Science Gifted Learning Program: Research & Education Model

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Abstract: This paper suggests a research & education (R&E) model for the gifted in science education. The model has been developed under three assumptions. The first is that using the sequences of a gifted educational program designed to facilitate the process will assist in gifted students' construction of scientific knowledge and comprehension of laboratory practice through concrete experimental experience. The second is that gifted students will be able to apply this learning to further study using and extending scientific knowledge and experience. The third is that challenging tasks and feedback at the requisite stage of development will improve instructional effectiveness. The R&E Model has five phases: engaging, exploring, planning, performing and elaborating; furthermore, it suggests roles for the mentee and mentor. The R&E model has two functions for gifted education. The first is providing guidance for gifted curriculum developers as they design a mentor program, and the second is helping a mentor improve instructional effectiveness through use of strategies. This model has potentials to educate the gifted students in the Science Education Institute for the Gifted.

Key words: research & education model, the gifted, science education, mentee, mentor

I. Introduction

Educators that teach gifted science students expect to be able to develop these students' creative potential, enrich their knowledge and experience and direct them toward improving scientific and technologic areas. To achieve these goals in science-gifted education, it is necessary to develop a differentiated program or curriculum for the science-gifted (Renzulli, 1988; Shim *et al.*, 2001; 2003). Scientifically gifted students need projects and facilities that create stimulating scientific environments (Korlevic, 2005). Most programs for the science-gifted possess the characteristics of stimulating the students' interest, providing multiple sources, and helping the students to experience short-term laboratory learning through experiments. However, there has been a lack of understanding of both the nature of science and the nature of the laboratory experience that future scientists must face.

Empirical observations and laboratory experience have been proposed for elite students as a process of cognitive apprenticeship, and as being very useful in learning to master laboratory techniques (Ritchie and Rigano, 1996). In addition, laboratory learning has been shown to positively affect students' attitudes toward science. Working in a university or institute laboratory under the mentorship of scientists involved in research projects has been demonstrated to be a very effective way for elite students to gain mastery of laboratory techniques and to gain an understanding of scientific phenomena through the research projects. These students could develop their research capabilities through learning featuring critical and reflective thinking: the students focused on results-oriented, rational and logical thinking, and experienced a wide range of possibilities for decision-making (Schallies and Lembens, 2002). Buerger (2003) introduced examples of experiment or project-based education for science gifted students in German high schools and universities, and insisted on the needs of the gifted students being met through training with experiments and research. Natural sciences workshops such as the Youth Science Camps and the Summer School of Science (S^3) are mentoring programs for scientifically gifted students in Croatia (Korlevic, 2005). The Youth Science Camps are programs that introduce scientific

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**Received on 28 October 2004

methods, and stimulate and challenge the enthusiasm of gifted students. The Summer School of Science (S^3) is a program that consists of international and multidisciplinary workshops for gifted students, featuring a mixture of science and technology: astronomy, microbiology, zoology, biochemistry, chemistry, physics, mathematics, electronics, and sociology among others. In Korea, mentoring programs (under the name of research and education) have been performed in various academic fields such as mathematics, physics, chemistry, biological sciences, earth sciences and information sciences (computer sciences) for gifted high school students supported by the Ministry of Science and Technology, and the Korea Science and Engineering Foundation.

Ritchie and Rigano (1996) reported that inquiry with structured environment or research project that was planned and set up by supervisor or expert mentor were educationally effective rather than open-ended inquiry. But, one-sided leading the elite or the gifted to face on laboratory experiences should reduce interest in science. Therefore, there was need for the gifted to develop an appropriate education program, and especially, it is necessary to develop research and education programs by long-term research project. Choe (2004) insisted that research and education program was an effective differentiated teaching strategy for the scientifically gifted. But, there are lacks of educational theoretical principles to manage mentoring programs. Present paper suggested a research and education model (R&E Model) for managing effectively mentorship program in the science-gifted education.

II. Mentoring for the Gifted in Science Education

The characteristics of the gifted imply a capacity to learn basic material much faster than other learners, and handle more complex and sophisticated material at an earlier stage of development (Van Tassel-Baska, 1992). Outcomes of gifted students are appropriately challenging for them at the requisite stage of development.

The science education curriculum for gifted students suggested by the Center for Gifted Education at the College of William and Mary include emphases on the following: learning concepts, higher-level thinking, inquiry, especially problem-based learning and use of technology as a learning tool, and learning scientific process, using experimental design (Van Tassel-Baska, 1998). Often gifted students want to maintain their relationships after the program, and some students supplement this relationship with face-to-face contact with their teachers or mentors (Whiting, 2004). Mentoring is a method to increase the connection between program concepts and the real world, and a powerful process for carrying out the purposes of gifted education, and for enhancing the development of individuals.

