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Development of an Elaborated Project-Based Learning Model for the Scientifically Gifted

Hyekyung KIM*
Seoul National University

Seungkyu CHOI
Sejong Science High School

Korea

This study was to investigate the elaborated project based learning model for scientifically gifted in the context of R & E project learning. It is important for the scientifically gifted to provide the appropriate learning environments instead of general learning model for the gifted. Although R & E project learning model is effective, the model has the limitations of managing the course for the scientifically gifted. To improve R & E learning model, the elaborated project based learning model was suggested with integration of both project based learning model and goal based scenario. The elaborated project-based learning model was comprised with 'basic learning process', 'elaboration through inquiry', and 'presentation and reflection'. To measure the satisfaction, eighty scientifically gifted students participated in the class. The result shows that learners were satisfied with the elaborated project-based learning up to 90%, and teachers were satisfied with this model up to 77%.

Keywords : R & E *project learning, project-based learning, goal-based scenario, elaboration*

*Department of Education, Seoul National University, hkkim1@snu.ac.kr

Introduction

Education for the gifted mainly covers higher intellectual ability and instructional method to promote thinking ability and self-regulated learning skills. Current issues regarding the gifted education focus on how to assess the giftedness. In addition to it, another major area is how to educate the gifted students who are selected. However, the second issue could not be systematically dealt, and the general instructional methods are applied to the gifted education (Kim, 2006). Nonetheless, there are the major instructional models for the gifted including Renzull's Enrichment Triad Model, Treffinger's Self-Directed Learning, Clark's Integrated educational model (Park, 1997). However, these models revealed their limitation on promoting scientific thinking ability and facilitating creativity for the scientifically gifted. It is doubtful whether those models are applicable to specialized instructional context for scientifically gifted Because experiment-based programs are short-term basis, the programs could not provide enough support for the scientifically gifted to identify and discuss the problems on the basis of their own resolutions and interpretations through the process of experiment they acquired (Shim, 2007). Then, what is the differentiated teaching and learning methods for the scientifically gifted learners? The instructional methods for the scientifically gifted should focus on the characteristics of natural science and engineering rather than that of the general subjects. In addition, the learning goal for the scientifically gifted is to improve understanding the science, to enhance expertise in science and creative problem solving ability. As a recent instructional approach for the scientifically gifted, research and education(R&E) project and independent research have been adopted for 10th or 11th graders in the science high school and science academy. R&E project refers to a program designed for about three or four the scientifically gifted students to experience research at the university science laboratories with supervising from subject matter experts or professors in science (Lee, 2006). In the independent research, one or two students take the whole

process of an independent research from choosing topics from their own interest, studying for a half or full year to write scientific paper.

In spite of its practical insights, the research task was too difficult for the novice learners without readiness for the project based learning. The students struggled throughout the process from identifying problems and creating solutions. This brought the need for support system for R&E project, so that students could be involved in the project easily. The scientifically gifted learners enhance their project performance by scientific investigation or experiments with authentic problems in regular courses in school. Therefore, R&E project model need to be modified to improve novice learners' performance with supporting the project process.

The present study is to design the project based learning environment in order for the scientifically gifted to enhance research project performance as well as knowledge acquisition. Project based learning is a well structured learning method in which students solve complex problem along with participating investigation process and acquiring knowledge within given time period. Project based learning is student centered and self-regulated learning (Buck Institute for Education, 2001). Throughout project based learning, students develop procedural knowledge for research, achieve final output, increase responsibility through research plan, organize ideas and thoughts, and promote creativity (Lee, 2006). Goal based scenario is an appropriate instructional model to enhance creativity by situating students in authentic context. Students would focus on the authentic problem and the goal they pursue to achieve (Schank & Cleary, 1995).

This study is to develop elaborated project based learning model which promote student leading activity in R & E project. To modify R & E project model, the existing model was analyzed, and the modification was suggested in the view of integration both project based learning model and goal based scenario. Research questions are:

A. What is the elaborated project-based learning model for scientifically gifted?

B. What is the learner's satisfaction of the elaborated project-based learning model?

Theoretical Background

In this research, we searched the learning models which had been used for the scientifically gifted and developed flexible 'elaborated project-based learning model' which could be used for every subject including science. For this purpose, we educed the strong points from the R&E project learning model, Project-based learning model, and Goal-Based Scenario

R & E Project learning model

'R&E' is the abbreviation of 'Research & Education' and R&E project learning can be called 'mentorship'. That means a mentoring program in which a college professor(or researcher) and some students organize one team as a mentor and mentees to co-work with science quests.

