom and waste management at school. Then, the learner examines the cause or system of the problem, how the problem is in other cases, the disadvantages of the problem, or the benefits after solving the problem. After analysing the problem and stating the importance and necessity of the problem and solving the problem, the learner thought about his potential to solve such a problem alone or work to find a group solution and to solve the problem using the process of creating innovation.

Phase 2 Access to incentives to acquire knowledge and information to provide different solutions using 5 stages of knowledge that include

1 the goal of pursuing students
2 planning to share and develop knowledge
3 knowledge processing followed
4 review and analyse data.
5 gather knowledge.

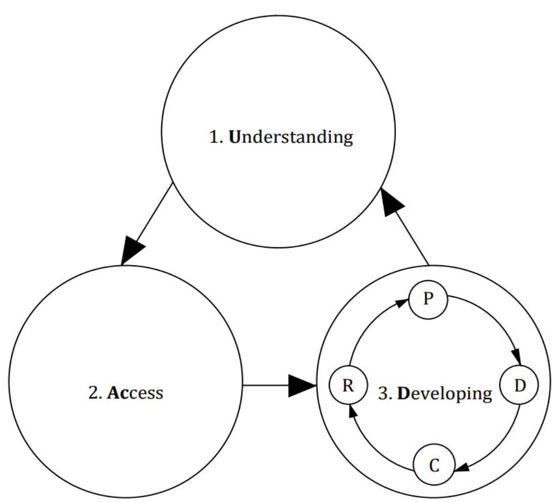
As the learner acquired enough knowledge to innovate to solve the problem, he or she went to phase 3.

Phase 3 Development. Develop problem-solving innovation based on the knowledge gained from step 2. Innovation to solve a problem may be a way of thinking, acting, or inventing that is different from a traditional concept, method, or choice. The trend of the development cycle was innovation, which consisted of 4 stages: planning, implementation, review and feedback.

4 Media and learning resources: Use media and learning resources at school, home or community, as well as online media or resources, and develop the right person or wisdom with the problem that the learner wants to develop.

5 Assessment and feedback: For assessment and evaluation by observing the skills of creativity and pervasive innovation was done individually or as a team. Scoring and archiving indicators based on valid evaluation; be tested with various learning activities. Feedback was provided to the student through encouragement, confidence building, and the purchase of individuals to use to improve thinking and efficient learning. The learning management model for improving creativity and innovation skills is as follows:

Figure 3 The ‘UACD’ model



Source: Arieti (2011)

9 Background research

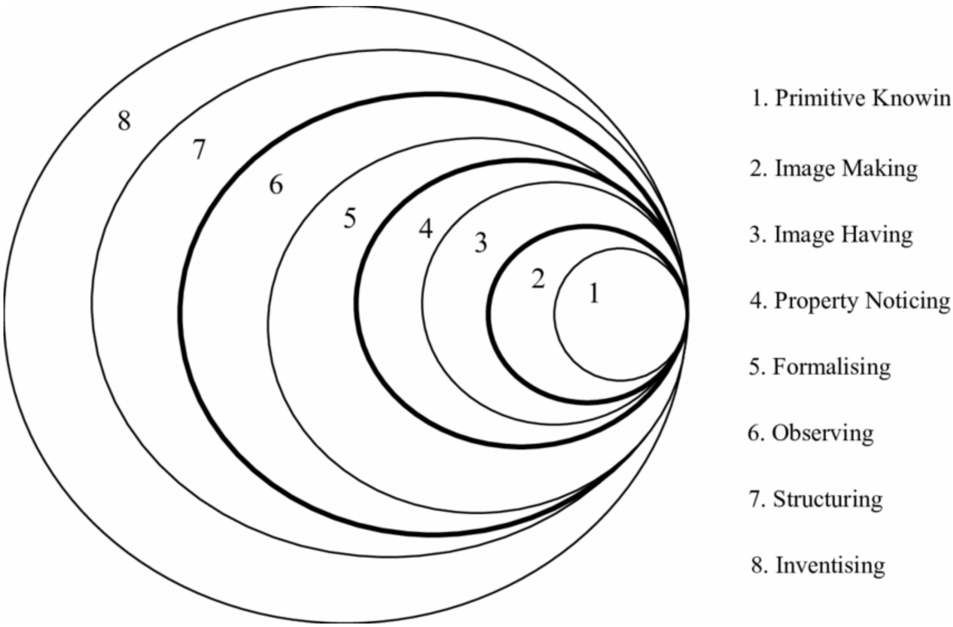
9.1 Introduce models and frameworks designed to examine and develop students' perceptions

