APPLYING SCAMPER METHOD TO INSTRUCT STUDENTS TO EXPLOIT GEOMETRY PROBLEMS WITH THE AIM OF DEVELOPING CREATIVE CAPACITY FOR SECONDARY SCHOOL STUDENTS

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Abstract: Many educational researchers and educators have long acknowledged developing learners' creative capacity as an important goal of education. The literature review on creativity also affirmed that although everyone has creativity potential, they cannot fully develop their potential without appropriate conditions. This paper presents the scientific basis for applying SCAMPER method into teaching students to solve the geometry problem to develop creative capacity for secondary school students.

Keywords: Creative capacity, SCAMPER method, geometry exercises, secondary school.

1. INTRODUCTION

Many educational researchers and educators have long considered developing creative capacity for learners to be an important goal of education. Especially in the fourth industrial revolution (Industry 4.0), the strong development of science and technology has impacted on all aspects of social life, which requires people to constantly innovate to improve their creative capacity and create new breakthrough achievements.

Many creative methods developed by educational researchers have become useful tools in developing human's creative capacity. Many methods have been widely disseminated and applied to teaching in schools. Among them, SCAMPER is one of the most effective methods. It is used in industry and marketing to create new ideas, products, and to improve the mode of operation and problems' solutions. SCAMPER can be applied effectively in teaching in order to develop creative capacity for students.

In this paper, some following issues will be presented: - Literature review of creative capacity, SCAMPER method; - Expressions of creative capacity of middle school students in solving geometry problems; - Proposing SCAMPER-based eliciting questions and suggestions to exploit geometry problems order to develop students' creative capacity; - Giving samples of applying SCAMPER-based eliciting questions and suggestions to instruct students to solve geometric problems.

2. LITERATURE REVIEW

Despite appearing a long tim ago in the past, the Science of Creativity has not become a matter of interest among scientists in the world until the middle of the twentieth century. The American psychologist - Guilford J.P. presented a model of intellectual structure consisting of two basic blocks: *intelligence and creativity*. At this stage, research on creativity mainly referred to some of the basic issues of creative activity: basic standards of creative activity, the difference between creativity and non-creativity, the nature and rules of creative activity, developing and stimulating creative activities, personality attributes of creative activity, imagination, psychological inertia, etc. in the process of creative thinking.

SCAMPER is a creative method that includes a list of evocative questions to improve existing products, processes, services or development plans. It based on brainstorming techniques to find different ways to answer a series of questions. Some questions in SCAMPER were first introduced by Alex Osborn in 1953. Later, Alex Osborn's questions were arranged, developed into a memorandum by Bob Eberle named SCAMPER.

In Vietnam, the research topic of applying SCAMPER method in teaching to develop creative capacity for students has not been paid enough attention. SCAMPER method is only mentioned in the book about creativity and creative methods in the field of business. With outstanding advantages which are suitable for many objects and fields, SCAMPER method needs studying and applying in teaching at an appropriate level in order to develop students' creative capacity.

3. METHODS AND RESULTS

3.1. Definition of "creativity"

Based on a variety of approaches, researchers have come up with different definitions.

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According to Vygotsky L.X (1985), the creative activity is any human activity that creates something new, regardless of whether the result is a specific object or an intellectual or emotional product which only exists and expresses inside a human.

Pham Thanh Nghi (2013) stated that creativity is expressed when people face a problematic situation. This process is the combination of qualities and capacities which people use along with their experience and independent thinking to generate new, original and unique ideas at personal and social level. There, the creators who have put aside traditional solutions offer new, unique and appropriate solutions to the issues.

In short, creativity can be considered the process of creating something new, capacity of creating something new. Creativity is assessed on the basis of new, unique and valuable products.

3.2. Creative capacity and its components

According to Hoang Phe (2016), capacity is the psychological and physiological quality that gives people the capacity to complete a certain activity with high quality. From psychological perspective, capacity is the combination of unique psychological attributes of an individual that are suitable for the requirements of a given activity, ensuring that the activity is efficiently performed. Capacity has three features: Formed and expressed in operation; Associated with a specific activity; influenced by innate, genetic, environmental, and personal activity factors.

