韓國數學教育學會誌 시리즈 E <數學教育 論文集>
https://doi.org/10.7468/jksmee.2022.36.3.373
제 36집 제 3호, 2022. 9. 373-395

J. Korea Soc. Math. Ed. Ser. E:
Communications of Mathematical Education
Vol. 36, No. 3, Sep. 2022. 373-395

# Prospective Mathematics Teachers' Perceptions of Collaborative Problem-posing as a Means to Promote Students' Creativity and Character

Lee, Bongju (Kyungpook National University, Professor)

This study aimed to examine how prospective mathematics teachers (PMTs) perceive collaborative problem-posing (CPP) as a method to cultivate students' creativity and character in mathematics education. This is to propose the introduction of CPP at the stage of preparatory math teacher education as one of the ways to reinforce the creativity and character education capacity of PMT), and to attempt to be an opportunity to actively utilize CPP in math teaching-learning in the school field for the education of students' creativity and character. To achieve this objective, I designed PMTs taking the 'Educational Theories for Teaching Mathematics' course, required in the second year of university, to experience CPP tasks. Data were collected through questionnaires or interviews over three years on how PMTs recognized the CPP tasks as a tool to cultivate students' creativity and character in secondary schools. The results of the study are as follows. First, PMTs recognized regardless of their CPP experience that CPP might have a positive impact on improving students' ability to devise various ideas and that it positively influences students' attitudes toward building interpersonal relationships, including teamwork, respect, and consideration. Second, the experience of PMTs participating in the CPP made them more positively aware that CPP is effective in improving students' ability to elaborate on ideas. Third, the PMTs' experience of participating in CPP led to a more positive perception of the impact of CPP on the students' abilities and attitudes, namely, the students' ability to elaborate on ideas and their inner attitudes toward individuals, including honesty, fairness, and responsibility, and the attitude of students regarding logically presenting their opinions and making rational decisions. Finally, if there are downsides to the offline environment, an online environment may be more beneficial.

## Ⅰ. INTRODUCTION

The Ministry of Education (MOE; 2009, 2010) has repeatedly prompted human resource development through harmony of creativity and consideration as the basic plan for creativity and character education. In 2015, the 'Character Education Promotion Act', which specified the formation and operation of the school curriculum that cultivate the core competencies of students' character was passed and enforced, and it has become mandatory for all curriculum to practice character education (Cho, Choi, & Eun, 2015).

The role of teachers is the most important in effectively practicing creativity and character education with

* 접수일(2022년 8월 8일), 심사(수정)일(2022년 9월 8일), 게재확정일(2022년 9월 8일)
* 2000 Mathematics Subject Classification : 97C70
* Key words : prospective mathematics teachers (PMTs); collaborative problem-posing (CPP); students' creativity and character; creativity education; character education
* This research was supported by Kyungpook National University Research Fund, 2020.

students and is being increasingly emphasized in school education. The results of the perception survey of mathematics teachers on the possibility of creativity and character education in mathematics education are as follows. First, the perceptions of elementary school and most secondary school mathematics teachers were positive regarding improving students' creativity through mathematics education, but training is necessary on the teaching-learning methods to cultivate creativity (Lee, 2012). Next, lower-grade elementary school teachers had positive perceptions of the possibility of character education through mathematics, but higher-grade teachers tended to be more negative than that group (Park & Kim, 2014). Secondary school mathematics teachers were not only more negative about the possibility of character education in mathematics class than elementary school teachers but also more likely to be less interested in pursuing this objective. These survey results reveal that creating an opportunity for mathematics teachers to think positively of the possibility of character education through mathematics class is necessary. As indicated by the saying "You teach what you learn" opportunities should be provided to mathematics teachers, especially prospective mathematics teachers (PMTs) to be positively aware of the possibility by experiencing the teaching-learning methods used to develop creativity and character.

In this study, I suggested collaborative problem-posing (CPP) as a method to practice both creativity and character education in mathematics education and provided an opportunity for PMTs to perform CPP as a task. The reasons are as follows: first, problem-posing in mathematics education has been proved to improve the students' creativity (e.g., Silver, 1997; Lee & Hwang, 2007; Sheffield, 2009; Van Harpen & Sriraman, 2013); second, cooperative learning techniques accompanied by discussion were suggested as a character education plan in school education (e.g., Berkowitz & Bier, 2005; Moon, Choi, Kwak, & Lee, 2010; Lee, 2014; Bae & Hwang, 2015). Discussion is one of the most suitable methods to develop students' mathematical creativity and character. In this perspective, CPP is a combination of the two strategies already suggested to promote creativity and character in the education of students.

Thus, in this study, the PMTs performed CPP as a task; next, I examined how they perceived CPP as a method to cultivate students' creativity and character in mathematics education. I aimed to reveal that implementing CPP in PMTs' training to enhance their creativity and character education competencies required in the present state, based on the findings of this survey, will motivate them to more actively practice creativity and character education with their students. CPP refers to activities in which two PMTs are paired as a group and collaborate in creating problems, example answers, and scoring criteria. I expect that this study will provide an opportunity for CPP to secure its place as a teaching and learning method that enhances the creativity and character education competencies of PMTs, and provide implications for CPP to be used more efficiently in the training of PMTs and in school mathematics education.

## Ⅱ. BACKGROUND OF THE STUDY

### 1. Theoretical Background

#### A. Creativity Education in the National School Curriculum

The origins of creativity research have been traced to the 1930s, 1940s, and 1950s (Runco & Jaeger,

2012). The definition of creativity varies by scholar, for example, although some have defined it in terms of a product, others have done so in terms of a process (Torrance, 1965). Stein (1953) defined creative work as new work that at a certain point was accepted by the group as sustainable, useful, or satisfactory. Guilford had substantial influence on the psychology of creativity (Sternberg & Grigorenko, 2001), and Guilford (in Kim, 2016, p. 4) explained creative thinking as involving divergent thinking and emphasized fluency, flexibility, originality, and elaboration. Torrance (1965) described creativity as a series of processes that enable individuals to recognize difficult problems, devise solutions and hypotheses, test and retest these hypotheses, and finally, communicate results. Runco and Jaeger (2012) proposed a standard definition that creativity demands both originality and effectiveness, but acknowledged that this standard definition was incomplete.

