

Comparison on Positive Experiences about Science between Gifted and General Students in Middle School

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Abstract: In this study, we investigated the difference in the affective characteristics between science-gifted students and general students through the positive experiences about science (PES) index. We also explored ways to apply the characteristics of gifted classes suggested by the teachers of this study, which had a positive effect on science-gifted students, to general science classes. For this study, a PES survey was carried on middle school science-gifted students enrolled in the gifted education center in the central region and general middle school students in the same area who had no experience in gifted education. Based on the survey result, we conducted in-depth interviews with teachers, having teaching experience with both science-gifted and general students. The results revealed that science-gifted students showed a significantly higher PES index than general students in all five areas of PES. The area with the largest difference between the two groups was science-related self-concept and the smallest was science academic emotion. Teachers suggested ways to apply the characteristics of science-gifted classes to general science classes, such as organizing general science classes around inquiry activities, supporting class materials such as MBL or tablets, reconstructing the classes using materials reflecting students' needs, and changing the textbook content and narrative style, to induce students' interest and curiosity. Based on the study results, ways to enhance the PES through science classes for general students were proposed.

Keywords: Positive Experiences about Science (PES), science gifted education, science gifted classes, science gifted students

Introduction

The first goal of the 2015 science curriculum is to 'cultivate curiosity and interest in natural phenomena and an attitude to solve problems scientifically' (Ministry of Education, 2015: 4). It shows a big difference from the first goal of the 2009 science curriculum, to 'understand the basic concepts of science by exploring natural phenomena (Ministry of Education, Science and Technology, 2011: 4). This means that the improvement of the affective aspect

such as cultivating interest and curiosity about nature and objects as well as the improvement of the cognitive aspect such as understanding of science concepts and enhancement of scientific inquiry ability has become an important science education goal.

The need for changes in goals are supported by recent research results, such as that affective characteristics of learners affect cognitive achievement as much as cognitive characteristics, or that affective characteristics determine cognitive achievement by influencing cognitive characteristics. Kim & Lee (1996) discussed the need for science teaching strategies that consider the affective perception, emphasizing that the learners' positive perception of science through science learning experience affects their science inquiry ability and science learning achievement. Cho (2011) found that self-efficacy of 128 middle school students indirectly affected science academic achievement through

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cognitive self-regulating learning strategies, and that it also directly affected science academic achievement by analyzing second-year data of Korean education longitudinal study. Lee & Jung (2014) argued that positive attitudes toward science and high motivation for science learning affect the improvement of middle school students' science achievement, and that it is necessary to develop a program that takes this into consideration through analyzing survey results. Lim (2014) found that the correlation between Korean middle school students' affective characteristics and academic achievement increased over time based on the TIMSS results. As a result, research results have been drawn that it affects students' career decisions. As such, the affective characteristics have a great influence on the learner's ability to concentrate on and maintain learning activities. Shin et al. (2016) also derived research results that primary as well as middle school students' affective characteristics can predict academic achievement and affect students' career decisions. As such, the affective characteristics affect the learner's ability to concentrate on and maintain learning activities. The TIMSS study also pointed out that students' positive attitudes toward science learning or classes have a significant effect on science achievement, and argued that students should help develop students' positive attitudes (Mullis & Martin, 2013; Martin, et al., 2016).

However, according to the results of Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), the affective characteristics of Korean students were lower than the average of participating countries (MOE, 2016a; 2016b). This is in contrast to the world's highest level of academic achievement in science. Considering the effect of affective characteristics on academic achievement, policy measures are needed to positively change the affective characteristics of Korean students (Ku et al., 2017; MOE, 2016b; Sang et al., 2016). In order to positively change the affective characteristics of students, we should derive the strengths and strategies by studying the learning environment and conditions of a group of learners

with positive affective characteristics. The group evaluated as the most positive for science-related affective characteristics is science gifted students (Ahn & Choi, 2017; Jeon, 2008; Kim & Kwon, 2014; Kim et al., 2015; Shim et al., 1999). Innate giftedness is not discovered or developed over time, but develops as a talent through intentional and planned learning activities, where affective characteristics related to learning are major factors in developing talent that sustains learning (KEDI, 2017). Accordingly, the field of science gifted education has been already taking into consideration not only the cognitive aspect but also the affective aspect that affects learning (Yang et al., 2003). Therefore, in order to come up with an effective method to positively change the affective characteristics of general students, it is necessary to explore various aspects of science gifted education that affect students' affective characteristics along with a study on affective characteristics of science gifted students.