Mentoring is described as the relationship between an experienced person (mentor) and a less experienced person (learner or mentee) (Hudson and Skamp, 2002). The less experienced person is provided with guidance, advice, support and feedback. Hudson and Skamp (2002) proposed the following examining factors in mentoring practices: personal attributes, system requirements, pedagogical knowledge, modeling, and feedback. Phillips-Jones (2004) suggested that mentoring be approached in two ways: through the mentors' behaviors and through the eyes of the mentered. The first approach concerns the mentoring that is performed to help the mentees develop: listening attentively, explaining concepts, inspiring, arranging observations, coaching on tasks and projects, providing feedback and other assistance. The latter approach concerns mentoring as it is defined by the mentees, and depends upon whether the mentees perceive the various actions performed by the mentors (with the intent to help the mentees develop) as being mentoring or not.

Mentor programs have to focus attention on the development of the students' gifts as well as provide a nurturing environment, and strong potential for success to enhance the mentees' self-esteem and self-confidence (Shevitz *et al.*, 2003). The Wings Mentor Program by MCPS (Maryland's Montgomery County Public Schools, U.S.A.) is founded on four basic principles (Shevitz *et al.*, 2003). The first principle is that attention is directed to the students' strengths and interests and focus on the gifted by increasing the mentees' knowledge and skills in an area of interest with potential for success ("Focus on Strengths"). The second principle is that the program will provide the students with an opportunity to be successful and gain an awareness of their abilities ("Build in Success"). The third principle is that the students need to be excited about school, and begin to believe in themselves ("Enhance Self-Esteem"). The fourth principle is that the program should serve as a catalyst for positive change for future success ("Plant a Seed"). Mentoring relationships evolve over time. Kram (1983) identified four phases of the mentoring process:

Initiation Phase. Mentor and protégé learn each other's characteristics, and the mentor provides exposure and sponsorship to the protégé through introduction to others in power, provides support and empathy.

Cultivation Phase. The relationship typically becomes more intense during this phase.

Separation Phase. During this phase, mentor and protégé may begin both a physical and psychological separation, due to other responsibilities, and the protégé becoming more self-reliant.

Redefinition Phase. The mentor and protégé renegotiate their relationship to a more collegial and peerlike relationship. By this time, the protégé should have acquired the necessary skills to negotiate the system, acquire a fair amount of self-identity, and effectively network with those in power.

It is necessary to develop strategic models that help the mentor to effectively teach gifted students. A good model should inspire the development of strategies for creatively implanting activities that teach the students more effectively (Gibson and Efinger, 2001). For successful mentoring, the mentees need to directly observe the scientists' behaviors (using experimental equipment, documents, inquiry processes among other tools and methods) and their scientific attitudes; furthermore, the students need to feel the scientists' enthusiasm toward science. The mentees need to be provided with opportunities to be exposed to all of these factors. Therefore, one of the most important educational approaches for effectively mentoring the gifted is mentoring through scientific research.

Ⅲ. Research and Education Model (R&E Model)

1. Roles of mentor

Traditionally, a mentor is defined as a more experienced person who acts as a guide, advocate, and teacher to a younger, less experienced person (Casey and Shore, 2000). A mentor can provide many benefits for students such as career, academic, psychological, and role modeling functions (Donaldson *et al.*, 2000). In addition, student academic training has educational potential for gifted students and promotes mentoring, because they can learn to take a more active role in their mentoring experiences (Packard, 2003). As a trait of a successful mentor, sharing and counseling traits were identified. Successful mentors are positive in their interactions with those whom they counsel, and the concept of mentors possessing a positive attitude is supported (Mincemoyer and Thomson, 1998). We suggest the following roles for a mentor in a university-based science gifted center:

- Motivating: assisting the gifted to believe in what he or she is doing, and providing catalytic force to spur the student into action
- Teaching: instructing the gifted, usually informally, in the knowledge and skills necessary to be successful in the immediate environment
- Guiding: helping orient the gifted to the research or inquiry, and suggesting ideas
- Advising: advising the gifted with heavy dose of candor and support to help orient him or her to the research goals
- Encouraging: encouraging the gifted not to be depressed when facing failure or unpredictable results, and helping him or her orient to the research or inquiry
- Sponsoring: assisting the gifted through association, and sharing with him or her available resources to help insure success
- Validating: verifying data of research, and bestowing his or her blessings where appropriate

on the goals of research project

- Communicating: discussing with the gifted of results and interpretations, and striving to find a way of communicating the expertise he or she has accumulated
- Providing a Role Model: being aware of the relationship with an aspect of a model of the gifted to emulate in some way