Although creativity has aspects that are difficult to define with one unified terminology, creativity in education is more necessary than ever because 21st-century society demands its members to not only know what they know or how much they know but also how to think and act creatively. Resnick (2007) referred to this society as a creative society and emphasized the individuals with attitudes that consistently find creative solutions to unexpected problems. In line with these demands of the times, creativity education is becoming more emphasized (seo & Park, 2021), and educators including researchers are endeavoring to improve students' creativity more effectively.

Since the 1990s, in South Korea, creativity education has been a priority when revising the national school curriculum (Korea Educational Development Institute; KEDI, 2012). In the national school curriculum, creativity was emphasized in the 6$^{th}$ curriculum and particularly evident in the educational goals of the 7$^{th}$ curriculum announced in 1997. As one of the development directions of the 6$^{th}$ curriculum, it was set "to develop creative ability to respond to changes in society (MOE, 1992, p. 3)." However, in the 6$^{th}$ school mathematics curriculum, creativity education was not mentioned. In the 7$^{th}$ curriculum, "the student-centered curriculum for improving learners' autonomy and creativity (MOE, 1997a, p. 4)" was one of the characteristics of the curriculum. Based on this revision direction, in the 7$^{th}$ school mathematics curriculum, a creative solution plan and execution for solving math problems and the cultivation of mathematical thinking and creativity through math learning were presented (MOE, 1997b). This trend continued in the 2007 revised school curriculum, but expressions related to creativity disappeared from the school mathematics curriculum. These curriculum documents suggested neither the definition of creative thinking nor how to promote students' creativity in math classrooms.

In the 2009 revised school curriculum, 'the creative experience activity curriculum' was announced as a separate volume and creativity education was further emphasized. The characteristics of the curriculum remained the same as those of the prior curriculum, and the target human image related to creativity was described in more detail as "a person who demonstrates creativity with new ideas and challenges based on basic ability (MOE, 2011a, p. 1)." Therefore, to further emphasize creativity, one of the goals of mathematics education in the mathematics was "cultivating the ability to creatively solve problems identified from mathematical phenomena around life, society, and nature (MOE, 2011b, p. 5)." Furthermore, to enhance mathematical creativity, four points to apply to teaching and learning were presented.

The 2015 revised school curriculum emphasized the core competencies that should be cultivated throughout school education. As one of the core competencies, the curriculum suggests promoting a "creative

thinking competency to create new things by fusion of knowledge, skills, and experiences in various specialized fields based on extensive basic knowledge (MOE, 2015a, p. 2)." In line with this outline, in the mathematics curriculum, the creative-convergence competency was set as one of the mathematics subject competencies. The creative ability was explained as the ability to solve problems by generating and elaborating new, meaningful, and various ideas based on mathematical knowledge and skills (MOU, 2015b). Furthermore, to improve creative ability, two points were emphasized in teaching and learning math.

① Promote creative thinking of students by providing mathematical tasks that can produce various and abundant new and meaningful ideas; and
② Let students solve a problem in several ways and compare solutions to find or elaborate more efficient methods (MOU, 2015b, p. 40).

As reviewed, the 2015 revised school mathematics curriculum revealed the meaning of creativity and presented in more detail than the prior revision the math teaching-learning methods to cultivate the creativity of students. Therefore, in this study, subordinate skills or abilities related to creativity education were extracted based on the school mathematics curriculum and applied to the investigation of changes in the perceptions of PMTs.

### B. Character Education in the National School Curriculum

Educators have become increasingly interested in character education in schools. Character education teaches students about basic universal values that enable them to become morally responsible, self-disciplined citizens (Berkowitz & Bier, 2005). Berkowitz and Bier (2005) presented assumptions for their conceptual model, for example, "character is the composite of those psychological characteristics that impact the child's capacity and tendency to be an effective moral agent, i.e. to be socially and personally responsible, ethical, and self-managed (p. 2)." Moon and his colleagues (2010) argued that character includes moral values and is a personality trait that can be cultivated through education. They suggested honesty, promise, forgiveness, consideration, and responsibility as the virtues of human relations and moral sensitivity, moral judgment, decision-making ability, and action execution ability as the ability to judge personality.

Character education has also been a priority in revisions of the South Korean school curriculum since the 1990s (KEDI, 2012). In the national school curriculum, the guidance on character education was more clearly presented after the 7$^{th}$ school curriculum announced in 1997. In the 7$^{th}$ and 2007 revised school curriculum, this direction of operation was suggested: "It is necessary to ensure that character education is integrated and systematically implemented throughout the school education activities (MOU, 1997a, p. 24; 2007, p. 20)." Based on this direction, some subject curriculum suggested character education as one of the goals, but the school mathematics curriculum did not. The school mathematics curriculum emphasized a positive attitude toward mathematics as one of the goals.

In particular, MOU (2010) established a policy to organize a curriculum to promote creative talents who practice caring and sharing. In line with this policy, the 2009 revised school curriculum further emphasized the cultivation of global talents equipped with creativity and character, and the 2009 revised school mathematics curriculum provided details essential for character education in math teaching-learning. Notably,

the 2015 revised school mathematics curriculum did not contain the term character but continued to emphasize character education by including "attitude and practical ability" in six core competencies for mathematics education. For cultivating attitude and practical ability, the following math teaching-learning directions were suggested.

> Behave honestly, fairly and responsibly through mathematical activities, have a courageous attitude to challenge to overcome difficulties, an attitude of caring for, respecting and cooperating with others, an attitude of presenting opinions based on logical grounds and making rational decisions, and practice these attitudes (MOU, 2015b, p. 40).