The evaluation tools mainly used to measure the affective aspect in science education (classes) are TOSRA (Test of Science Related Attitudes), SAI (Scientific Attitude Inventory), PISA, STEBI-A/B (Science Teaching Efficacy Belief Instrument-A/B), which examines the efficacy and beliefs of science teaching, SMQ (Science Motivation Questionnaire), which examines science motivation, and MSLQ (Motivated Strategies for Learning), which examines beliefs and self-direction Questionnaire) (Chung & Shin, 2019). Studies applying these evaluation tools only deal with some of the characteristics that indicate the affective aspect of learners, and few studies comprehensively examined the affective characteristics. To solve these difficulties, Shin et al. (2016) revealed the affective constructs related to science learning among various affective characteristics, and identified science learning experiences inside and outside of school that have a positive effect on these affective characteristics as 'Positive Experiences about Science (PES, hereinafter)'. In other words, PES are experiences that affect the affective characteristics of science learning, and these positive learning experiences indirectly

affect learners' cognitive achievement. The quantification of the impact of such PES is called 'Indicators of Positive Experiences about Science (IPES)' (Shin et al., 2016). The IPES identifies the affective domains and factors that affect learners' PES, and it consists of five categories such as science academic emotion, science-related self-concept, science learning motivation, science-related career aspiration, and science-related attitude (Shin et al., 2017). The IPES can be used as an index that comprehensively shows the learners' affective characteristics of science in various aspects.

First, the meaning of key terms related to PES is as follows (Shin et al., 2017: 2).

- Positive Experiences about Science (PES): It is the totality of experiences that positively influence students' perspectives on science and science learning, and refers to experiences that influence the process and outcomes of science learning.
- Indicators of Positive Experiences about Science (IPES): It is an indicator of the degree of expression of PES. The IPES consist of five areas: science learning emotion, science-related self-concept, science learning motivation, science-related career aspirations, and science-related attitude.
- Index of Students' Positive Experiences about Science (Index of PES): It is an index quantifying the degree of PES expressed by recalculating the T score for the sum of the standardized T scores for each area after obtaining the T score (mean 50, standard deviation 10) for each component of PES.

In this context, this study aims to investigate the difference in the characteristics of the affective domain between science gifted students and general students by confirming the difference through the Science Positive Experience Index (IPES). In addition, we will explore the cause of the difference in PES between gifted students and general students in terms of the characteristics of science gifted classes, and derive implications for general students' PES.

Methods

This study analyzed the PES of middle school science-gifted students and general students through the IPES survey, and conducted in-depth interviews with teachers who have experience teaching both science-gifted and general students (hereafter, science-gifted tutors). The purpose of this study was to understand the causes of high PES of gifted students in terms of the characteristics of science classes experienced by the science-gifted students.

Research participants

A total of 236 students participated in the study: 80 science gifted students from the Institute for Gifted Learning attached to A, B, and C universities in the midwestern region, and 156 general students from H middle school. The detailed grades and genders of student participants are shown in Table 1. Considering the results of a previous study (Shin et al., 2017) that male students had more PES learning than female students, we tried to compose a similar gender ratio between science gifted students and general students.

PES survey tools and analysis methods

The PES survey tool (Shin et al., 2017) was used to measure PES. The PES survey tool consists of 5 domains, totaling 35 items (Table 2). Each item was described on a Likert 4-point rating scale. As a result of the reliability test, Cronbach's α coefficients were .79~.97 in all five domains including all questions.