According to the General Education Curriculum - the Overall Curriculum (7/2017), capacity is a personal attribute formed, developed by available virtue and the process of learning and training, allowing people to mobilize and synthesize knowledge, skills and other personal attributes such as excitement, belief and will, etc. to successfully undertake certain types of activity, achieving desired results under given conditions.

Based on the literature review of the concept of capacity and creativity, the author defines Creative capacity as the capacity to create something new and valuable, based on a combination of unique psychological attributes of that individual. Creative capacity is formed and expressed in problem-solving activities. Creative capacity includes the following main elements: - The capacity to recognize new problems; - The capacity to present new ideas; - The capacity to create new things; - The capacity to detect and clarify problems; - The capacity to propose and select solutions; - The capacity to plan and implement new ideas; - The capacity to implement and evaluate solutions, develop problems; - The capacity to think independently.

3.3. Expression of creative capacity of secondary school students in solving geometry problem

Geometry is an important branch of mathematics. Studying geometry not only requires logical reasoning but also a high degree and strong development of geometric visualization, imagination and intuition. It can be seen that the process of teaching and studying geometry is especially advantageous for the development of students' creative capacity.

Based on the analysis of psychological and educational studies on the intellectual development of secondary school students, the elements of creative capacity and the characteristics of geometry, the expressions of creative capacity of secondary school students in solving geometry are presented as bellow:

- Being able to independently analyze hypotheses and conclusions and exploit the given conditions of problems to find solutions; - Being able to express problems clearly, instructively and in a simple and easy way to understand, express problems in different ways; - Being able to draw shapes accurately and clearly; and at favorable angles for observation and exploitation of drawings; - Being able to draw additional diagrams to link the hypothesis and the conclusion of the problem in order to find the solution; - Being able to imagine diagrams of geometry problems that are not too complicated, predict some simple results without drawing diagrams, make quick and accurate predictions based on visualization; - Being able to flexibly apply thinking techniques, formulas, and methods, etc. in problem-solving process; - Being able to apply the results and solutions of known geometry problems to solve related geometry problems; - Being able to find different solutions for a geometry problem, from which to evaluate and choose the optimal solutions; - Being able to find short and unique solutions (different from normal solutions) in spite of already known solutions (teachers give suggestions when needed); - Being able to detect contradictions, mistakes, lack of logic, etc. leading to the search for more effective solutions; - Being able to generate a new Math problem from a given Math problem.

Thus, one of the expressions of the creative capacity of students in solving geometry problem is to exploit the given problem to create new math problems. Therefore, instructing students to exploit problems will contribute to developing their creative capacity.

3.4. SCAMPER method

SCAMPER is an abbreviation formed using the first letters of English words including Substitute, Combine, Adjust, Modify/ Magnify/ Minify, Put to other uses, Eliminate, Rearrange/ Reverse. SCAMPER is proposed by Alex Osborn and then rearranged by Robert F. Ederle for more convenient use. SCAMPER method has then been presented in his book with the same name and is widely applied into businesses, schools, organizations, etc. around the world.

SCAMPER is based on the notion that new things are actually just a few additions or adjustments to what exists. SCAMPER is a creative method for improving existing products, processes, services or development plans. It based on brainstorming techniques to find different ways to answer a series of questions. Questions are asked in order, with the goal of generating as many creative ideas as possible.

SCAMPER is also recommended for use in combination with other innovative methods for higher efficiency.

3.5. Applying SCAMPER method in instructing students to exploit geometry problems

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SCAMPER is also recommended for use in combination with other innovative methods for higher efficiency. To apply SCAMPER method in teaching to solve geometry problems, teachers can use eliciting questions and suggestions to guide students along the reasoning process. SCAMPER-based eliciting questions and suggestions include:

- *Suggestions 1: Substitute*

+ Which elements of a geometry problem can be replaced to create a new problem?

+ Can a part of the hypothesis be replaced without affecting the conclusion of the problem? How to replace?

+ Can a conclusion (or a part of the conclusion) be replaced without changing the hypothesis of the problem? How to replace?

+ Can some parts of assumptions and conclusions of a problem be replaced to create a new problem? How to replace?

- *Suggestion 2: Combine*

+ What components and results can be combined to create a new problem or a new result?

+ Can two results of different problems be combined to create a new problem?

