SCIENTIFIC CREATIVITY IN SCIENCE EDUCATION

Dear Readers!

Divergent thinking, which indicates the capacity to generate multiple alternatives or solutions, received attention as a component of creative thinking after the "Sputnik shock" of the late 1950s. Since then, numerous special programs for fostering creativity in convergent, critical, associational or analogical thinking have been developed. As a result, an article in 1993 reported that there were about 250 programs for improving creativity, and in 1998, a researcher classified various teaching strategies used in the programs into 170 types.

Even though there have been debates about whether creative thinking is domain-specific or domain-free, creativity is without a doubt a crucial factor that defines the nature of science. Therefore, many science educators have stressed that students need to acknowledge the creative work involved by nature in scientific endeavors. Project 2061 of AAAS stated that inquiry activities such as inventing hypotheses are creative work like writing poetry; National Science Education Standards of NSTA noted also that understanding science and the processes of science can contribute to creative thinking. The recently revised Korean national science curriculum also stressed the importance of creative thinking in teaching and learning science in schools. This signals that nourishing creativity has become one of the basic goals of science learning in schools. Despite of the long history and much effort for improving teaching of creativity, however, little studies for teaching creativity in the area of science education have been done.

With Garnder's Multiple Intelligence Theory, many researchers agree on the domain-dependency of creativity, which means creativity in science may have different aspects compared to creativity in art or in literature. Therefore, I suggested a 3-dimensional model of scientific creativity consisting of three axes: creative thinking, scientific knowledge, and scientific inquiry skills. If someone suggests a new experimental technique while conducting an experiment (scientific inquiry skill), related to Faraday's law (scientific knowledge) by thinking divergently (creative thinking), it is said that his/her new experimental technique is invented by the virtue of scientific creativity.

To teach scientific creativity, I with my research colleagues suggested a learning model consisting of three steps: spontaneous Activity, Guides for creative thinking, and Activity Again (AGA2 model). According to this model, students are first provided with a task or a problem to be solved, such as to 'revise the presented ordinary electroscope for a more diverse usage', or to 'suggest new and interesting scientific situations in which unusual phenomena might be shown'. Here, students solve the tasks by themselves without any aids or guides. Therefore, some students can show a high number of creative ideas, while some other may solve the tasks using their common sense or in rather conventional ways. Or some students may have difficulties in suggesting creative ideas. Therefore, in the second step, students are provided with instructions or guidelines to help them think creatively. 'Think reversely', 'change the conditions', or 'use other similar situations' are good examples of such guidelines. After exercising how to think creatively to solve the tasks, students apply the given leads in new situations in the last step.

Creative ideas often can be generated by collecting, sharing, discussing about other ideas. Therefore, in other models, students are encouraged to share the initial ideas with others to revise or refine them through additional steps, discussing the advantages or disadvantages of their ideas. Based on models such as above, various scientific creativity activities have been recently developed and applied to students.

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However, there are still many studies to be conducted related to teaching scientific creativity in schools. We first need more concrete and various pieces of evidence to prove that scientific creativity can be nourished by appropriate training and education. Of course, many researchers have reported that their efforts for improving creativity proved to be effective. However, many of those studies were about general creativity, not scientific creativity. For example, Torrance showed the effectiveness of teaching creativity in several studies using TTCT, which was developed to test creativity. In this case, the number of ideas is counted to test fluency, one of the defining components of divergent (creative) thinking. But, to be scientifically creative, more conditions need to be present. That is, we need to check which ideas are actually scientifically plausible or more useful to conduct scientific inquiries. However, this kind of assessment of scientific creativity is not so popular in the area of science education yet.

Interestingly, many people think creative thinking doesn't really apply to ordinary people or that it cannot be generated by mundane tasks or in ordinary contexts. Therefore, some science teachers also think that teaching creativity suits only for special, talented, or gifted students. In fact, the area of gifted education has emphasized teaching and nourishing creative thinking. Moreover, some science teachers try to use unusual, strange, or sometimes, very difficult-to-solve situations when developing teaching materials for creativity, which cannot be experienced in everyday context easily.

Contrary to the popular belief, Weisberg, who analyzed Watson and Crick's process of discovering the DNA structure, concluded that there was no particular way of thinking in their process of the study. Moreover, researchers emphasize that creativity is more of a thinking habit, rather than an intellectual ability. Following that logic, creativity can and should be taught not only to the gifted, but to students in ordinary schools. We need to place more weight on designing a science curriculum for all students on scientific creativity. Of course, someone can insist that more time is necessary for students to think creatively, like an incubation phase. This time frame could be an obstacle for teaching scientific creativity in ordinary science classes because time schedule for running science curriculum is usually pre-determined. However, according to the view that creativity is a habit of thinking, short but iterative experiences of creative thinking in science learning can be a possible solution to this obstacle.

Therefore, I with my colleagues have recently started to develop a new model called the 'small-scale iterative experiences for teaching scientific creativity'. The following studies will focus on finding alternative ways to incorporate this model into the ordinary science curriculum, and to measure the effectiveness of these methods in improving creativity. Furthermore, we will strive for an additional proof that these ways of creative thinking are still in contact with the nature of learning science in understanding scientific knowledge, conducting scientific inquiry, as well as in nourishing scientific thinking. On a final note, I hope I have inspired a healthy curiosity on the subject matter of scientific creativity, for more authentic science teaching and learning experiences to come with many science educators.

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