The index for each area of the IPES is the average value of the scores answered for each area, and the average value of the index for each area is the IPES. To find out what kind of difference between science

Table 1. Student participants by grade level and gender

		7th grader	8th grader	9th grader	Total (%)
science gifted students	male	30	13	0	43 (54%)
	female	21	13	3	37 (46%)
general students	male	31	0	48	79 (51%)
	female	0	48	29	77 (49%)
Total		82	74	80	236

Table 2. Questionnaires and reliability of PES survey (Shin et al., 2017: 340)

Areas	Items	N. of items	Cronbach's α
Science academic emotion	A1, A2, A3, A4*, A5*, A6*	6	.86
Science-related self-concept,	B1, B2, B3, B4, B5, B6	6	.90
Science learning motivation	C1, C2, C3, C4, C5, C6*, C7, C8, C9, C10	10	.87
Science-related career aspiration	D1, D2, D3, D4, D5	5	.90
Science-related attitude	E1, E2, E3, E4, E5, E6, E7, E8	8	.91
	Total	35	.96

*Reverse-score items

gifted students and general students in PES, the mean and standard deviation for each area were calculated, and a t-test was performed. SPSS 24.0 for Windows was used for statistical analysis.

In-depth interview with science-gifted tutors

In this study, in-depth interviews were conducted with science-gifted tutors to investigate the cause of the difference in PES between science gifted students and general students. We tried to find the effect on the PES by focusing on the science teaching and learning aspects experienced by gifted students, excluding individual characteristics (e.g., IQ, home environment, etc.) that are non-manipulable variables. For this purpose, in-depth interviews were conducted with current middle school teachers who had experience in teaching both middle school science gifted students and general students. Through in-depth interviews, the characteristics of science gifted students compared to general students, and the characteristics of science classes (science gifted classes, hereinafter) at the gifted education center were derived.

The interview questions consist of (1) the characteristics of science positive experience of the gifted science, (2) the characteristics of classes at the gifted education center, (3) strategies to expand and

spread science gifted classes to general students, and (4) improvement plans and implications for increasing PES of general students.

The teachers who participated in the interview had 2-5 years of teaching experience for the gifted (Table 3), and have conducted an average of 3-9 lessons for the gifted per semester. In addition, these science-gifted tutors have experience in teaching group experiments and discussion classes for each group through educational activities such as experiential activities, creative product contests, intensive classes during vacations, and camps for the gifted.

The validity of the interview questionnaire was verified through the review of four science education graduate students and field teachers who are also conducting research on the affective characteristics of students, and the interviewees received the questionnaire in advance, devised their answers, and then participated in individual interviews. Interviews were conducted over the phone at a convenient time for the participant, and each participant had an interview for about 60 minutes. The interview was recorded and then transcribed. Three science education experts each carried out open coding with the transcribed interview data, and extracted related themes and features for each major category, such as the characteristics of the

Table 3. Background information of Interview participants

Participant	Gender	Teaching experience	Gifted Education Experience	Major
A	female	7	3	Physics
B	male	8	5	Earth science
C	male	4	3	Physics
D	female	7	2	Earth science
E	female	4	4	Physics

curriculum, teaching and learning methods and materials, and evaluation. Three analysts repeated the process of classification and comparison to improve consistency among them. In addition, the derived main themes were reviewed once again in light of previous studies and their meanings were discussed. In this process, science education experts and science education master's and doctoral graduate students were continuously reviewed to ensure validity.

Results and Discussion

Comparison of PES of science gifted students and general students

Table 4 shows the comparison result of the PES index by area for science gifted students and general students.

In the PES index, which is the mean score of the five areas of PES, the mean score of science gifted students was 0.749 points higher than that of general students. Science gifted students had the highest average of science-related attitudes among the five areas, followed by science-related career aspirations, Science academic emotion, science-related self-concept, and science learning motivation. For general students, the highest domain was the Science academic emotion domain, and the science-related self-concept showed the lowest in the order of science-related attitude, science learning motivation, and science-related career aspirations. The area with the largest difference in scores between science gifted students and general students was science-related self-concept (0.987), followed by science-related career aspirations (0.898), science learning motivation (0.697), science-related

attitudes (0.677), and science academic emotion (0.486).

The results of the PES survey of science gifted students and general students for each area of the PES are as follows:

(1) Science academic emotion

First, the science gifted students scored 0.490 points higher than the general students in 'Science academic emotion', 'the learner's emotion about science learning, which was a statistically significant difference. This is consistent with the results of previous studies (Ahn et al., 2016) that science gifted students have a more positive Science academic emotion than general students. According to the results of the in-depth interview with the science-gifted tutors, tutors said that the science gifted students showed higher science positive experiences than general students in science academic emotion due to the characteristics of science gifted students who like scientific thinking.