This program emphasizes that the students look for the problem themselves, develop the ability to solve it reasonably, take the scientific research methods from the process by which students find a scientific knowledge and accomplish a research. In Korea, this program has been applied to every science high school since 2003(S. G., Lee, 2006). Many researchers suggested the process of R&E project learning as the following (Table 1).

Table 1. Comparison with R&E Project Learning Models

Process	Van Tassel-Baska(1997)	Hur(2004)	Bishop(1999)	Lee (2006)	Lee, Shim, Kim (2008)	Hwang(2007)	
Beginging	Selecting a topic	Decide the subject	Selecting a topic	Prepare	Engagement	1.Educational research process 2.Creative research process	RQ
	Find the research problem	Research the main idea	Exploring for a Focus	-Exploration -Find the problem			Exploration
		Form the main idea	Forming a Focus	Plan	Exploration		Inquiry
Development	Collecting Information	Collecting Information	Collecting Information	Perform	Explanation		Presentation & Discussion
	Analyzing Information				Elaboration		Elaboration
Closing	Report	Prepare for presentation	Preparing to Present	Conclude	Expansion		Report/ Sharing
		Evaluate (process/product)	Assessing the Product and Process	Presentation &Discussion			New RQ

Like this, the R & E learning model is the project learning model which includes scientific inquiry process and takes the advantage of making the students have experience of scientific discovery. However, during the actual operating process, a number of difficulties or problems were pointed out. (S. K., Lee., 2006, M. J., Hwang., 2007, Sejong Science High School, 2009). We can take a look at the following three aspects with these issues. First, the problem is lack of experience of learners with R&E learning process. Learners aren't trained for R & E project. In other words, Learners don't have comprehensive view for the lack of experience and knowledge on project learning. Second, the problem is lack of ability of learners to research. In other words, Learners have trouble in deciding their research question/issue, and can't make it themselves. They fall short of meta-cognitive activities for inspecting, collecting, evaluating errors of research. Third,

Schools can't resolve the problem of distributing the guideline for learners; the lack of effectiveness on guideline. In other words, The problems in R & E project repeat every year; the lack of instruction, but it is insufficient to share knowledge of effective teaching method. Fourth, the evaluation is not fair in R & E project learning because the level of contribution doesn't feed into evaluation.

Project-Based Learning model

Project-Based Learning (PBL) is generally the instructional model to emphasize the learner's research, reflection, spontaneity and activeness. PBL is the model based on constructivism and inquiry, and it has been effective on developing product of learning with their own research question (Blumenfeld, 1991). Many researchers suggested project-based learning models as the following (Table2).

Table2. Comparison with Project-Based Learning Models

Stage	Katz & Chard (1993)	Kim (1999)	Jung & Shin (2004)	Jo (1999)	Jung (2003)
Beginning	Be Ready	Be Ready	Be Ready		
	Begin	-Select a topic -Plan activity	- Select a topic -Make teams -Plan the activity	-Understand the content -Plan the process and activity -Goal setting	Plan
Development	Develop	-Research -Express -Discuss	-Collect data -Research -Interim check and presentation	-Create ideas -Communicate -Design and develop the content	-Communicate & Cooperate -Explore -Reflect &Evaluate
Closing	Closing	Arrange		-Solve the problem -Conclude	-Report -Presentation
		Evaluate	Evaluate		

We saw the variety of project-based learning models. Those have three parts which are 'select a topic and plan the activity' - 'research and discussion' - 'make reports and presentation'. Because these three steps are core process in project based learning, the instructors have to include them in order to design a project-based learning.

Goal-Based Scenario

Goal-Based Scenario(GBS) is started by Schank and his colleagues at learning science institute in U.S.A. the character of the GBS is purpose-oriented. The learners pay attention to real situation , infer and learn because the real situation gives them the directivity to purpose. The learners who participate in GBS are given the variety of tools and information. This is a simulation in which they achieve their pre-planned aim while performing real project. The GBS started from the cognition of the problems that teachers' one way knowledge delivery could make short or distorted information, to natural learning as a human's intrinsic learning methods. Then natural learning means learners learn involuntarily by doing in real context . One of the main aims of this model is not to get learners to know facts but to use learned skill in real (Schank & Cleary. 1995).