9.1.1 Kieren model

In the Kieren model (1993), quoted by Stewart (2005), mathematical understanding showed by using eight circular levels. The surface below the motion diagram between these levels does not require from the smallest to the largest circle. Also, in this model, due to returning recursively property, the more the learner returns to the previous levels, the more his knowledge of the subject increases. The following is a brief description of each of them.

1. Primitive doing: It is the core of action and includes the learner's basic knowledge. In the fractions, students' ability to separate an object, such as splitting a pizza, is the primary action and core of fraction perception.
2. Image making: At this level, mental images form, and with specific actions, the learner can apply his informal knowledge in new situations. In the fractions, working with different sharing problems and representing such actions using the fraction symbol corresponding to the result falls into this level (Stewart, 2005).
3. Image having: One of the activities at the level of image having is that the learner forms objects and mental images and responds to the summoning of an action. Fractions are a mental issue for the learner.
4. Property noticing: This level is a return to previous levels. The learner is able to develop patterns, properties, conjectures, and connections between concepts from the previously formed subject matter. For example, the learner believes that a sequence of equivalent fractions made from the given one.
5. Formalising: At this level, the learner engages in self-conscious thinking. Knowing is achieved beyond specific actions and mental imagery in the previous stages, mathematical definitions are formulated. For example, the learner can see all fractional numbers in expressions and knows that any fractional number can be written in the form provided that the opposite denominator is zero (Stewart, 2005). At this level, it is seen that mathematics is a metaphor for the events of the material and real world. Mathematics is abstract, although it does not need to be expressed in generalised mathematical terms or symbols.
6. Observing: At this level, the learner can consider his consciousness, process his or her thoughts, and at the same time structure and organise them. For example, the learner realises that there is no smallest positive fraction.
7. Structuring: The learner can now organise his previous level observations into a set of systematic assumptions. Formal proofs form at this level. About fractions, the learner will not see the sum of fractions only as of the act of combining values, but as a logical consequence of the nature of formal equivalence.
8. Inventing: At this level, the learner acquires the ability to change the whole process of thinking about a mathematical subject without removing the structure and by understanding the previous ways of knowing. New questions arise that may lead to an entirely new meaning.

Figure 4 A retrospective approach to mathematical understanding



Source: Stewart (2005)

The results of the Muelas and Navarro study (2015) entitled "Learning Strategies and Academic Achievement" show that learning strategies are significantly related to students' academic performance, especially the subject of language. On the other hand, in mathematics, a significant correlation was seen with the encryption strategy.

In a study entitled "Differences in the application of learning strategies in mathematics in the eighth and ninth grades" conducted by Gasco et al. (2014), the findings found a statistically significant difference in the interest of ninth-grade students in the use of organisation, metacognition and helping strategies.

In Radisic et al. (2015), in their study entitled "Mathematical Anxiety, the contribution of individual and school factors", stated that success and interest in mathematics, high mathematical self-concept, and classroom and school atmosphere are associated with lower levels of math anxiety.

Andrei et al. (2014), in their study entitled "Comparative study between study tracks: math and sciences or humanities, regarding academic motivation and learning strategies in the 9th grade students". They have come to the conclusion that the methods of organising and teaching mathematics students are more important than those of humanities students. Those who improve their planning strategies in different environments become more efficient, better plan and structure their tasks, and ultimately better influence students' academic performance.

Sadi and Uyar (2012), in their study entitled "The relationship between cognitive self-directed learning strategies and the development of biology lessons", noted that students who use learning strategies are more successful than other students. They also stated that cognitive self-directed learning strategies are useful for predicting and improving students' learning goals and strengthening their social aims and success.