The 2015 revised school mathematics curriculum included the detailed elements presented in research related to character education (e.g., Kohn, 1997; Berkowitz & Bier, 2005; Moon et al., 2010; Bialik, Bogan, Fadel, & Horvathova, 2015) and was thus more specific than in the prior school mathematics curriculum. These specifications are interpreted that mathematics education has attempted to continually emphasize character education. As reviewed, the 2015 revised school mathematics curriculum clearly stated character education and presented in more detail the math teaching-learning methods necessary to cultivate the character of students. Therefore, in this study, subordinate skills or abilities related to character education were extracted based on the school mathematics curriculum and applied to the investigation of changes in the perceptions of PMTs.

## 2. Method

### A. Objects

The CPP tasks were performed from September 2014 through December 2016 at a college of education of a national university in a metropolitan city of South Korea. These tasks were implemented in the 'Educational Theories for Teaching Mathematics' course that was opened as a required course for the department of mathematics education in the fall semester of each year. The lecturer was the researcher, and the research objects who took this course included the 54 PMTs in Group A in 2014, the 37 PMTs in group B in 2015, and the 40 PMTs in Group C in 2016. Table Ⅱ-1 shows the distribution according to the gender and major of the members of the three groups. The major category was divided into PMTs majoring in and PMTs minoring in mathematics education. All 130 PMTs who took the corresponding course participated in the CPP activity. I randomly grouped them by referring to the roll book each year, and they collaborated among the members of their initially assigned group for 1 semester.

<Table Ⅱ-1> Objects

| Year | Group | Gender | | Major type | |
|---|---|---|---|---|---|
| | | Male | Female | Major | Minor |
| 2014 | A | 27 | 27 | 34 | 20 |
| 2015 | B | 23 | 13 | 22 | 15 |
| 2016 | C | 23 | 17 | 26 | 14 |

### B. Lecture Topics

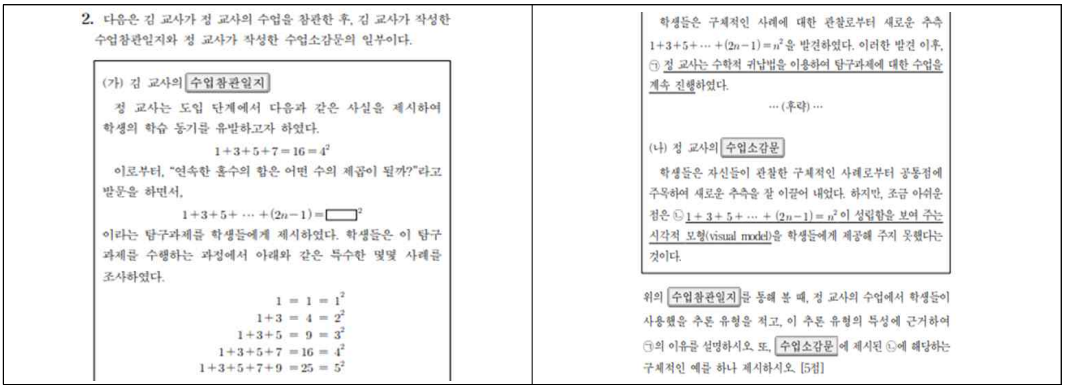
The 'Educational Theories for Teaching Mathematics' is one of the required courses for the department of mathematics education in most universities, although the title may vary slightly, and it is a lecture mostly for sophomore students. The objective of this course is to briefly examine the theories and practice of mathematics education that have been discussed thus far and the recent trends, to understand overall mathematics education and help PMTs prepare to become mathematics teachers. The five main topics were mathematics curriculum, philosophy of mathematics education, educational of mathematical problem solving, psychology of mathematics learning, and theories of teaching and learning mathematics. Notably, because covering all these topics might be difficult to accomplish in 1 semester, only the key content of each topic was introduced to provide the PMTs with a general understanding of the theories in mathematics education. Each main topic was covered for 2-3 weeks, with two 75-minute sessions per week. Learning content covered in these topics were formed into paper-based examination questions (i.e., short-answer, descriptive, and essay-style questions) from the teacher recruitment examination for secondary school, which is one method used to select mathematics teachers for public secondary schools in South Korea.

### C. The Meaning of the Problem

The problems that PMTs must pose in this study are different from the mathematical problems solved in the school classroom because what is taught and learned in this course is not about mathematics. The problems in this study are descriptive items that present a specific mathematical teaching-learning situation in a scenario applying each theory of mathematics education and request students to describe the related theory by specifically associating it with the classroom setting of the given text. The text may be constructed in a scenario in which students are asked questions in imagination by applying the theories of mathematics education learned by PMTs to specific mathematical teaching-learning situations and the students answer those questions, or may be described as not a conversation but a simple mathematical teaching-learning situation or assessment context. The former is a type of thought experiment in which PMTs plan and conduct class in imagination prior to actual instruction. The latter includes student activity sheets, mathematics teachers' class observation logs, study journals written by students, and mathematical assessment context in mathematics class.

Figure Ⅱ-1 shows an example of the type of problems that PMTs must pose in collaboration. The example here was presented in the paper-based examination from the teacher recruitment examination for secondary school. This CPP not only achieves the purpose of enhancing creativity and character education competencies in this study but also provides PMTs with experience in thought experiment in which they apply the theories of mathematics education to real mathematical teaching-learning situations. Furthermore, this thought experiment experience will enable PMTs to prepare for good classes and lessons in the future (Kim, 2014).

In addition, PMTs participating in CPP were informed to include example answers for the problems as well as rubrics. Analytic scoring was suggested to use for rubrics. The problems can be rechecked in the process of making up example answers and the problems and example answers can be repeatedly checked in the process of making the scoring criteria, and thus such elements are also included in CPP.