GBS model has seven important components, such as goal, mission, cover story, role, scenario operation, resource, and feedback. Goal-Based Scenario (GBS) is a constructivistic instructional design model based on learning by doing. In GBS, learners would explore a scenario including activity, resource and mission. Also, They would play a role of mission, and finally achieve the goal. Students would learn naturally, that is, experience incidental learning (Jo, et al 2004).

- Set of Mission : After setting goals, mission and tasks are developed for students to achieve. The mission indicates that many students need to attain the status by applying some sort of knowledge and skills. The successful execution of missions means that the achievement of goals set.

- Cover Story Development: Cover story is premised that the students have to achieve this mission. the mission which students have to perform is explained in the form of the story , by refining the scene in which the action that students need to take occur, the context, conditions, and circumstances. Cover Story plays a role that the students understand the mission to carry out faithfully, provide the necessary detailed information, and develop learning motivation by realistic and exciting story.
- Play Role Development: in the GBS, the play role is assigned to people in the cover story. students perform the mission according to the role in the cover story. There, the instructor should develop the plat role focusing on what role allows students to practice necessary skills and knowledge to the goal. In addition, the play role should be associated with a real role which students will experience

Goal-Based Scenario can be divided into two parts: one part is activities to develop the case such as the mission, the cover story, the role, etc and the other part is operating scenarios developed

Integration of Project-Based Learning, R & E Project Learning and Goal-Based Scenario

To develop the elaborated project-based model, firstly we had compared three model, and then integrated main processes of them. Total processes are comprised of 11 stages of deciding the subject, exploring core ideas, establishing learning goals, planning the activity, researching, doing experiment & application, interpreting the result, checking and presenting halfway, drawing the conclusion, evaluating the result, and presenting the product of learning(Table 3).

Table3. Components of an elaborated Project-Based Learning Model

Integrated Process	Project-Based Learning	R&E Project Learning	Goal-Based Scenario
Select a topic	-Select a topic -Organize team	- Select a topic -Find the problem of study -Study the basic ideas: Educational Research Process	-Set up the learning goals -Understand the mission and cover story
Explore core ideas	Exploration	-Form a focus -Decide the details and methods -Explore	
Establish learning goals		Establish the plan of study	
Plan the activity	Plan activity		
Research	-Collect data -Research -Create ideas	-Collect data -Research -Creative research process	
Experiment & Application	-Discuss/ Communication	-Analyze -Explanation -Perform	
Interpret the result		-Elaboration	
Midterm check & Presentation	-Midterm check & Presentation -Express		
Draw the conclusion		-Draw the conclusion -Expansion	
Evaluate the result	Reflection & Evaluation	Evaluate the process and result	
Present the product of learning	Presentation	-Present creative product -Present and Discuss -Write the report	

To develop the elaborated project-based learning model, we analyzed and integrated with R & E projects learning model, project-based learning, and the goal-based scenario. We constructed main frame through project-based learning activities, put the mission scenario from GBS in early stage, and integrated R&E project learning which is appropriate to scientific work into each micro step.

Research Method

The study of research was confirmed the problem of R & E project learning, introduced the stages in the process of project-based learning, and developed the PBL model based on GBS. Firstly, the elaborated project-based learning was developed mainly through literature review about R & E project learning model, Project-Based Learning model, and Goal-Based Scenario. Secondly, this model was verified by experts 4 by questionnaire. This questionnaire consists of 5 items such as explanation, utilization, validation, understanding, universality and was answered in 5-point Likert scale that ranged from strongly agree (5) to strongly disagree (1). Result was following: Explanation referred whether this model can help teachers to draw the main frame of PBL activities(Mean= 5, SD=.00). Utilization referred whether this model can be utilized for teachers in stage of preparing and practicing PBL(Mean=5, SD=.00). Validation referred whether this model can be validated for teachers to prepare and practicing PBL(Mean=4.5, SD=.58). Understanding referred whether this model can be expressed for teachers to feel easy(Mean=4.5, SD=.58). Universality referred whether teachers can plan and carry out all the classes with this model(Mean=4, SD=.81). Validation of this model for scientifically gifted was carried out by four experts, one doctoral degree and three doctorate candidate in this field.

