Contribution of Divergent Thinking in Creativity by Solving Mathematical Problems

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Abstract

Creativity is not only a privilege of the arts or people associated with the arts. Creative thinking can also be fostered and demonstrated in all school subjects and curriculum areas. Even trivial subject-specific content can nurture creativity in students, provided that the pedagogical approach allows for the expression of creative thinking and imagination. One of the main barriers to creativity in schools is the heavily charged curriculum. We need to rethink the traditional division of school subjects and skills, and design a more flexible, balanced and less-extensive curriculum with a provision for diverse and cross curricular activities, such as projects, school blogs or magazines. Cross-curricular activities could nurture creative thinking and learning, but they require close collaboration between students and teachers with different backgrounds, knowledge, competencies and expertise. Give activities to the students which promote divergent thinking. Critical and creative thinking are integral to activities that require students to think broadly and deeply using skills, behaviours and dispositions such as reason, logic, resourcefulness, imagination and innovation in all learning areas at school and in their lives beyond school. Engaging students in reasoning and thinking about solutions to problems and the strategies needed to find these solutions are core parts of the Mathematics curriculum. Also use the creative techniques to inculcate creative thinking to the students that will improve their knowledge enhancement of the students. Once the problem has been solved, the learner reflects on the meaningfulness of the solution (critical thinking). Problem solving and critical thinking are elements of creativity and divergent thinking. When the problem is solved, the creativity has just begun (Sheffield 1999). From the solution of the problem, the learner looks for new relationships e.g. changes the problem and solves the new problem. These relationships and understandings are what are left after the problem has been solved.

INTRODUCTION

Creativity and mathematics has a natural connection (Jakubowski and Unal 2004; Silver, 1997). Divergent thinking is an important element of creativity. “Creative people often have lots of ideas. The ability to generate a large number of ideas on a topic is one aspect of creative thinking. Although a large number of ideas is not necessarily valuable in itself, the ability to produce or brainstorm a large number of ideas is a helpful stage before further sifting or considering a range of options. Creative thinking often produces a wide range of ideas. This involves thinking beyond the obvious ideas in any situation to explore a wide variety of options or possibilities. “(HMIE report, 2006, p4). According to Silver (1997)” the number of formulations or reformulations generated or the number of different the number of different solution paths explored or solutions obtained. These are precisely the forms of cognitive activity assessed in tests of creativity”. Hashimoto

(1997) discuss that "open-ended approach is one aspect of fostering mathematical creativity". In this study we have investigated whether or not divergent thinking effects mathematical achievement.

DIVERGENT VS CONVERGENT THINKING

When trying to solve any problem, there are two basic ways we can think about the possible solution. These two types of thinking are called convergent and divergent thinking.

Convergent thinking:

It is the type of thinking we do when solving a well-defined, straightforward, correct answer to a problem. Convergent thinking is used when there is a simple, correct answer to a question. For example, what's the capital of England? The answer is London. If we knew the answer, we used convergent thinking. Creativity is not relevant to convergent thinking because we don't have to be creative to know the answer to this problem; all we have to do is come up with the stated, factual answer. When we're in school and we take a multiple-choice test we are probably using convergent thinking.

Divergent thinking:

It is the type of thinking we do when solving an abstract or new problem that has many possible answers, solutions, or outcomes. Remember the beginning of this lesson when we thought about how to make a structure to protect an egg from breaking? There are many possible structures we could make, so coming up with that solution required creativity, or divergent thinking. When we write a poem or story you have an endless supply of possible characters, words to use, and themes or events that might happen, so this creative process requires divergent thinking.

CONTRIBUTION OF RIGHT BRAIN VS LEFT BRAIN IN CREATIVE THINKING

The brain also has two distinct hemispheres, **left brain versus right brain**. According to the theory of left-brain or right-brain dominance, a person who is 'left-brained' is said to be more logical, and analytical, while a person who is 'right-brained' is more intuitive, thoughtful and creative.

To fully **develop both hemispheres** of the brain, it is important to vary thought processes so that children use both **convergent** and **divergent thinking**, both the linear, and the creative thought processes.

Divergent thinking is mostly found among people who are curious, willing to take risks, and persistent. Research shows that musicians are more likely to use both hemispheres of their brain and more likely to use **divergent thinking** in their thought processes.

CREATIVITY AND INTELLIGENCE

While convergent thinking is straightforward and simple, divergent thinking is complex. It could be argued that some people are more creative than others. For example, Stephen King is a famous author of horror novels, and he's written about 50 different books. Shakespeare wrote 38 plays and over 150 sonnets, or short poems. These two

authors are surely very creative. Some psychologists have argued that creativity is one type of intelligence.

Specifically, a famous psychologist named Robert Sternberg has argued that creativity requires three different types of intelligence. Sternberg's theory about different types of intelligence is popular in both educational psychology and cognitive psychology.

Mathematics: We can help our students to develop their problem-finding and problem-solving skills, and mathematical competence through creative and authentic activities. For Students' creative thinking can be nurtured in all school subjects and curriculum areas, and especially in cross-curricular activities.

Example, students could carry out a survey on the use of personal devices such as mobile telephones, computers or games among the members of the school community and create a report with tables and charts that could be published in the school newspaper or blog. Playing with cards, configuration games such as tangrams and other toys and observing other everyday practices can also be used for creative learning, if these activities are used to engage the students and are integrated into the mathematical exercises.