2. 다음은 김 교사가 정 교사의 수업을 참관한 후, 김 교사가 작성한 수업참관일지와 정 교사가 작성한 수업소감문의 일부이다.

(가) 김 교사의 수업참관일지

정 교사는 도입 단계에서 다음과 같은 사실을 제시하여 학생의 학습 동기를 유발하고자 하였다.

$$1+3+5+7=16=4^2$$

이로부터, "연속한 홀수의 합은 어떤 수의 제곱이 될까?"라고 발문을 하면서,

$$1+3+5+\cdots+(2n-1)=\square^2$$

이라는 탐구과제를 학생들에게 제시하였다. 학생들은 이 탐구과제를 수행하는 과정에서 아래와 같은 특수한 몇몇 사례를 조사하였다.

$$1=1=1^2$$
$$1+3=4=2^2$$
$$1+3+5=9=3^2$$
$$1+3+5+7=16=4^2$$
$$1+3+5+7+9=25=5^2$$

학생들은 구체적인 사례에 대한 관찰로부터 새로운 추측 $1+3+5+\cdots+(2n-1)=n^2$을 발견하였다. 이러한 발견 이후, ㉠ 정 교사는 수학적 귀납법을 이용하여 탐구과제에 대한 수업을 계속 진행하였다.

… (후략) …

(나) 정 교사의 수업소감문

학생들은 자신들이 관찰한 구체적인 사례로부터 공통점에 주목하여 새로운 추측을 잘 이끌어 내었다. 하지만, 조금 아쉬운 점은 ㉡ $1+3+5+\cdots+(2n-1)=n^2$이 성립함을 보여 주는 시각적 모형(visual model)을 학생들에게 제공해 주지 못했다는 것이다.

위의 수업참관일지를 통해 볼 때, 정 교사의 수업에서 학생들이 사용했을 추론 유형을 적고, 이 추론 유형의 특성에 근거하여 ㉠의 이유를 설명하시오. 또, 수업소감문에 제시된 ㉡에 해당하는 구체적인 예를 하나 제시하시오. [5점]

[Figure II-1] The example of problem from "http://www.kice.re.kr/boardCnts" by Korea Institute of Curriculum and Assessment

### D. CPP Assignment Design

PMTs about to take the course were informed in advance that the course would include CPP as a task, and a detailed explanation of CPP was provided once again in the first class. To help the PMTs more clearly understand the problems, five questions including example answers and rubrics were provided as examples.

In 2014 and 2015, the PMTs were informed that CPP would be performed on the five main topics. That is, they would collaborate with their partners in problem posing after they completed each topic, and the problems created were to be uploaded on the smart learning system. In 2016, the number of times CPP was reduced to two because of the feedback ("the task is performed too many times") on CPP from the PMTs in Groups A and B. PMTs' autonomous choices were allowed among topics learned before submitting the CPP task. PMTs in Group C were notified that the timing of CPP tasks submission was before the mid-exam and before the final-exam respectively.

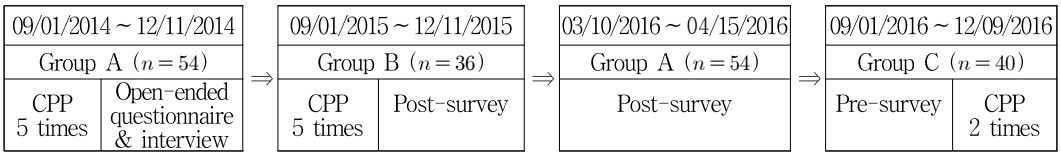
In terms of feedback, in 2014 and 2015, after reviewing all problems uploaded on the smart learning system, I selected four well-made problems and more elaborately revised and improved the texts, passages, example answers, and rubrics. The PMTs solved the problems that were revised, checked the answers that I explained, and exchanged the answer sheets with their partners and graded them according to the rubrics. In the last class, feedback on some of the problems created by the PMTs was provided. In 2016, all problems of each group received feedback online, and the post-survey was not conducted; thus, this feedback procedure did not affect the research findings.

### E. Data Collection

The three sources of data were an open-ended questionnaire, a survey, and interview. The data were collected for 3 years. The data source by year and group is presented in Figure II-2. In 2014, the CPP task was performed 5 times on the PMTs in Group A, after which their perception of CPP was investigated by using a qualitative method with an open-ended questionnaire and interview. In 2015, the CPP task was

performed 5 times on PMTs in Group B, after which the perception of how helpful CPP would be in improving creativity and character education was investigated anonymously by using a quantitative survey. Next, during the first month of the spring semester of 2016, the same questionnaire used in 2015 was placed in the department office, allowing the PMTs in Group A to participate anonymously. The same survey used in 2016 was conducted before performing CPP on the PMTsin Group C. All the PMTs could choose whether to respond or not.

On the other hand, in 2016 the number of times CPP performed was different, and it was also impossible to conduct a paired samples $t$-test by matching the pre-survey respondents and post-survey respondents; thus, the post-survey was not conducted. Pre-survey group C was compared to the post-survey, which combined two groups A and B together.




[Figure II-2] Data source by year and group

### 1) Open-ended Questionnaire

The open-ended questionnaire did not directly ask the PMTs whether they thought CPP would help cultivate students' creativity and character in secondary school mathematics education. Instead, the questions were on whether the PMTs would apply CPP to students when they become teachers and why, the advantages and disadvantages of CPP, and what must be changed for these activities to improve. This method was used to determine whether the PMTs perceived CPP as a suitable means to cultivate students' creativity and character. Moreover, this open-ended questionnaire focused on receiving feedback on how to improve CPP activities used in training prospective teachers. The open-ended questionnaire survey was conducted on all PMTs in Group A, but 49 of the 54 PMTs responded to the open-ended questionnaire.