2. Activities of the science gifted (mentee)

Renzulli (1988) suggested that gifted student activities be assimilation and retention, information analysis, information synthesis and application, and evaluation. The activities of a special program for the science-gifted as a mentee are reading and comprehension of scientific concepts, observing scientific phenomena, manipulating experimental tools, and the understanding of scientific principles and theories, and methods. In addition to these, such activities as planning a research project, designing experiments, manipulating data, interpreting results, discussing and concluding can be performed only through a special long-term research and education program. We proposed the following activities for gifted students in research and education programs: (1) learning (understanding) and recognizing; (2) exercising and experimenting; (3) planning and designing; (4) manipulating and interpreting; (5) verifying and discussing; (6) concluding and generalizing.

3. R&E Model

Research and education in science-gifted education involves science education in scientific research. A science education in scientific research consists of "education by scientific research" and "education through scientific research". Education by scientific research is to be educated according to scientific research approaches, and education through scientific research is education in the processing of scientific research.

Kwon (2003) suggested that the "research and education" mean the education and training of professional and scientific research for pre-scientists or pre-engineers. The mentees have experienced scientific research as pre-scientists, and they can interact with mentors in research and education programs. Gifted education programs in scientific research are known for effectively encouraging self-directed learning, and the development of creative thinking and problem solving (Choe, 2004; Heo, 2003).

A research & education (R&E) model is proposed for the gifted in science education. This model is characterized by gifted learning through scientific research with a mentor (scientist). The R&E model has three assumptions. The first assumption is that using sequences of gifted educational program designed to facilitate the process will assist in gifted students' construction of scientific knowledge through the mentor's support (teaching and explaining about the scientific topic and the nature of the scientific research) and comprehension of laboratory practice through concrete experimental previously developed experience. The second assumption is that, by using and extending scientific knowledge and experience, gifted students will be able to apply these factors toward further study. The third assumption is that instructional effectiveness will be improved by challenging tasks and feedback after evaluation at the requisite stage of development.

As shown in Figure 1, the research and education model (R&E Model) has five phases: Engaging, Exploring, Planning, Performing and Elaborating. The orientations of each of these phases are as follows:

- Phase I. Engaging: This phase initiates research and education. This phase should organize the thinking of the gifted students toward the learning outcomes of the research topic, and induce them to recognize the values/implications of research and the research topic.
- Phase II. Exploring: This phase provides gifted students with experimental experiences. In this phase, the students should understand scientific methodology, and obtain training in experimental methods and improve inquiry skills by exercising their skills through established experiments.
- Phase III. Planning: This phase challenges and extends upon new experience (scientific research).

In this phase, the students should find a new topic based on previous scientific experiences, plan other research related to previous scientific experience, and design experiments to apply the conceptual understanding, inquiry skills and scientific abilities of gifted students.

- Phase IV. Performing: This phase encourages and sponsors gifted students to actively practice research. In this phase, the students should thoroughly experience the scientific research process, and to use adequate inquiry skills.
- Phase V. Elaborating: This phase focuses on the application of the scientific reasoning of gifted students. This phase should help the students facilitate and verify the interpretation of results, formulate conclusions, scientifically generalize the research implications, and write reports.

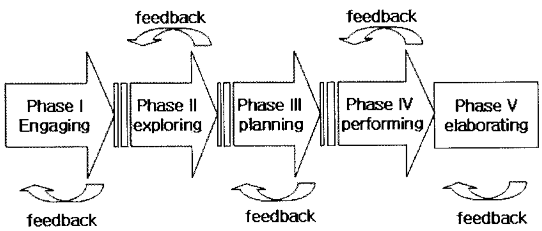

Fig. 1 *The research and education model (R&E Model) for the science-gifted*

This model has two functions. The first function is providing guidance for gifted curriculum developers as they design a mentor program, and the second function is helping a mentor improve instructional effectiveness through use of strategies. The model has differentiated the roles of the mentee (the gifted in science) and the mentor (scientist) (Fig. 2). The mentee should perform the following according to the individual phase: (1) Learning the research topic and recognizing the values/implications of the research topic in Phase I (Engaging); (2) Learning the experimental method and performing the established experiments in Phase II (Exploring); (3) Designing a new research topic for him/herself, and inventing and designing experiments in Phase III (Planning); (4) Experimenting with and manipulating data, and interpreting the results in Phase IV (Performing); (5) Verifying and discussing interpretations, formulating conclusions, making generalizations, and writing a report in Phase V (Elaborating). The mentor should play the following roles according to the individual phase: (1) Motivating, and teaching the research topic in Phase I; (2) Teaching experimental methods and guiding experiments in Phase II; (3) Guiding and advising the mentee through the research plan in Phase III; (4) Encouraging and sponsoring the mentee in Phase IV; Validating data and results, discussing interpretations, and helping the mentee perform a supplementary experiment in Phase V.