Participants and Context of the study

The participants are 10th grade science high school students in Seoul, Korea. 80 students were participated, and they were assigned to each group by 4 students. In this study, we aimed to develop elaborated project-based learning model for gifted students in science, focusing on life science classes: one of the science subjects by applying the model. verifying efficiency of the model, pre-test and post-test were executed for the learner's perception on activities and performance during the elaborated project-based learning. We executed pre-test before our model applied and post-test, after 2 weeks of lessons.

Class management: the developed biology lesson applied to10th grade students as three lectures. One lecture is applied per week, then total three lectures were applied to each class. The students are divided into small teams by 4~5. Students are assigned to teams through a lottery for facilitating high score students' co-woking with the low. In first Class, students were presented with mission scenario. After giving guidelines about activities, students did group study such as internet search, etc. with laptop computers. they developed their own research subject, made team activity plan and at the end of lecture, submitted the first mission-accomplishment-plan. Before the second class, students had to do research for the subject, improve their knowledge and submit the second mission-accomplishment-plan. Students conducted the experiment with the apparatus in the life science laboratory and materials which each team prepared. Before the third class, student wrote his(her) reflection report and submitted it. The third lecture is the last in this model applied class. Each team presented their activities and results by PPT. After that they submitted the PPT file as one of the products. The presentation was evaluated by pre-planned criteria. The components of the criteria were the validity of experiment plan, the creativity, arrangement of data, the validity of interpretation from results, etc. The reflection report was evaluated with the sincerity. The mutual evaluation was used to prevent free riders.

Assessment Instrument

To assess the learner's satisfaction, we developed the questionnaire. The questionnaire included 14 items scored on a 5-point Likert-type scale: 6 items referred to topic selection(e.g., "I investigate topics of interest before team meeting.", "I Persuade the subject to be adopted actively."), 6 items referred to inquiry (e.g., "I analyze survey data from every angle and compose it into the useful data.", "I compare with other team member's surveys, found the appropriate information to complement."), 2 items referred to expression (e.g., "I connect each data gathered logically, and write the final report with reflects creative ideas.", "The results of the project matched up to standards and achievement of the project." Cronbach's alpha was used to calculate the internal consistency of the test items and was found to .89 in this study, indicating high reliability. Also, it was added by questionnaire to measure the satisfaction about the effectiveness of the class, interest in the mission, facilitation during learning process and perception by the learners.

Data Analysis

The pre-test for students was applied before the first class, and post-tests were conducted after last class. We used SPSS ver. 15 program, and analyzed data by paired sampled t-test.

Result

This study provides a model for design of project-based learning environment for the scientifically gifted, which can be applied to both classes of experiment and theoretical studies under curricula for the scientifically gifted. The study is also intended to arouse learners' natural interest in a task through presentation of problems in the form of a mission scenario. To this end, we have developed an

elaborated project based learning model by means of integrating features of R&E project, project-based learning and goal-based scenario.

Development on an Elaborated Project-Based Learning model

The principles for developing an elaborated project-based learning model were the following.

- Design the entire process by core process of Project-Based Learning model such as selecting a topic, inquiry, and presentation.
- Design the elaborated learning process by R & E project learning model, so to speak, it was two folded learning processes; inquiry after learning basic ideas, research plan after activity plan, elaboration after experimentation etc.
- Design the learner's deep interest on a task by Goal-Based Scenario.