Perez et al. (2012), in a study entitled "Explanatory model of academic success based on talent, goal orientation, and self-concept and learning strategies", achieved the following results: Intelligence is one of the variables that give the most explanation about academic success.

Sharifi et al. (2014), in his research entitled "The role of mathematical self-efficacy, self-concept, and perception of the classroom environment in the mathematical progress of students with gender control". They stated that with the introduction of the variables of self-efficacy and mathematical self-concept, perception of the classroom environment became meaningless. It also showed that self-efficacy and self-concept play a mediating role between the perception of the classroom environment and mathematical progress.

According to the results of the study of Arabzadeh et al. (2013) entitled "Review of the effectiveness of teaching self-directed learning strategies on controlling students' social problem-solving", teaching self-directed learning strategies helps students to be able to talk about their social and educational issues. Decide better and offer solutions. Be more intense and more accurate about their thinking and learning process, and believe they can resolve issues.

In Soleimani and Rekabdar's (2013) research entitled "Study of the relationship between study approaches and academic achievement of mathematics with the mediating role of mathematical anxiety", the results showed that students with a cursory study approach show weaker mathematical performance even in non-conceptual exams.

In Namour et al. (2012) study entitled "The effect of teaching metacognitive strategies on the scientific literacy of female students in the third grade of middle school", findings indicate a positive and significant relationship between teaching metacognitive strategies and subsets of scientific literacy such as understanding key concepts, understanding the nature of science, the scientific method and the scientific attitude.

In the study "Study of the relationship between cognitive and metacognitive strategies and academic performance of female high school students" conducted by Talezadeh et al. (2012), the results showed that there is a positive relationship between cognitive strategies and academic performance of third-grade female students in literature. And there is meaning.

Miri et al. (2012), in a study entitled "The effectiveness of teaching cognitive strategies on reducing learning disabilities in primary school children", Concluded that by considering pre-test scores as a scattering variable, teaching cognitive strategies affected increasing and improving math performance, spelling, and reading of elementary school students with learning disabilities.

Dolati et al. (2012) conducted a study entitled "Study of teaching self-regulatory strategies on procrastination and academic self-concept of first-grade high school students". The results showed that training self-regulatory strategies has reduced academic procrastination and increased students' academic self-concept.

Torabi et al. (2013) entitled "Study of the role of mathematical anxiety on performance in mathematics and the role of gender". The results showed that among the components of mathematical anxiety, only mathematical learning anxiety could predict performance in mathematics, but the difference between male and female students was not significant.

10 Research methodology

The statistical population of this research includes elites and professors of accounting, auditing, and financial management and formal and independent auditors. The statistical sample of it was selected using a purposeful and homogeneous sampling method with a sufficient number of university faculty members and experts who have expertise in the fields of accounting, auditing, and financial management and at least three years of experience in related activities. The sample members were selected by purposive non-random method, and if necessary, by snowball method. This research, with the help of a panel of experts, includes 13 people.

For data collection, a researcher-made questionnaire was used, which was collected through the words of respondents. After completing the questionnaires by decision makers, linguistic variables (verbal expressions) were converted to fuzzy numbers for calculations. For this purpose, in the present study, a fuzzy spectrum was used, which shows the corresponding relationship between verbal expressions, their code, and triangular fuzzy numbers. In this regard, in the present study, the research questions are:

1. What are the factors affecting math learning?
2. According to the structural fuzzy comprehensive interpretive modelling approach, how are mathematical learning levels designed in a model?

In this research, with the help of SPSS statistical software version 25, Maxqda version 12, MATLAB, and Excel to perform comprehensive fuzzy interpretive structural modelling calculations to answer questions.

11 Stages of comprehensive fuzzy interpretive structural modelling (fuzzy-TISM)

Stage 1 Identify the factors affecting mathematical learning

Factors affecting the learning of mathematics, which are enumerated in this step, indicate the answer to the first question of the research, which is shown in Table 3.