Phase	Activities of the Mentee	Roles of the Mentor
I. Engaging	Learning the scientific concepts of a research topic Recognizing the values/implications of a research topic	Motivating Teaching (explaining) a research topic
↓		
II. Exploring	Learning experimental methods Performing (exercising) the established experiments	Teaching (exercising) experimental methods Guiding experiments
↓		
III. Planning	Finding a new topic Planning other research Designing (inventing) experiments	Guiding the outline of a research plan Advising on designing experiments
↓		
IV. Performing	Experimenting Manipulating data. Interpreting results	Encouraging to actively perform experiments Sponsoring available resources
↓		
V. Elaborating	Verifying and discussing interpretations Formulating conclusions Generalization Writing a report (or paper)	Validating data and results Discussing interpretations Helping with supplementary experiments

Fig. 2 *The roles of the gifted (mentee) and mentor in the R&E Model*

Mentoring programs should be designed to meet the special needs of the gifted students (Choe, 2004). In addition, mentors should possess the teaching and counseling skills necessary for these programs; furthermore, the mentors require the abilities to elaborate the structure, procedures and substances of these mentoring programs (R&E programs). Modeling teaching practices help the mentor to effectively teach the mentees by harmonizing education and research. There are sequential stages for developing effective science teaching for the gifted. A particularly important point in this development is the challenging of the tasks and the feedback after evaluation at the requisite stage of development. For example, discussing and supplying information after evaluating the level of understanding of the research topic; evaluating the principles and methods of the experiments in the Engaging and Exploring Phases;

Table 1
Example of a mentoring program on the basis of the Research and Education Model in the Engaging Phase of the R&E Model

Main Contents: Topics and Activities	Materials and Tasks	Teaching Method
1. Allelopathic effects 2. Allelochemicals 3. Inhibitory effects on plant species 4. Observing the phenonmena of auto-inhibitory effects in a pine tree forest - inhibitory phenanmena in eco-system (fields) - auto-allelopathic effects in a pine tree (*pinus densiflora*) forest	1. Journal - The Korean Journal of Ecology, 25(4), 313-319 2. Book - Chang et al, 2000. Ecology, Academy Pub., Co.(In Korean) - Kil et al. 1997. Allelopathy. Wonkwang Univ. Press (In Korean). Investigating *pinus densiflora* forests on Mt. Gyeryong and on the campus of Kongju National University	Lecture Field work
Feedback	1. evaluation by interview - definitions of allopathy, understanding of allelopathic effects - kinds and applied fields of allelochemicals → lacking of understanding of allelopathic effects, and interactions among plants, inhibitory and facilitative effects of allelopathy 2. feedback - reading articles The Korean Journal of Ecology, 27(1), 3-10. Kil et al. 1997. Allelopathy. Wonkwang Univ. Press (In Korean). - survey cases of allelopathic effects among other living things	Interview Discussion Assignment of tasks

counseling, discussing and supplying information after verifying whether it is possible to validate the design experiment for the research topics in the Planning Phase; verifying whether it is appropriate to construct a report of the research results in Elaborating Phase.

IV. Conclusion

very effective in teaching students scientific understanding, improving their inquiry abilities, and increasing their interest and attitude toward science-making (Ritchie and Rigano, 1996; Schallies and Lembens, 2002). The development of an effective research and education model is very important in constructing education programs that teach through research. We have suggested the R&E Model, which stresses the roles of a mentee (a gifted student) and a mentor (a scientist), and is managed via a relatively long-term (one year) research program. This model has the potential to educate the gifted and talented students within the Science Education Institute for the Gifted. An example of the main activities and feedback in the Engaging Phase of the research and education model is shown in Table 1. To effectively apply the R&E Model, a gifted student needs to satisfy his or her curiosity by connecting with the programs or experiments, and the mentor needs to help the students understand the value and implications of the research (as well as the nature of science itself), and to provide feedback programs (or assignments) for the gifted students during the respective phases of the program.

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