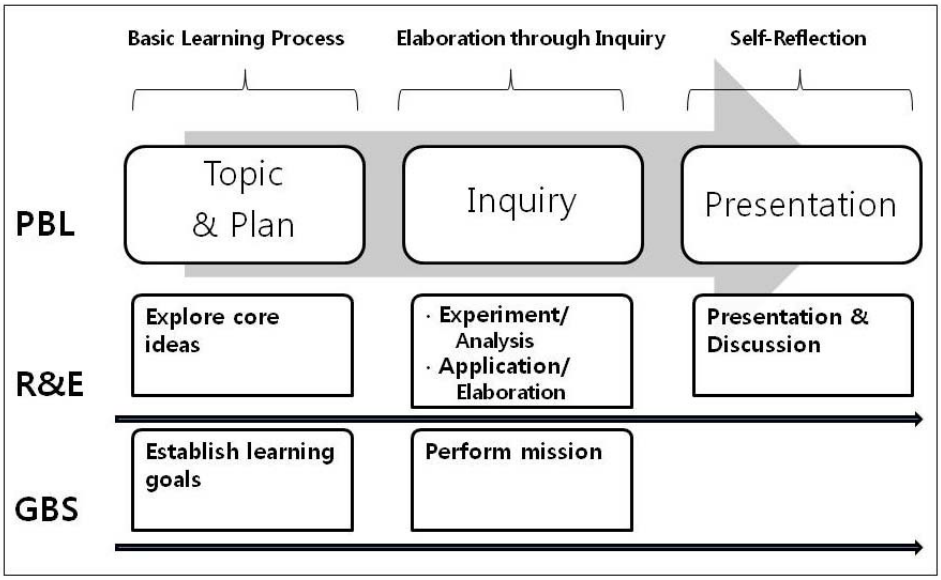

Figure 1. Design principles of an elaborated Project-Based Learning model

The following is the concrete activities for the elaborated Project-Based Learning Model for the scientifically gifted

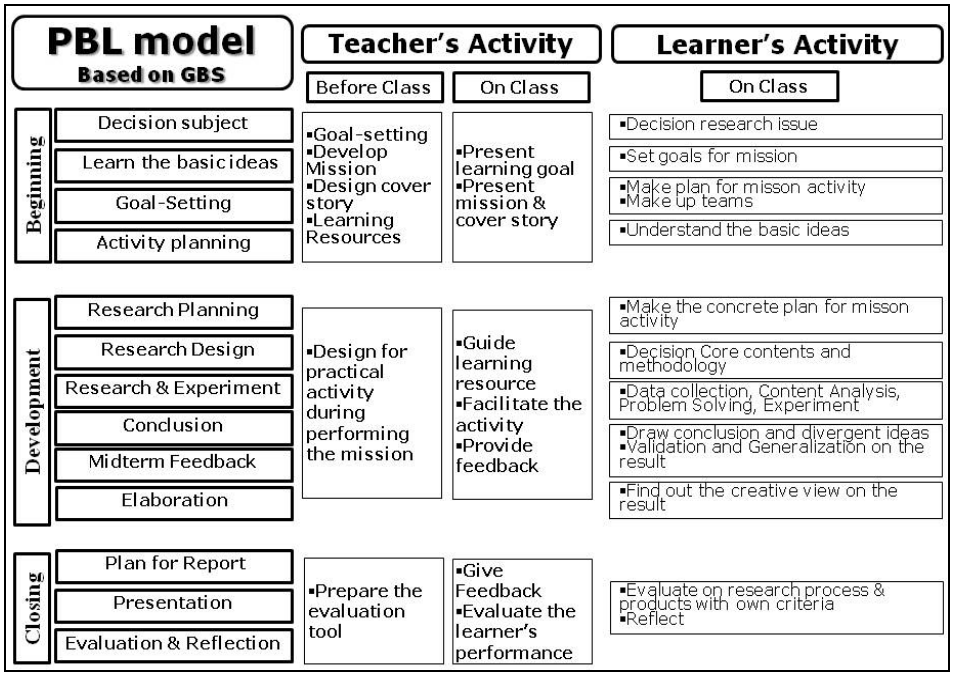

Figure 1. Elaborated Project-Based Learning Model for the scientifically gifted

Initiating Stage (Beginning): 'Basic Learning Process'

At this stage, learners are to select a topic, learn basic courses, set goals and establish activity plans. Instructors design by set the learning goals, determine missions and then design cover stories. Planning how support the learner by learning resources are also to be established. An instructor presents missions on class whereas learners make up teams and analyze the missions given by the instructor. Each team is to set goals for its mission, determines research issues and its members learn basic contents all together. In the course of this, they will prepare a mission performance plan provided as a learning tool provided. The learning tool was designed by two steps; One is a draft which is prepared by means of arrangement of contents obtained through working group discussions and data

collection while the other is a modified version refined further through in-depth learning. Primary mission performance plan is a draft and its main contents include topic title, research goals, basic learning ideas, and research plan such as procedure, role sharing, and schedule. Secondary mission performance plan is a refined version consisting of final topic title, advanced research goals, elaborated learning ideas by each learning, and research design.