Table 3 Factors affecting mathematical learning

Symbol	*Variable*	*Sources*
C_1	Ability to understand the content and concepts of a variety of knowledge	Pooyamanesh and Ramezani (2011) and Zarea et al. (2011)
C_2	Responsibility	Smiling et al. (2011) and Rahmani (2004)
C_3	Appropriate environmental stimuli (light, temperature, etc.)	Seif (2011), Gasco et al. (2014) and Anderson (2002)
C_4	The power of expression and the body language of the teacher	Kazemi and Aliei (2019) and Wheeldon (2008)
C_5	Proper cooperation and communication with the teacher	Karshki (2013), Olson (1988) and Yadollahi et al. (2012)
C_6	Participatory-centred educational layouts in the classroom	Samadi (2019) and Maidani and Sharifi, (2014)

Table 3 Factors affecting mathematical learning (continued)

Symbol	*Variable*	*Sources*
C_7	Students' accuracy and readiness	Andrei et al. (2014) and Namour et al. (2012)
C_8	Paying attention to the active hemispheres of the brain	Muelas and Navarro (2015) and Amer (2006)
C_9	Decision making and problem-solving skills	Aliei et al. (2019) and Miri et al. (2012)
C_{10}	Familiarity with note-taking tools of all kinds of knowledge	Lowrie and Whitland (2010) and Baddeley (2017)
C_{11}	Group participation	Teymouri (2017), Alamolhodaei (2009) and Airasian and Miranda (2002)
C_{12}	Learning speed	Green and Kris (2010) and Aghajani et al. (2012)
C_{13}	Students' sensory perception and memory	Zhan and Zarea (2020) and Saha (2007)
C_{14}	Indoctrination of themselves and others	Ashcraft and Krik (2001)
C_{15}	Motivation	Aliei et al. (2019) and Pezeshki et al. (2011)
C_{16}	Perseverance	Radmehr and Alamolhodaei (2010)
C_{17}	Variety of assignments	Meelissen and Luyten (2008)

Stage 2 Formation of a pairwise comparison matrix using a survey of experts (D)

In the pairwise comparison matrix, the factors are compared in pairs.

V the variable i affects the variable j

A the variable j affects the variable i

X the variables j and i affect each other

O factors i and j are unrelated.

Table 4 Verbal expressions, related codes, fuzzy numbers, and how to show the intensity of the impact in the model

Triangular fuzzy number	*Code*	*Verbal phrase*	*Likert spectrum number*
(0.25, 0, 0)	NO	No effect	0
(0.25, 0.5, 0)	L	Low impact	1
(0.5, 0.75, 0.25)	M	Medium impact	2
(0.75, 1, 0.5)	H	high impact	3
(0.75, 1, 1)	VH	Very high impact	4

Table 5 Best non-fuzzy performance (see online version for colours)

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*
C1	0.000	0.027	0.011	0.015	0.014	0.025	0.030	0.043	0.049	0.014	0.013	0.037	0.013	0.019	0.016	0.022	0.017
C2	0.025	0.000	0.018	0.015	0.017	0.015	0.014	0.014	0.049	0.018	0.017	0.032	0.019	0.027	0.043	0.014	0.013
C3	0.024	0.042	0.000	0.048	0.047	0.049	0.047	0.041	0.043	0.041	0.069	0.033	0.032	0.013	0.041	0.022	0.033
C4	0.025	0.028	0.042	0.000	0.011	0.034	0.046	0.049	0.026	0.060	0.036	0.036	0.019	0.020	0.037	0.022	0.050
C5	0.050	0.040	0.013	0.013	0.000	0.034	0.036	0.040	0.045	0.048	0.062	0.023	0.042	0.041	0.043	0.035	0.035
C6	0.044	0.035	0.036	0.050	0.049	0.000	0.037	0.048	0.044	0.052	0.036	0.060	0.042	0.062	0.041	0.014	0.039
C7	0.025	0.038	0.017	0.010	0.017	0.036	0.036	0.031	0.036	0.017	0.016	0.036	0.020	0.016	0.039	0.022	0.017
C8	0.022	0.028	0.015	0.002	0.018	0.032	0.020	0.000	0.013	0.027	0.020	0.017	0.036	0.018	0.011	0.019	0.035
C9	0.029	0.028	0.012	0.017	0.011	0.015	0.044	0.033	0.000	0.017	0.018	0.014	0.013	0.022	0.019	0.016	0.015
C10	0.025	0.024	0.018	0.013	0.030	0.019	0.035	0.015	0.013	0.000	0.021	0.012	0.023	0.018	0.015	0.033	0.016
C11	0.035	0.025	0.018	0.011	0.009	0.015	0.017	0.011	0.019	0.018	0.000	0.022	0.016	0.013	0.036	0.014	0.015
C12	0.023	0.024	0.011	0.014	0.011	0.015	0.033	0.015	0.018	0.020	0.027	0.000	0.018	0.011	0.014	0.021	0.011
C13	0.027	0.025	0.014	0.014	0.018	0.017	0.033	0.038	0.016	0.021	0.015	0.018	0.000	0.015	0.045	0.050	0.015
C14	0.025	0.025	0.015	0.020	0.016	0.035	0.038	0.015	0.011	0.018	0.049	0.053	0.014	0.000	0.016	0.023	0.018
C15	0.045	0.030	0.019	0.011	0.030	0.018	0.015	0.017	0.041	0.012	0.013	0.033	0.016	0.023	0.000	0.023	0.002
C16	0.027	0.028	0.017	0.017	0.013	0.019	0.036	0.012	0.053	0.015	0.017	0.030	0.039	0.014	0.013	0.000	0.008
C17	0.035	0.023	0.015	0.015	0.014	0.014	0.173	0.041	0.015	0.043	0.038	0.054	0.054	0.036	0.044	0.015	0.000