Science-gifted tutors said that science subjects, in which the logical inquiry process proceeds and answers are derived as a result, fit well with the propensity of science gifted students who like scientific thinking, and that their Science academic emotion is higher than that of general students. In other words, the science-gifted tutors said that science gifted students who like scientific thinking like science subjects themselves.

(2) Science-related self-concept

There was a big difference in scores between science gifted students and general students in the 'Science-related self-concept', which indicates self-efficacy and self-esteem related to science learning. Science gifted students scored 3.404 points, and general students

Table 4. Comparison result of PES between science gifted and general students

Areas	science gifted students (Mean)	general students (Mean)	difference	t
Science academic emotion	3.442	2.956	0.486	6.270*
Science-related self-concept,	3.404	2.417	0.987	10.823*
Science learning motivation	3.364	2.667	0.697	9.544*
Science-related career aspiration	3.535	2.637	0.898	11.005*
Science-related attitude	3.572	2.895	0.677	8.690*
PES index (Mean)	3.463	2.714	0.749	

* $p < .001$

scored 2.415 points. The average score difference between the two groups was 0.989, which was a statistically significant difference. Kim et al. (2015) also suggested that science gifted students have higher self-confidence than general students.

The science-gifted tutors said that the science gifted students' confidence in science learning leads to high positive experiences related to science-related self-concept. The science-gifted tutors said that students with confidence in science applied for the Science Gifted Education Center. In order to be admitted to the Science Education Center for the gifted, students should go through a multi-step selection process, including the process of confirming their scientific talent. According to previous studies, science gifted students who have officially passed the verification of scientific talent think that their talents have been recognized, and people around them also recognize their scientific talents (Kim et al., 2016). Tutors explained that such an atmosphere acts as a factor in increasing students' self-concept.

(3) Science learning motivation

In the case of 'Science learning motivation', which is the will to learn by participating diligently in science class, the attitude to apply the learned knowledge to everyday life, and the driving force to solve the given task, the science gifted students scored 3.364 and general students scored 2.689. The average score difference between the two groups was 0.674, which was a statistically significant difference.

The science-gifted tutors explained that science gifted students have a goal orientation to create successful results using the scientific knowledge they have learned. In addition, the teachers argued that science gifted students have a good teaching attitude and a willingness to participate actively in class, which leads to learning motivation.

(4) Science-related career aspiration

Science gifted students scored 3.535 points and general students scored 2.870 points, showing a significant difference of 0.914 points for 'science-

related career aspirations', which is about the social impact of science-related occupations, job types, and career hopes. These results are consistent with the results of previous studies (Shim et al., 1999) that science gifted students have a higher vocational interest in science than general students.

According to the results of the in-depth interview with the science-gifted tutors, science gifted students showed a higher positive experience in science-related career aspirations than general students because they know a lot about science-related jobs and hope for such jobs. Science gifted students, the science-gifted tutors said, can learn about a variety of science-related occupations while performing various activities at the Science Gifted Education Center.

(5) Science-related attitude

The science gifted students scored 3.572 points and general students scored 2.710 points, indicating that the science gifted students scored 0.702 points higher than the general students for the 'science-related attitude', which is the value, influence, interest, and opinion of science. These results are similar to those of previous studies (Shim et al., 1999; Jeon, 2008, Kim et al., 2014).

Science-gifted tutors said that gifted students in science appreciate the value of science because they know various cases where scientific knowledge is used, and that they accept the usefulness of science more sensitively than general students because they have many experiences in which science is valuable in everyday life. In other words, it is said that the explanatory power or efficacy of scientific knowledge is linked to the value recognition of science, and this value recognition leads to the improvement of positive experiences toward science-related attitudes.