### 2) Interview

In the interview, the PMTs were directly asked for their opinions on whether CPP helps cultivate students' creativity and character in secondary school mathematics education, how much it helps, and why they think it helps. The questions and responses were exchanged freely, but for the perception of character education, the questions were based on the elements of character education derived from our literature review: honesty, fairness, responsibility, consideration, respect, teamwork, patience.

The interviews were conducted after the final exams, according to each PMT' schedule; five PMTs volunteered after responding to the open-ended questionnaire. The three PMTs majoring in mathematics education -PSJ, KGM, and KMS- were interviewed individually, and two PMTs majoring in mathematics and minoring in mathematics education -SGM and JSJ- were interviewed together. The content of the interviews was recorded with the consent of the interviewees. The duration of each interview was 15 to 45 minutes, depending on the PMT.

### 3) Survey

The PMTs were asked to mark how much they agree that CPP provides an opportunity in secondary school mathematics education to cultivate the 13 subordinate skills and attitudes of creativity and character education (Table Ⅱ-2) extracted from the explanation of creativity and character in the mathematics curriculum. The 13 items were rated on a 5-point Likert scale (Strongly disagree=1, Disagree=2, Neutral=3, Agree=4, Strongly agree=5). The survey was conducted with all PMTs who performed the CPP tasks. However, 31 PMTs in Group A, 24 PMTs in Group B, and 38 PMTs in Group C participated in the survey.

<Table Ⅱ-2> Subordinate skills and attitudes of creativity and character education

| Field | Subordinate skills and attitudes | Field | Subordinate skills and attitudes |
|---|---|---|---|
| Creativity | 1. Ability to find various solutions from multiple perspectives<br>2. Ability to devise new and unique ideas<br>3. Ability to devise as many ideas or responses as possible in a specific problematic situation<br>4. Ability to develop existing ideas into something more valuable by adding more specific and useful details | Character | 5. Honesty<br>6. Fairness<br>7. Responsibility<br>8. Courage to try overcoming difficulties<br>9. Consideration<br>10. Respect<br>11. Teamwork<br>12. Presentation of opinion based on logic<br>13. Rational decision making |

### F. Data Analysis

The SPSS statistical program was used for the quantitative analysis of the survey results. Groups A and B were combined into one group to compare the results with those of Group C. Cronbach's α (reliability coefficient) of the two groups was calculated, and factor analysis was conducted by combining Groups A and B into one group, to determine the characteristics of variables and to check whether there were unimportant or unnecessary variables. A $t$-test was conducted to assess the perception gap between two groups regarding each subordinate skill and attitude toward creativity and character education.

The frequency of each response of the PMTs on CPP collected from the open-ended questionnaire was calculated, after which the quantitative analysis results were supported, complemented, and analyzed while focusing on the responses related to creativity and character education. Furthermore, based on the responses regarding the difficulties with and necessary changes of CPP, implications to apply CPP to training of PMTs were suggested. The recorded interviews were transcribed and analyzed to determine how the PMTs perceived CPP as a method to cultivate students' creativity and character.

## Ⅲ. FINDINGS AND DISCUSSION

### 1. Perception Difference about CPP among PMTs

### A. Reliability and Factor Analysis

A reliability test was conducted on the survey to determine the perception gap on CPP among the group of PMTs; Cronbach's $\alpha$ of the 55 PMTs who participated in the survey from Group A and Group B was

.842, and that of 38 PMTs from Group C was .764. Cronbach's $\alpha$ for the relevant skill and attitude among the 13 subordinate skills and attitudes of the group that performed CPP was smaller than .842. The subordinate skill and attitude with Cronbach's $\alpha$ greater than .764 when the relevant item was excluded for the group that did not perform CPP was .777 in 'courage to try overcoming difficulties' but was not considered big. Thus, factor analysis was conducted on all items of the questionnaire.

Table Ⅲ-1 shows the results of the factor analysis based on the survey responded by the 55 PMTs from Groups A and B. The results were divided into four factors. However, the first component 'courage to try overcoming difficulties' was a subordinate attitude of character education, unlike the other four subordinate skills that belong to creativity education, and was thus excluded. Additionally, 'ability to develop existing ideas into something more valuable by adding more specific and useful details' could be classified as 'ability to elaborate on ideas,' unlike the other three subordinate skills classified as 'ability to devise ideas,' and the correlation coefficient was .484, which was relatively low and thereby categorized as a separate factor. In other words, the first component was reclassified into 'ability to devise various ideas' and 'ability to elaborate on ideas'. The attitudes to character education were classified into three categories. Finally, in this study, it was categorized into 5 factors.

<Table Ⅲ-1> Factor analysis and categorization

| Subordinate items No. | Components | | | | Categorization |
|---|---|---|---|---|---|
| | Ⅰ | Ⅱ | Ⅲ | Ⅳ | |
| 3 | .789 | −.012 | −.140 | .305 | Ability to devise various ideas |
| 1 | .759 | −.152 | .352 | .224 | |
| 2 | .750 | .168 | −.030 | .362 | |
| 8 | .706 | .085 | .411 | −.305 | |
| 4 | .484 | .179 | .029 | .139 | Ability to elaborate on ideas |
| 11 | .102 | .862 | −.083 | .020 | Attitude in building interpersonal relationships |
| 10 | .134 | .852 | .343 | .111 | |
| 9 | −.078 | .794 | .362 | .178 | |
| 5 | .113 | .185 | .866 | .034 | Inner attitude |
| 6 | −.020 | .149 | .866 | .290 | |
| 7 | .235 | .511 | .552 | −.104 | |
| 13 | .266 | .237 | .099 | .826 | Attitude when presenting opinions and making decisions |
| 12 | .333 | −.025 | .158 | .809 | |
| Reliability | .782 | .861 | .791 | .816 | |

KMO (Kaiser−Meyer−Olkin) = .705. Results of Bartlett's test of sphericity: $X^2 = 354.164$, $df = 78$, $p = .000$

### B. Perception according to the Subcategory of Creativity and Character Education

The perception gap of CPP was analyzed between the group that already experienced CPP and the group that did not experience CPP yet. The two groups were divided into the 'after'-participation group and the 'no'-participation group. Table Ⅲ-2 presents the results of the perception gap between the two groups, according to the reclassified category. For creativity education, the perception that it will affect developing the ability to devise various ideas did not have a statistical difference at the significance level of .05, but there was a difference in the perception that it will affect developing the ability to elaborate on ideas. As for character education, the perception of the effect on two types of attitudes such as the inner attitude and the attitude when presenting opinions and making decisions had statistical difference at the significance level of .05, but there was no statistical difference in the perception of attitude in building interpersonal relations.