Table 6 Occurrence matrix (R) (see online version for colours)

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*
C1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
C2	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
C3	0	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0
C4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
C5	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1
C6	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1
C7	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
C8	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1
C9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C10	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
C11	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
C12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C13	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0
C14	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
C15	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
C16	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
C17	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0	0

Table 7 Initial access matrix (M) (see online version for colours)

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*
C1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
C2	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
C3	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
C4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1
C5	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1
C6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
C7	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0
C8	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1
C9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
C10	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0
C11	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
C12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
C13	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0
C14	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0
C15	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
C16	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0
C17	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0	1

Table 8 Final access matrix (M^*)

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*	*Influence power*
C1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3
C2	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	4
C3	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	17
C4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	14
C5	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	1	14
C6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	17
C7	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	8
C8	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	13
C9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
C10	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	9
C11	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	9
C12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
C13	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	8
C14	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	11
C15	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	4
C16	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	8
C17	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0	1	13
Dependence power	15	13	2	3	3	2	12	6	16	8	7	16	12	7	14	12	7	

Stage 3 Fuzzy judgment matrix formation (G)

To perform operations on interpretive structural equations, it is necessary to integrate the opinions of experts (Norsyahida and Lazim, 2015).

Stage 4 Creating a normalised matrix (N)

To calculate the normalised matrix, the judgment matrix, and the gamma value, γ which is calculated using the following equation, is used:

$$\gamma = \max_{1 sisn} \sum_{i=1}^{n} u_{ij}$$

Stage 2 Best non-fuzzy performance

There are several methods for converting a fuzzy matrix to a diphasic matrix with definite numbers. The best of these methods is the best non-fuzzy function. The following equation is used to calculate the non-fuzzy number (Akyuz and Celik, 2015):

$$BNP_{ij} = \frac{u_{ij} - l_{ij} - m_{ij} - l_{ij}}{3} + l_{ij}$$

Stage 6 Calculate the threshold (C)

It is necessary to obtain a threshold using the arithmetic mean of the values of the diffused numbers in the whole matrix.

Stage 7 Formation of the occurrence matrix (R)

We set the elements that are equal to or greater than the threshold to 1 and the values that are less than the threshold to zero (Zhong et al., 2011).

Stage 8 Formation of the initial access matrix (M)

$$M = R + I$$

Thus, the initial access matrix will look like this: (Table 7).

Stage 9 Formation of the final access matrix (M^*)

Expert polls were not included, but in the final access matrix their relationship is confirmed and has a number equal to one. They are transitional relationships and are marked with an asterisk.

Stage 10 Formation of input, output and common set and levelling of factors

In this stage, using the final access matrix, the output and input sets for each variable are obtained. The output and input sets for a variable are defined as follows.