Ways to apply the characteristics of science gifted classes to general science classes

In this study, in order to analyze the difference in science positive experience between science gifted students and general students, the PES survey was conducted. In addition, an in-depth interview was

conducted with teachers on how to apply the characteristics of science gifted classes to general science classes. The science-gifted tutors argued that applying the characteristics of science gifted classes that had a positive effect on gifted students to general science classes could be effective in enhancing general students' positive science experience. The changes in general science classes suggested by tutors through in-depth interviews are as follows:

First, general science classes should be reorganized mainly of inquiry activities. Tutors said that it is more effective for general students to have students explore the scientific principles hidden in their daily life or use them to interpret natural phenomena rather than lecture-style classes in which information is presented and listed. This is consistent with previous research results (Eo, 2004; Moon et al., 2018) that inquiry-centered classes have a positive effect on the affective characteristics of students. In other words, science classes centered on inquiry activities have a positive effect on students' PES.

Tutor C: Science gifted classes provide students with a variety of experiences and develop critical thinking skills through intensive experimental classes or project classes that are not available in general schools. Inquiry is important in science classes. However, it is difficult for science gifted students to be satisfied with inquiry classes because they have to conduct experiments as they are in the experimental process in general classes. Thus, in order to compensate for these problems, the science gifted class intends to organize an inquiry class that can fully demonstrate gifted students' potential ability.

Tutor D: I think that field trips that apply what they have learned are effective. If you go to the fossil findspot and observe it yourself, after learning fossils, it will be effective for general students because you will have the experience of applying what you have learned.

Tutor E: If you do an experiment in a group or show the experiment in front of the class, students will enjoy the class. It would be great for

students to actually experiment, but the students are very surprised that what they have learned is actually applied even when observing experiments.

Second, support for class instruments and materials such as MBL and tablets is necessary for general students. Science-gifted tutors said that teaching instruments such as MBL are necessary for science gifted students, but more needed for general students who cannot concentrate easily in class. In addition, the tutors pointed out that the experiment using MBL helps students to interpret data, which is difficult for ordinary students, so that they can feel the science class without difficulty, thereby motivating students to learn.

Therefore, it is necessary to provide general science classes that can enhance students' PES and their achievement by supporting cutting-edge teaching materials such as MBL and tablets. These tutors' assertions are also consistent with previous studies (Kim et al., 2014; Yu et al., 2007a) that various scientific equipment provided in class has a positive effect on students' affective characteristics.

Tutor A: It is necessary to use various senses while operating the device by hand. By using the various senses such as visual and auditory senses, general students can concentrate more and become interested when they pay more attention. There is a limit to the progress of the class only by thinking.

Tutor B: One of the best advantages of using MBL is that it can help students who have difficulty with drawing graphs. In addition, it seems to have a positive effect on the science academic emotion with curiosity to use advanced devices. Because the data is directly visible, the motivation for learning seems to be helpful if it inspires students to learn in the sense that they can interpret the data or draw conclusions from these data.

Tutor D: Classes using cutting-edge equipment can be taught in a variety of ways, increasing the learning motivation and career aspirations of science gifted students. Because rather than

thinking with your head and making things with your hands, the activities of designing the process yourself and making real objects using a 3D printer are specific, and the activity itself seems to inspire students' interest.

Third, the class should be reorganized by using materials that reflect the needs of the students. Tutors said that ordinary students exposed to a lot of information try to accept only the information they need. Therefore, tutors insisted that students' motivation to learn can be enhanced if tutors reorganize lessons by selecting a topic with high interest and demand from students. In other words, tutors said that class can provide students with a positive experience if the class is reorganized with meaningful content in daily life.

Tutor A: I think that students' motivation to learn could be increased if students create content using what they are interested in or organize the class in such a way, rather than learning the discipline of science separate from real life.

Tutor B: Classes for general students need to be more meaningful in real life compared to gifted students. It is believed that the PES will be improved as teaching and learning activities are conducted with content that matches students' interests in their career or field of interest.

Tutor E: Science gifted students have a different content level than general students. It seems that science gifted students think that the classes are worthwhile and good when they acquire new knowledge in class. So, when you introduce new scientific knowledge, the reaction is definitely good. Science gifted students seem to be highly satisfied when they are given something new and can be applied in daily life.

Fourth, the content of textbooks and the writing style should be changed in a way that can induce students' interest and curiosity. Tutors who say that current science textbooks are composed of science content that scholars have determined are necessary argued that the textbook content needs to be composed of real-life topics that can arouse students' interest and

curiosity. Tutors said that since textbooks are the books most often encountered by students, they need to be changed in a way that stimulates students' learning desires with a narrative style tailored to the level of the students.