<Table III-2> Results of the difference test of the perception of creativity and personality education by subcategory

| Field | Category | Group | $n$ | $m \pm s$ | $t$ | $p$-value |
|---|---|---|---|---|---|---|
| Creativity | Ability to devise various ideas | After-participation | 55 | $3.85 \pm 0.65$ | $-.855$ | .395 |
| | | No-participation | 38 | $3.96 \pm 0.51$ | | |
| | Ability to elaborate on ideas | After-participation | 55 | $4.20 \pm 0.68$ | $2.705^{**}$ | .008 |
| | | No-participation | 38 | $3.79 \pm 0.78$ | | |
| Character | Attitude in building interpersonal relationships | After-participation | 55 | $4.06 \pm 0.74$ | .706 | .482 |
| | | No-participation | 38 | $3.96 \pm 0.56$ | | |
| | Inner attitude | After-participation | 55 | $3.65 \pm 0.74$ | $2.823^{**}$ | .006 |
| | | No-participation | 38 | $3.22 \pm 0.70$ | | |
| | Attitude when presenting opinions and making decisions | After-participation | 55 | $4.18 \pm 0.61$ | $2.22^{*}$ | .029 |
| | | No-participation | 38 | $3.88 \pm 0.68$ | | |

$^{*}p < 0.05$, $^{**}p < 0.01$

More details of the analysis of the perception gap between the two groups are as follows. First, the PMTs who experienced CPP perceived that CPP would have a positive effect on improving the ability to develop existing ideas into something more valuable by adding more specific and useful details than the PMTsthat did not experience CPP. This finding occurs because the PMTs shared ideas while posing new problems during the thought experiment in which they applied the theories of mathematics education learned from collaboration to actual teaching and learning situations, thereby structuralizing them into better problems.

Meanwhile, there was no difference between the two groups in the perception of improving the ability to devise various ideas. Nonetheless, the two groups' mean scores were higher than the score of the effect on developing the ability to elaborate on ideas (3.79) with 3.85 and 3.96, respectively. This result can be interpreted from two perspectives. First, the PMTs perceived that CPP would have a positive effect on improving the ability to devise various ideas regardless of CPP experience. Second, the effect on improving the ability to elaborate on ideas was perceived to be weaker than the effect on improving the ability to devise ideas, but by performing CPP, there was a change so that they more strongly perceived the importance of CPP's role that develops students' ideas into something more valuable.

Next, the perception that changed the most positively after experiencing CPP in terms of character education was on the effect on cultivating the inner attitude. The mean score was 3.65, which is relatively lower than that of the other subcategories, but higher than the 3.22 of the no-participation group with the biggest gap. Of course, even before experiencing CPP, they were somewhat positive about cultivating responsibility (3.76), but the after-participation group tended to have a more positive perception (4.20). This finding occurs because CPP is a collaborative task and thus reveals that the need for responsibility is perceived even before experience, and the responsibility even became stronger for fulfilling their roles in the process of completing a single task in collaboration. Specifically, the mean scores for cultivating the attitudes of honesty, fairness, and responsibility were significantly ($p < 0.01$) higher in the after-participation group (3.62, 3.70, and 4.33) than in the no-participation group (2.89, 3.00, and 3.76). These results indicate that CPP is significantly helpful in the inner attitude such as that to promote the students' honesty, fairness, and responsibility.

Moreover, the PMTs who experienced CPP perceived that CPP would have a positive effect on cultivating the attitude of presentation of opinion based on a logical basis and rational decision making, that is, more

than that of PMTs who did not experience CPP. This difference occurs because the PMTs experienced rational decision making by sharing ideas and reaching consensus by presenting their opinions based on a logical basis to create better problems through collaboration.

By contrast, there was no perception gap between two groups for the effect of CPP on cultivating the attitude in building interpersonal relations, but the mean scores were 4.06 and 3.96 and thereby positive. This finding indicates that similar to improving the ability to devise various ideas in creativity education, most PMTs need an attitude that promotes consideration of and respect for others and collaboration with them in the process of creating a single problem, and thus perceive that CPP would have a positive effect on cultivating such attitude regardless of CPP experience.

### 2. Advantages of CPP Perceived by PMTs

Table Ⅲ-3 summarizes the advantages of CPP reported by 49 PMTs in Group Ain the perspective of learners by categorizing them into creativity, character, and others. Multiple responses were allowed because the questions were open-ended; thus, the frequency was calculated, and the rate of response was calculated as a percentage of all 49 participants.