Figure 5 The final model of fuzzy interpretive structure of mathematical learning levels

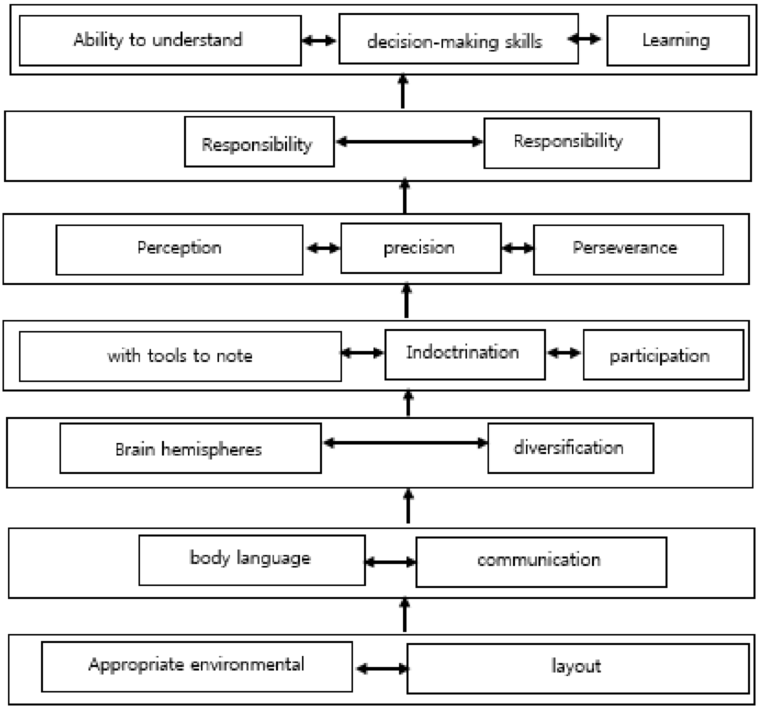


Table 9 Levelling in fuzzy comprehensive interpretive structural equations

Level	*Joint collection*	*Input set*	*Output set*	*Criteria*
7	1	12-9-1	-14-13-11-10-8-7-6-5-4-3-2-1 17-16-15	C1
6	2	15-12-9-2-1	-16-14-13-11-10-8-7-6-5-4-3-2 17	C2
1	3-6	-13-12-11-10-9-8-7-6-5-4-3-2-1 17-16-15-14	6-3	C3
2	4	-14-13-12-11-10-9-8-7-4-2-1 17-16-15	6-4-3	C4
2	5	-14-13-12-11-10-9-8-7-5-2-1 17-16-15	6-5-3	C5
1	3-6	-13-12-11-10-9-8-7-6-5-4-3-2-1 17-16-15-14	6-3	C6
5	7-13-16	16-15-13-12-9-7-2-1	16-14-13-11-10-8-7-6-5-4-3	C7
3	8-17	-16-15-14-13-12-11-10-9-8-2-1 17	17-8-6-5-4-3	C8
7	9	9	-14-13-11-10-9-8-7-6-5-4-3-2-1 17-16-15	C9
4	10	16-15-13-12-10-9-7-2-1	17-10-8-6-5-4-3	C10
4	11	16-15-13-12-11-9-7-2-1	17-11-8-6-5-4-3	C11

Table 9 Levelling in fuzzy comprehensive interpretive structural equations

Level	*Joint collection*	*Input set*	*Output set*	*Criteria*
7	12	12	-14-13-11-10-8-7-6-5-4-3-2-1 17-16-15	C12
5	7-13-16	16-15-13-12-9-7-2-1	17-16-14-13-11-10-8-7-6-5-4-3	C13
4	14	16-15-14-13-12-11-9-7-2-1	17-14-8-6-5-4-3	C14
6	15	15-12-9-1	-16--14-13-11-10-8-7-6-5-4-3-2 17	C15
5	7-13-16	16-15-13-12-9-7-2-1	17-16-14-13-11-10-8-7-6-5-4-3	C16
3	8-17	-15-14-13-12-11-10-9-8-7-2-1 17-16	17-8-6-5-4-3	C17