Tutor B: Since textbooks are the books most often encountered by students, the narrative method should be expressed in a more interesting way from the students' perspective. So, I hope that students will be interested in scientific knowledge while reading textbooks and think that they should study with interest.

Tutor E: The content contained in the textbook conveys the knowledge that scholars consider necessary rather than the curiosity or demand of students. The content of the textbook topic catches my eye only when I think that it has to do with life. However, in our textbooks, the theory is described first, followed by the contents related to real life in the form of an appendix. This order should be reversed.

In particular, Cho et al. (2012) argued that Korean students tend to value instrumental values more, and their tendency to regard science as more difficult than other subjects was investigated as the cause of the low affective achievement by analyzing student responses to science attitudes and class experiences based on PISA and TIMSS international academic achievement results. Therefore, it is necessary to change the way of describing the contents of science learning as well as textbooks so that general students as well as gifted students can think that science is helpful in their daily life (Kwak, 2017).

Conclusion

The purpose of this study is to find out the difference in the affective domain characteristics between science gifted students and general students through the PES index, and to explore ways to apply the characteristics of science gifted classes that have a positive effect on science gifted students to general science classes. According to the results, science

gifted students had significantly higher science PES than general students. Based on the results of the study, the conclusions are presented as follows:

First, the science gifted students showed significantly higher PES indexes in all areas of PES compared with general students. In particular, science gifted students showed the largest difference in their self-concepts related to science compared to general students. Therefore, it is necessary to apply the characteristics of science gifted classes, which had a positive effect on science gifted students, to general science classes, and strive to improve the PES of general students.

Second, according to the result of this study, science gifted classes tend to have a high degree of autonomy in restructuring the curriculum, and this characteristic appears as a positive experience in relation to science-related self-concept. It was found that the science gifted class can provide students with experiences related to scientific knowledge in various fields according to the interests and needs of gifted students since the tutors have a high degree of autonomy in restructuring the curriculum. Science learning experiences built on the basis of interest and attention act as a driving force for gifted students to have more confidence when dealing with science subjects than general students, and thus appear as positive experiences related to students' high science-related self-concept. It is, therefore, necessary to use materials that reflect the needs of students in general science classes, or to reorganize the classes mainly for inquiry activities.

Third, the characteristics of the methods and materials of science gifted classes explain the PES of gifted students in terms of science-related career aspirations and science-related attitudes. Science gifted students experience activities like scientists while performing inquiry activities using various class instruments, including MBL and tablets. In particular, Earth science have more graphs than other science subjects, and there are various types such as line graphs and isometry diagrams. Since digital equipment such as MBL converts data into graphs, it can help students who have difficulties in data conversion including scale comparison of celestial bodies, geologic

ages, etc. in Earth science in particular.

Finally, the characteristics of the science gifted class that require students' critical thinking and creative problem-solving ability and the science-historical approach appear as positive experiences in relation to science academic emotion. Science gifted students are interested in the life of a scientist or the process of changing science theory presented in class because the students accept it as a story rather than scientific knowledge. Therefore, it will be helpful to cultivate students' science learning emotions through narrative-type content access such as the mass extinction of Earth science or the history of biological change.

On the other hand, it is necessary to systematically analyze the textbooks used in the science gifted class in terms of inquiry activities, class materials, and curriculum reorganization reflecting student interests through follow-up research. In addition, it is worth noting that gifted teaching materials, curriculum reorganization with enhanced inquiry activities, and educational equipment such as MBL and tablets are superior educational opportunities provided to science gifted students. It is necessary to ensure equity of educational opportunities for general students, including differences in teacher professional competence that occur when the students to be taught are different.

In addition, a follow-up study on the effect of the personal characteristics of science gifted students on the PES is needed. The characteristics of teaching and learning aspects of science gifted students also affected the PES, such as Science academic emotion, science-related self-concept, science learning motivation, science-related career aspirations, and science-related attitude. Tutors evaluated that the original personal characteristics also had an effect. Therefore, a follow-up study on the change in PES before and after gifted students receive science gifted classes is necessary.

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