- *Suggestion 3: Adjust*

+ In what ways can a problem be adjusted to create a new one?

+ Which geometry elements of a problem can be change and how to change it to create a new problem?

+ Can the general problem, similar problem or separate case of the original problem be stated?

+ Can the results or solutions of a problem be applied to other problems?

+ Can the problem be solved differently? Can the problem be solved more concisely?

- *Suggestion 4: Modify*

+ Is it possible to change the form of the problem statement? (Express the geometry differently).

+ Can the size, shape of one or several objects in a problem be changed to create a new problem?

+ Can the type of the problem be changed? (For examples: Changing from calculating into proofing, from proofing to rendering, etc.).

- *Suggestion 5: Magnify/ Minify*

+ Consider problems in general or special form (macro, micro).

+ Can general problems or special cases of original problems be stated?

+ Is it possible to add or remove one (or several) elements to get new results, a new problems? Which elements to add or remove?

- *Suggestion 6: Put to other uses.* Can the results and the solutions of the original problem or the new one be used to solve other problems?

- *Suggestion 7: Eliminate*

+ Try reducing, eliminating the hypothesis or the conclusion of the problem to create a new one. Can any geometric factors of the problem be reduce yet achieve the desired results?

- *Suggestion 8: Reverse*

+ Reverse the problem. Consider the reversed problem of the given problem.

+ What if the hypothesis of the problem is negated?

- *Suggestion 9: Rearrange*

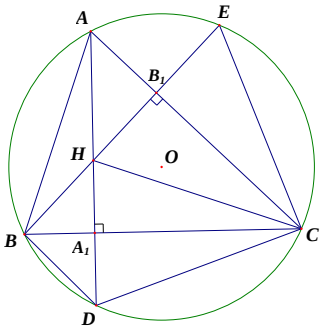
+ Try arranging the given information of the problem in a different order, swapping the elements to produce new predictions, new results.

+ Expressing the geometric problem differently.

Some notes when applying SCAMPER: - Based on the purpose and requirements of each period, each lesson and the level of students, teachers should choose suitable problems, questions and suggestions; - Teachers should frequently use SCAMPER-based eliciting questions and suggestions when instructing students to exploit problems, use the questions as a tool to stimulate creative and discovery thinking. At first, these questions are asked by teachers to help students think, then, students take the initiative in using them to solve problems, step by step growing in their creative process.

3.6. Sample of the process of applying SCAMPER into instructing secondary school students to exploit geometry problems

Given problem: The altitudes through vertices A and B of triangle ABC meet at H (C is not right angled) and meet the circumcircle of triangle ABC at D and E respectively. Prove that: a) CD = CE; b) BHD is an isosceles triangle; c) CD = CH.



After students have presented the solution, teachers use SCAMPER questions and suggestions to instruct students to exploit the problem:

Hint 1: Can you prove CD = CE in other ways? Can you prove it in shorter ways?

a) Let A1, B1 be the feet of the altitudes through vertices A, B.

Solution 1: Prove that the angles subtended by the minor arcs DC and CE are equal: $DAC = CBE$ therefore $DC = CE \Rightarrow DC = CE$.

Solution 2: Prove that $AA_1B = AB_1B = 90^0 \Rightarrow$ sđ AB + sđ DC = sđ AB + sđ CE = 180^0

$\Rightarrow DC = CE \Rightarrow DC = CE$.

Solution 3: Prove that two triangles CAA_1 and CBB_1 are congruent $\Rightarrow CAD = CBE$

$\Rightarrow CD = CE \Rightarrow CD = CE$.

Solution 4: Prove that $\triangle BA_1D$, $\triangle AB_1E$ are right angled at A_1, B_1 respectively $\Rightarrow$ complementary angles: $CBD + ADB = CAE + AEB = 90^0$. On the other hand, $ADB + AEB = \frac{1}{2}$ AB (subtended angles) $\Rightarrow$ $CBD = CAE \Rightarrow CD = CE \Rightarrow CD = CE$

The propositions b) and c) can easily be proved based on the previous solutions.

Hint 2: Are there other results for given problem? Do you have any comment on triangles HBC and DBC? From which give a comment on the circumcircle of the triangles above.