Table 9 shows the levelling iterations:

Seventh level	speed, ability to understand, decision skills
Six level	motivation, responsibility
Fifth level	perception and perseverance accuracy and readiness
Fourth level	participation, indoctrination, note-taking tools from
Third level	verity, pay attention to the hemispheres
Second level	cooperation and communication, power of speech
First level	educational layouts, appropriate environmental stimuli

Stage 11 Draw a comprehensive fuzzy interpretive structural model

Figure 6 Fuzzy interpretive structural model of mathematical learning

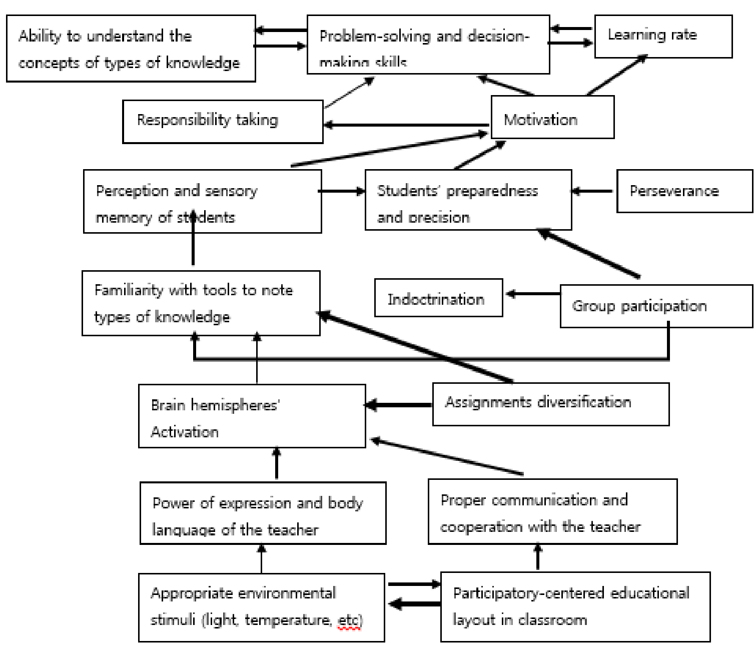


Figure 7 Fuzzy interpretive structural final comprehensive model of mathematical learning level (researcher)

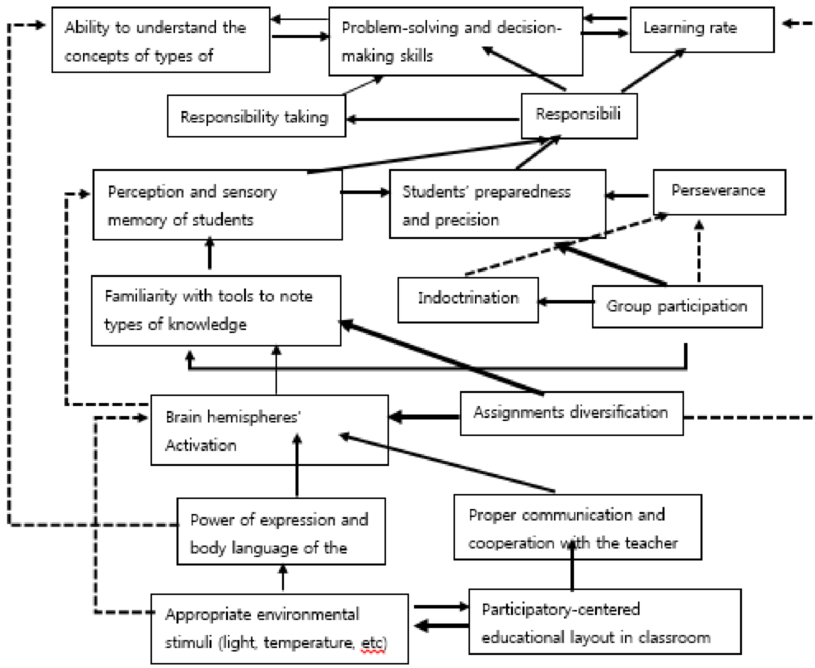


Figure 8 Mic-Ma diagram or dependence-penetration power of mathematical learning variables (see online version for colours)