Primary mission performance plan can be said to be one that is no more than an idea based on limited information but the secondary mission performance plan should contain more specific implementation plans for carrying out experiments based on more extensive contents.

Developmental Stage (Development) : 'Elaboration through Inquiry'

At this stage, research plan is further developed, research design provided, experiment carried out and conclusion to be drawn. Against this, the instructor provides midterm feedback whereupon elaboration takes place. The instructor performs a role of a facilitator by designing activities required in the course of mission performance, providing appropriate learning materials and coming back with feedback. Students modify or complement their mission performance plans to have them completed through individual learning and decide contents required for performing missions and methods to accomplish them. They also verify results through experiment and get them generalized.

Terminal Stage (Closing) : 'Expression and Self-reflection'

This stage is to make evaluation and reflection through a process of setting up a plan for report preparation and presentation thereof. The instructor prepares evaluation methods, provides feedback and evaluates leaner's activity according to criteria. Evaluation is made against an individual and a team as well. Individual evaluation takes into account a reflective journal prepared by each student. The reflective journal has been reviewed only to see if it was prepared with sincerity

without evaluating its content because its purpose is for a leaner to evaluate and look back in retrospect to his or her research process and results through the journal of reflection. On this basis, content of the journal has not been taken into the evaluation. Factors in grading for team evaluation included the feasibility of experimental design, creativeness, data arrangement, feasibility of result analysis and manner of presentation. Evaluation has been made in 3 phases of A through C and weighted points have been given to creative ideas. Evaluation has also been made from the perspective of process and results. Peer review has been taken into account as the part of process evaluation. It was announced from the first evaluation that peer review would be made to prevent free riders. In the third evaluation, students given low grades from peer review were interviewed for fact finding before evaluation.

The effectiveness on an elaborated Project-Based Learning Model

STEP	TEST	N	M	SD	t	Sig.(2-tailed)
Topic Selection	Pre-Test	75	22.49	3.25	-.67	.51
	Post-Test	75	22.80	3.30		
Inquiry (& Elaboration)	Pre-Test	75	18.19	3.14	-7.91*	.00
	Post-Test	75	21.57	3.49		
Expression (Report & Presentation)	Pre-Test	75	7.40	1.49	-.86	.40
	Post-Test	75	7.56	1.51		
Total	Pre-Test	75	48.08	6.87	-4.61*	.00
	Post-Test	75	51.93	7.11		

*$p<.5$

In the class where elaborated project learning model was applied, students received two types of learning tool. ; One is mission performance plan for elaboration, the other is monitoring tool for self-check the own performance. So, it was effective to the process of learning, especially inquiry (7.91, $p<.5$). However,

other steps weren't appeared effective. This might affect by the limited time. Students reported it was difficult to manage their project work in the short time, 2 weeks.

The Satisfaction on an elaborated Project-Based Learning Model

Level of satisfaction by the students participating in this program has been surveyed before and after the class. Satisfaction factors have been measured against effectiveness of the class, interest in the mission, facilitation during learning process and perception by the learners.

Satisfaction of the elaborated project-based learning model

82% of Students were found generally satisfied with the goal-based project learning model. Especially, they came up with comments that all team members participated positively and with sincerity and that themes should have been presented with contents which are creative, specialized and extensive. Specifically, they reported the effectiveness by stating that the learning through elaborated project learning model "called for originality in thinking and capabilities to observe things from new angles as the experiment missions required more teamwork and cooperation rather than simple group working and that deeper thought was necessary as they were supposed to turn out best results of experiment with limited experiment kits and under given conditions." Also, 77% of teachers were satisfied with this model.

Enhanced interest in a task by the mission scenario

90% of the students recognized positively the mission scenario given as an introductory activity under Elaborated project-based learning in order for them to initiate the learning. Moreover, many students answered that it aroused more interests and helped them in thinking creatively in respect of the theme .

Facilitation performance by self-check tool

While working on integrated project learning activities, learners submitted performance plans twice, did self-check in preparation for performance review and get them ready for peer review. Utilization of such checking tools appeared to have influenced course of researches by the learners. Students still found it difficult to make schedule adjustments and planning. Students had difficulties with split of responsibilities. So, it tells us that students need positive help and assistance in respect of scheduling and split of responsibilities. Methods of evaluation were relatively easier in having complaints and difficulties resolved. This model sought for evaluation of process and results simultaneously and attempted to prevent passive participants through self-evaluation (self-report, journal of reflection) and peer review as part of process evaluation. This appeared to have caused students to have a perception that the evaluation was fair, thereby encouraging their participation.