TECHNIQUES TO USE CREATIVE THINKING IN MATHEMATICS

i) Increase the Use of Open-Ended Questions

Open-ended questions help students develop creative thinking by applying, analysing, evaluating and synthesizing information and knowledge. Teachers spend a great deal of their time asking student's questions. Many different types of questions are used, but the main distinction is between closed questions and open-ended questions. Closed questions can be used to test comprehension and to aid retention of information (e.g. what is the capital city of India?). Open-ended questions have many possible answers that are not pre-determined (e.g. what if we had gills?). Open-ended questions can promote creative thinking and learning because they require students to find, combine and criticize information instead of simply recalling facts.

Research shows that on average, approximately 60% of the questions asked in classrooms are closed-ended, 20% are procedural, and only 20% are open-ended. One of the most ancient and effective questioning frameworks is Socrates' majestic method, which highlights the importance of questioning in deep and active lifelong learning. Socratic questioning differs from random open-ended questioning in the sense that it is planned, disciplined and deep; the questions are selected to probe reasons and assumptions in order to engage in higher levels of thinking progressively – including analytical, critical and creative thinking.

ii) Allow for mistakes and sensible risk-taking

Failure is an 'integral' part of the creative process and creative people often have many failed ideas or products before finding their successful ones. The creative process is inherently risky, and risk taking is among the key characteristics of a creative personality. Unfortunately, teachers tend to minimize failure of all types. A recent study on creativity

and innovation in education in European Union Member States revealed that schools prefer discipline to playful and risk-taking behaviour. The emphasis on the 'correct response' reinforces students' fears of making mistakes and this is one of the most widespread educational practices that inhibit creativity. As a result, students are not willing to take risks within school. They prefer to 'play it safe' and provide teachers with one 'correct response', instead of trying to explore more ideas and alternatives. Teachers' willingness to allow their students to take risks, to explore and experiment is related positively to students' creative learning. In order to foster creativity, schools could try reinforcing a 'culture of tolerance' that encourages 'sensible risk-taking' by teachers and students.

THE BALANCE BETWEEN MATHEMATICAL CONTENT AND PRACTICE

Students begin middle school exposed to mathematics as a very broad subject covering a wide array of topics: 2D geometry, probability, percentages, number theory, logic, patterns, statistics, graphing, number operations, proportions, elementary algebra, 3D geometry, and so on. They finish middle school and begin high school usually embarking on year-long studies of content-intensive mathematical subject areas: a year of Algebra 1, then a year of Geometry, then a year of Algebra 2, and so on. Though young adolescents begin middle school ready to think with more power, creativity, and independence, the accompanying increase in content expectations means that a balance between mathematical content and practice can be difficult to achieve. Developing good thinking and learning habits requires investment of time and patience, and well-intended educators can be drawn away from quality mathematical practices when the drive to learn content becomes too formidable.

CREATIVE THINKING AT THE MIDDLE SCHOOL LEVEL

Mathematical Content can be learned in ways that ask young adolescents to harness and develop their new cognitive abilities. For example, a traditional 2D geometry question might ask:

Calculate the perimeter and area of a rectangle with a 15-inch length and a 9-inch width.

This question can be answered by performing a routine calculation using formulas for the perimeter and area of a rectangle. Similar content can be studied with a question that asks for critical thinking:

For what whole number values of length and width will the rectangle have an area of 60 square yards and a perimeter of 38 yards?

This second question (from Mathematical Reasoning Middle School Supplement) requires students to develop a strategy to construct a solution. Indeed, a common approach involves making a mental or physical list of pairs of whole numbers that multiply to 60 and then searching for the pair of numbers that add up to 19 (since a rectangle's perimeter is twice the sum of the length and width). The correct answer is a length of 15 inches and a width of 4 inches (assigning the larger number to length). Note the depth and value of a critical thinking opportunity: the solution strategy connects 2D geometry with the number theory technique of factoring and is a precursor to a more sophisticated factoring procedure used in Algebra. The second question requires greater

time investment than the first question, but is worth the extra time if one is committed to young adolescents learning content in a way that fully engages their reasoning skills.

ACTIVITIES WHICH PROMOTE DIVERGENT THINKING:

- Learning **how to ask** questions;
- Learning **how to think and meditate** – students are allowed to think and explore their own learning patterns, and to invent new ones, students are given time and space for reflection;
- Creating bridges to **abstract concepts** using common **experiences, experiments** and experiential learning. Teachers should not separate learning from life; they need to find ways to use nature as a learning setting;
- **Brainstorming** can be used as a tool that generates a series of random associations, stimulating creative processes;

CREATIVITY, DIVERGENT THINKING AND THE PROBLEMCENTRED APPROACH TO TEACHING AND LEARNING

In mathematics class, instruction begins with the solution of problems, and for this purpose learners have to be creative and divergent thinkers. In solving new problems they think of a similar previous problem that was solved successfully. Once the problem has been solved, the learner reflects on the meaningfulness of the solution (critical thinking). Problem solving and critical thinking are elements of creativity and divergent thinking. When the problem is solved, the creativity has just begun (Sheffield 1999). From the solution of the problem, the learner looks for new relationships e.g. changes the problem and solves the new problem. These relationships and understandings are what are left after the problem has been solved. They constitute knowledge for the participant (Hiebert, Carpenter, Fennema, Fuson, Human, Murray, Oliver & Wearne 1996).

CONCLUSION

Students develop capability in critical and creative thinking as they learn to generate and evaluate knowledge, clarify concepts and ideas, seek possibilities, consider alternatives and solve problems. Critical and creative thinking are integral to activities that require students to think broadly and deeply using skills, behaviours and dispositions such as reason, logic, resourcefulness, imagination and innovation in all learning areas at school and in their lives beyond school. Engaging students in reasoning and thinking about solutions to problems and the strategies needed to find these solutions are core parts of the Mathematics curriculum.

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