<Table Ⅲ-3> Advantages of CPP

| Field | Response | Frequency (%) |
|---|---|---|
| Creativity | Sharing ideas | 18 (36.7) |
| | Complementary effect (in terms of ideas) | 12 (24.5) |
| | Improving the quality of problems | 3 (6.1) |
| | Expanding thoughts | 2 (4.1) |
| | Securing the opportunity to use new problems | 1 (2.0) |
| | Creativity | 1 (2.0) |
| Character | Teamwork | 7 (14.2) |
| | Respect | 2 (4.1) |
| | Responsibility | 1 (2.0) |
| Others | Helping understand the conten | 11 (22.4) |
| | Securing the opportunity to learn | 6 (12.2) |
| | Determining the main contents | 6 (12.2) |
| | Effect of retention | 3 (6.1) |
| | Helping with self-directed learning | 2 (4.1) |
| | Opportunity to recall knowledge | 2 (4.1) |
| | Giving positive motivation | 2 (4.1) |
| | Easy to perform tasks | 2 (4.1) |
| | Meaningful experience | 1 (2.0) |

The PMTs perceived that the best aspects of CPP were sharing ideas and complementing ideas. This finding indicates that CPP can be effectively used in creativity education in association with the ability to devise ideas and elaborate on ideas. Another positive aspect was that CPP helped them understand what they had learned, which occurs because understanding the content must be preceded before applying the theories of mathematics education to classroom situations and creating problems. It is also effective in prolonging the memory of the content learned, by providing an opportunity to directly apply what is learned. The PMTs also responded that CPP helped develop teamwork, indicating that CPP may perform a positive role in character education such as cultivating the teamwork of students.

The following is an analysis of the effects of CPP that focuses on creativity and character education and is based on the specific cases of responses given by the PMTs in Group A. First, Table Ⅲ-4 presents a few response cases and classification details in terms of creativity education. 'Sharing ideas' and 'complementing ideas', the most commonly reported advantages of CPP, are both closely related to the ability to devise as many ideas as possible or the ability to devise various ideas from multiple perspectives. This is well revealed by the responses of 4 PMTs: WDH, CJH, LKH, and LDY.

<Table Ⅲ-4> Classification of responses related to creativity education

| Response cases | Classification | Category |
|---|---|---|
| Because we think together instead of alone, we could share more ideas. I realized from this task that ideas, when shared with each other, have twice the effect than when only one person is engaged. (WDH, math education major) | • Sharing ideas | Ability to devise various ideas |
| We can discuss and share different thoughts. (CJH, math education major) | • Sharing ideas | |
| Problem posing helps me more clearly understand the intentions of the examiner, which is very helpful for my studies. It's also efficient because I can think of the things I otherwise would have not by myself when I work with a partner. (LKH, math education major) | • Complementing ideas | |
| I can realize something I have never thought of before and have diversity in perspectives. (LDY, math education major) | • Complementing ideas<br>• Sharing ideas | |
| I can listen to other people's thoughts, and it helps me expand my thoughts. (PJE, math education minor) | • Sharing ideas<br>• Expanding thoughts | |
| My partner can make up for what I haven't thought of or what I lack. And it also helps me mentally compared with when I'm doing it alone. (CSR, matheducation major) | • Complementing ideas | Ability to elaborate on ideas |
| We could share each other's thoughts and move on to a better task. (LWS, math education major) | • Sharing ideas<br>• Improving quality of problems | |
| I could discover and talk about the things I haven't thought of before by having discussions with my partner, which helps me have a broader understanding than studying alone, and makes the problems more complete. (KMS, math education major) | • Sharing ideas<br>• Improving quality of problems | |
| My partner can make up for what I lack. The completeness of the problems can be increased by solving the problems made by each other. (KDG, math education major) | • Complementing ideas<br>• Improving quality of problems | |

The responses from WDH and CJH that the CPP task enables them to share more ideas with their partners imply that CPP provides an opportunity to devise as many ideas as possible in problem posing. The responses from LKH and LDY that CPP helps them realize the ideas they could not have thought of on their own imply that CPP can also provide an opportunity to devise various ideas from multiple perspectives. The response from PJE that sharing ideas helps them expand their thoughts reveals that CPP may create an opportunity to devise diverse new ideas by expanding their thoughts in the process of collaborating with their partners. These results reveal that although there was no difference between the no-participation and after-participation groups regarding the perception that CPP provides an opportunity to improve the ability to devise various ideas, the biggest advantage of the joint problem-posing situation of CPP is providing an opportunity to devise various ideas through discussion.

Moreover, 'sharing ideas' and 'complementing ideas' are also related to the ability to develop existing

ideas into something more valuable, according to the perspective. This is well displayed in the responses of 4 PMTs: CSR, LWS, KMS, and KDG. The response from CSR that their partner compensates for their shortcomings in the CPP process indicates that the existing ideas may develop further through collaboration with their partner. The responses from LWS, KMS, and KDG that the quality of problems is improved by sharing ideas through discussion and complementing each other's ideas more directly show the effect of CPP on further developing the existing problems.

Next, Table Ⅲ-5 shows a few responses and classification details in terms of character education. The biggest advantage in terms of character education was cultivating teamwork, which is required to build interpersonal relations. The 4 PMTs -HSY, JSI, PSJ, and SMG- all responded that they can develop teamwork in the process of collaborating with their partners in performing CPP and can better understand the learning contents. PSJ especially mentioned that CPP may be an opportunity to learn how to collaborate with partners. These results, similar to the perception of the two groups of the ability to devise various ideas, had no difference between the no-participation and after-participation groups but reveal that CPP can cultivate teamwork among students through collaborative activities.

<Table Ⅲ-5> Classification of responses in terms of character education

| Response cases | Classification | Category |
|---|---|---|
| Collaboration leads to better understanding. (HSY, math education minor) | • Teamwork | Attitude in building interpersonal relations |
| Students can develop teamwork, and CPP may be a positive motivation for and meaningful experience about mathematics (JSI, math education minor) | • Teamwork | |
| Effect of learning and reviewing how to collaborate (PSJ, math education major) | • Teamwork | |
| Can develop teamwork and have a more in-depth understanding of the content by posing problems (SMG, math education major) | • Teamwork | |

Finally, Table Ⅲ-6 shows a few responses and classification details in terms of creativity and character education. A few prospective teachers mentioned that the aspect of character education in cultivating the inner attitudes of individuals such as respect and responsibility is the advantage of CPP. The responses from KGH and LSH claiming that they can respect, accept, and learn the good ideas given by partners imply that CPP can cultivate respect by potentially demanding a respectful attitude toward other people or their ideas. In this perspective, complementing ideas, presented in terms of creativity education, can be a potential educational plan to cultivate the attitude of respect even though the expression "respect" is not used, because it is only possible to accept other people's opinions when there is respect.