Comment: Use the proposition b) we can easily prove that $\triangle HDB = \triangle DBC$, therefore, the circumcircles of these triangles are equal.

We can add a new proposition to given problem as follows:

d) Prove that the radius of the circumcircles of triangles HBC and DBC are equal.

Hint 3: Use d) to make a new proposition for given problem.

Comment: The circumcircles of triangles HAC and DAC have equal radius. Therefore, the circumcircles of triangles (ABC), (HAC), (HBC), (HAB) have the same radius.

Replace the proposition d) with the new one: Prove that the circumcircles of triangles (ABC), (HAC), (HBC), and (HAB) have equal radius.

Hint 4: Can you replace the recently added proposition with a more general proposition? Can the proposition be expressed in a different way? Express a new problem?

Problem 1: Prove that the circumcircles pass through orthocenter and two vertices of acute triangle ABC have the same radius as the circumcircle of triangle ABC.

Hint 5: Do you have any comment on the position of the points H and D to the line BC? What are the features of the point D?

Comment: Based on the above result, it is easy to infer that H and D are reflected over BC (D is the end point of the altitude through A on the circumcircle of triangle ABC).

From which, we can add a new proposition to given problem:

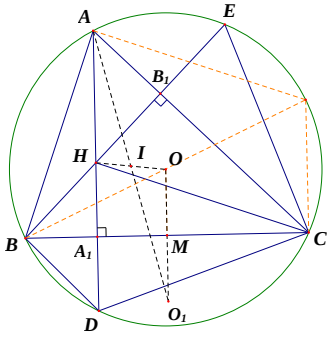
e) Prove that H is the image of D over BC.

f) Prove that the reflections of orthocenter H across the sides of triangle ABC lie on the circumcircle of triangle ABC.

Hint 6: Let's try changing the nature of an object. For example, given that A moves on the circle, explore what happens to the results and create a new problem.

Suppose that the point A moves on the circle (O), the points B and C are fixed on (O). Find the locus of orthocenter H of triangle ABC. The new problem is to find the locus of points.

Problem 2: Given that O is the center of a circle, two points B and C are fixed on the circle. The point A moves on the circle. Find the locus of orthocenter H of triangle ABC when A moves on (O).



Comment: Using the results from above, the orthocenter H of triangle ABC is the image of O over BC.

Hint 7: Substitute one or more elements of the hypothesis and conclusion to have a new and simpler problem.

Problem 3: The altitudes through A and B of triangle ABC meet at H (angle C is not 90^0). Let O be the center of circumcircle (ABC), M be the midpoint of the arc BC. Prove that $AH = 2OM$.

Hint 8: Let O_1 be the center of the circumcircle (HBC). Use results of Problem 2 and 3, comment on the position of O_1. Comment on the shape of quadrilateral AHO_1O, then, produce new problem.

Comment: O_1 is the image of O over BC and $OO_1 = AH$, thus, quadrilateral AHO_1O is a parallelogram.

Problem 4: The altitudes through A and B of triangle ABC meet at H (angle C is not 90^0). Let O_1, O_2, O_3 be centers of the circumcircles of triangles HBC, HAC, HAB respectively. Prove that AO_1, BO_2, CO_3 are concurrent.

Comment: AO_1, BO_2, CO_3 are concurrent at I which is the midpoint of OH.

In short, applying the eliciting questions and suggestions to exploit problems will gradually develop students' creative capacity. Teachers can also require students to continue practicing at home to strengthen their skills of finding new problems and solutions. When students are able to create new problems on their own and present their own new ideas, it is a sign that they are gradually improving their creative capacity.

4. DISCUSSION AND CONCLUSION

The paper presents some theoretical issues about creative capacity, elements and expressions of creative capacity of students in learning and teaching mathematical geometry. It also introduces the SCAMPER method and the application of this method to guide students to exploit geometry problems in order to develop their creative capacity. The essence of creativity is to discover new things; therefore, training about creative methods to discover new things is essential. Although everyone has the creative capacity in different fields and levels, it takes regular trainings and practices for each individual to develop the capacity. Education at school must play a key role in developing students' creative capacity. To achieve the best results, teachers need to continuously study and practice to improve their professional capacity and creative capacity as well as the quality of their teaching.

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