Conclusions

This study intended to develop instruction and learning methods not applicable to ordinary gifted education but something suitable for the scientifically gifted. R&E project methods recently developed for instruction and learning for the scientifically gifted are more suitable for experiment based class and difficult to be utilized to entire curricula for the scientifically gifted. More than anything else, education for the gifted should provide suitable types of education programs and learning experiences (Park. et al., 2003) but the R&E project learning widely used at science high schools these days has difficulties in enhancing educational excellence of the scientifically gifted. Bearing this in mind, this study has identified practical problems associated with the R&E project learning and newly developed "elaborated project-based learning model" by integrating elements of the project

based learning, R & E project learning and goal-based scenario.

The purpose of this model is firstly to be suitable for science curriculum for the scientifically gifted. So, the new model was required to be based on scientific experiments or researches accounting for characteristics of curricula for the scientifically gifted. Secondly, instructors and learners should be encouraged to participate easily and with interest. So, through the new model, teachers have to understand the steps of instruction easily, and students have to participate autonomously. To support this, learning tools were provided to enhance scientific creativeness and self-direction of the scientifically gifted.

Principles in development of "Elaborated project based learning model" include. Firstly, entire courses of instruction and learning should follow the procedures of "topic selection-inquiry-expression" of the project based learning. Students perform to acquire the basic ideas and research design in the basic learning process. While they could do activity for checking their learning process, they could investigate the elaborated ideas based on the basic ideas in the process of elaboration by inquiry. These processes could be suitable for experiments as well as theory in the curricula for the scientifically gifted.

Secondly, problems have been presented in the form of goal based scenarios for the sake of arousing interest and inducing enhanced creativeness of learners. This is to say that missions and cover stories have been presented with contents properly serving the purpose of learning making learners fully absorbed naturally in what they are learning.

As a result of application of the model developed under this study to the scientifically gifted, following implications came up: Firstly, learners were generally found satisfied with the integrated project based learning applied to the scientifically gifted (82%). Especially, learners reported that originality in thinking and capabilities to observe things from new angles were necessary in the experiment missions requiring teamwork and cooperation rather than simple group working. In other words, instruction and learning methods for the scientifically

gifted not only facilitate knowledge acquisition but also grow them into "learners who learn together and produce synergy effect "while geared with high skills of problem solving, teamwork and leadership. Park (2003) emphasized that education for the gifted is investment for the future made at a national scale and should be able to grow them into leaders who can make great contribution to the nation. Seen from this perspective, elaborated project based learning has great significance as it provides a learning environment well surpassing simple group activities.

Secondly, 90% of the learners came back with positive responses to the learning activities performed in mission scenarios under elaborated project based learning as applied to the scientifically gifted. Especially, they reported that it helped motivation and creative thinking in respect of themes. The scientifically gifted were given mission scenarios providing missions in the context of real situation in order to let them display creativeness because social and cultural environments are important for people to demonstrate creativeness (Csikszentmihalyi, 1999).

This means that it could be the meaningful environment. Especially, learning tools provided for this model might be useful.Based on practical necessity that the scientifically gifted should be provided with appropriate instruction and learning methods suitable for actual application with effect, this study has developed the elaborated project based learning model.

Elaborated instruction and learning development procedures, presentation of goal based mission scenario and utilization of self-checking tools and performance plan turned out to be effective for the scientifically gifted allowing them to have positive learning experience in scientific classes. This model is expected to be further applied to classes of theoretical study, mathematics and other non-experiment courses in order for its effectiveness and improvements to be complemented. It cannot be overemphasized that learning environments allowing the gifted to demonstrate unlimited scientific creativeness should be designed and provided. Follow-on studies should, therefore, be continued to have such objective accomplished.

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Hye Kyung KIM

Doctoral candidate, Department of Education, Seoul Nat'l University. Interests: Project-Based Learning, Instructional Design and Development, Performance-Support System Design, Competency-Based Education

E-mail: hkkim1@snu.ac.kr

Seungkyu CHOI

Teacher, Sejong Science High School. Interests: Science (Biology)

E-mail : genesis3212@naver.com

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