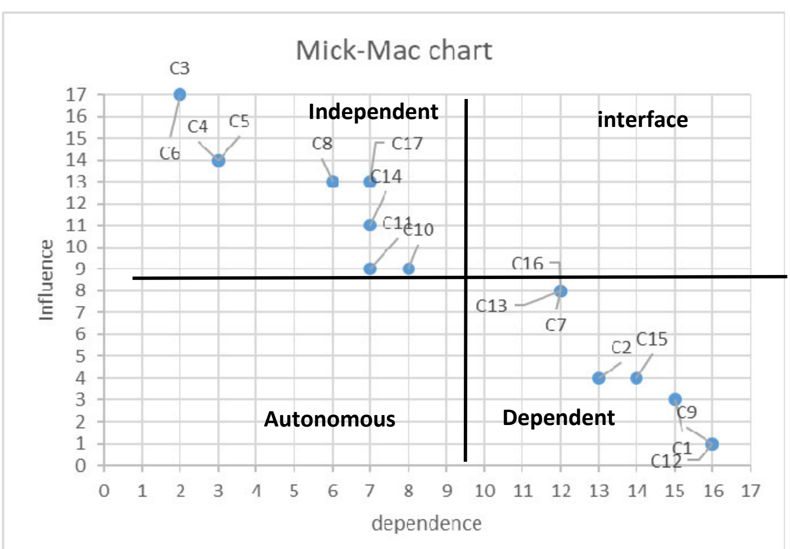


Table 10 The intensity of relationships' effect in the model

Type of relationship	*Impressibility intensity in the model*
Direct with moderate impact	
Direct with high impact	
Direct with a lot of impact	
Transitional relations	

Stage 12 Analysis of penetration power and extent of enablers' dependence (Mic Ma diagram)

A better understanding of the relationships between variables occurs when the relationships between variables are investigated more precisely and recognise the variables' impacts on each other.

12 Discussion and conclusions

The purpose of this research is to design a comprehensive structural interpretive analysis model and to determine the factors affecting the mathematical learning of high school students in Tehran province of Iran. After identifying the components affecting mathematical learning through the formation of the achievement matrix, an attempt was made to investigate the layers affecting mathematical learning. In analysis of the obtained result, it should be mentioned that the most fundamental factors affecting the mathematics learning are perseverance, perception and sensory memory and accuracy, which are placed in the category of interface variables (Narimani et al. 2015). Mathematics is the science of thinking and reasoning and is an important method and tool for improving the ability to think in the processes of teaching and learning and understanding the causes and consequences. Many math teachers in Iranian educational institutions lacked the ability to present and focus on the importance of managing mathematical learning to increase the power of creative thinking, and female students were not encouraged to think creatively through more problem-based learning strategies. Math learning activities for students have not been successful in improving students' creative thinking. However, most math teachers were not encouraged and supported to come up with innovative and practical strategies to improve creative thinking. Kraft (2011) concluded that fostering creativity with wisdom can contribute to students' moral development. In fact, the teacher should express the concept of creativity in general and creativity and problem solving in a specific topic. Concepts of creativity in school lessons may affect what they do, the atmosphere in the classroom and their value and reward. In this regard, teachers in the Netherlands and other countries were asked to be creative in all classrooms, including mathematics. Develop in students. However, only providing problem-solving opportunities for learners can increase their mastery, flexibility, and originality in problem-solving (Silver, 1997). Therefore, problem solving is included in the heart of students' creativity in math classrooms, and problem solving is the most important point in effective learning and creativity in mathematics. In this regard, it is suggested that:

- With regard to the curiosity morale of students, the learning method should be guided in such a way that students achieve positive thinking and creative and constructive thought.
- Avoid restricting students from discussing or informal tools of teaching during teaching.
- Training workshops, seminars and other teaching methods should be implemented to familiarise the teachers and parents with new teaching methods and its impact on learning.
- Mathematics homework should be organised and an active method should be used in doing homework.
- The students' interests and taste in classroom administration should be used.
- Teaching through games or other teaching tools to learn in other courses should be used.

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