Regarding creativity education, KGH mentioned that CPP provides an opportunity to improve the ability to devise various ideas, and LSH, the ability to devise new and unique ideas. LSH responded that CPP requires more creativity and responsibility than other collaborative tasks. This finding reveals that it is necessary to consider actively implementing the task of problem posing through collaboration in school education for creativity and character education.

<Table III-6> Classification of response cases mentioning both creativity and character education

| Response cases | Classification | Category |
|---|---|---|
| We can learn each other's shortcomings and what we did well. And we can see the problems from a more diverse perspective in approaching the problems. (KGH, math education minor)<br><br>When posing problems together, we can easily accept other people's original or novel ideas that we have never thought of before. CPP takes up more portion in creativity or responsibility than the other collaborative tasks do. (LSH, math education major) | • Respect<br>• Sharing ideas<br>• Sharing new and unique ideas<br>• Creativity<br>• Respect<br>• Responsibility | • Inner attitude<br>• Ability to devise various ideas |

Additionally, creativity education has a greater portion of the advantages of CPP perceived by PMTs in Table Ⅲ-3 than character education does. Thus, we must beware not to perceive that CPP is somewhat weak as a way of character education. This was also revealed in the interview with the PMTs in Group A.

As mentioned in the excerpts from the interviews with JSJ and SGM, they gave at least 9 points to character education, which is higher than the 7 points for creativity education. KGM also gave 10 points to the effect of character education. JSJ and SGM devised new problems by applying the concepts they learned, as demonstrated in the underlined excerpts ① and ② from the interviews, and responded that CPP helps creativity education because creativity may be revealed despite it being insufficient in the process.

In terms of character education, JSJ and SGM responded that CPP develops honesty, responsibility, consideration, teamwork, and patience. More specifically, they said that there is a need for teamwork and responsibility because they must complete the task with their partner until the end (③ and ④), for honesty because they listen to and accept the ideas suggested by their partner (⑤), and for consideration because they listen to their partner's opinions in the process (⑥). Furthermore, they believed that patience could also be cultivated because they must think persistently to overcome the difficulties experienced in the process of solving the task together (⑦). Patience was also mentioned as an element of creativity.

Interviewer: You performed the CPP task in a pair. How much do you think CPP can develop creativity in mathematics education? Suppose you must rate it on a scale of 0, doesn't help at all, to 10, helps a great deal.

JSJ: I'd say 7 or higher. There is no right answer to creativity; it's just making something based on your ideas. Problem posing is making something new based on what we learn, so I think it will help a lot.

Interviewer: Can you be more specific?

JSJ: Posing problems is like becoming the examiner who sets exam questions beyond just learning and ① connecting ideas or concepts and making something new out of them. I think that kind of thing will help.

SGM: Being the one to pose problems requires us to be more clearly aware of the concepts. I think ② if I know the concepts for certain, creativity can be revealed as I pose the problems even if there is not enough to begin with.

Interviewer: I see. Now let's think in terms of character. If CPP is implemented in secondary school, how much effect do you think it will have on students' character education? Please rate it on a scale of 1 to 10.

JSJ: I think there may be an effect up to 10. Posing problems is ③ cooperating with others. Since the two people have different thoughts, they would have to exchange each other's thoughts and coordinate them, each with different jobs as they pose the problems. I think ④ that requires responsibility. Starting and finishing something may have a great impact on personality or character.

SGM: I'd also like to rate it high, around 8, 9, 10.
Interviewer: Could you be more specific as to why you think so?
SGM: In the process of posing problems or explaining each other's problem-solving process, ⑧ the act of sharing your thoughts and listening to your friend's different thoughts will have a great effect on character.
Interviewer: Which of the seven character elements presented here do you think is helpful?
SGM: ⑤ I think character can be cultivated in terms of honesty as well, and actually all of them.
Interviewer: Why do you think it helps honesty?
SGM: ⑤ Because you must be able to accept other people's thoughts if they're right. And ④ responsibility is definitely developed because it's a cooperation, ⑥ and having to listen to your friend also helps cultivate the sense of consideration as well. Also cooperation and harmony.
JSJ: I agree. I think ⑦ patience is also developed. It's meaningful because we endure and keep on thinking with patience in order to overcome the difficulties we face together when posing difficult problems.

Although not directly mentioned by JSJ and SGM, the underlined ⑧ in the dialog shows that CPP helps present opinions about their partner's opinion and cultivate an attitude to make rational decisions based on the ideas. The effect of cultivating the presentation of opinions and decision-making attitude was revealed more directly in PSJ's excerpt, which focuses on personal experience. The response that the ideas suggested individually were reviewed together to select a better topic more rationally while posing problems in cooperation with the partner (⑭) indicates that CPP may help present logical opinions and cultivate the attitude to make rational decisions.

In addition, PSJ learned or experienced all the subordinate attitudes of character education listed in Table Ⅱ-2, such as honesty, responsibility, fairness, consideration, respect, and teamwork while performing CPP. PSJ performed the task with an honest attitude and without false actions, such as copying the assignment (⑨ and ⑫), and responded that he had attempted to carry out the responsibility to the fullest (⑩). While reviewing each other's ideas and selecting better ideas, PSJ experienced attitudes such as consideration and respect (⑪), and fairness (⑬). PSJ collaborated with the partner by thinking of a better problematic situation to apply the theories they learned (⑮). The interview results explain why the perception gap of PMTs before and after CPP experience was observed.

Interviewer: Let's think in terms of character. If you are to rate the effect of CPP on a scale of 0 to 10, what would it be?
PSJ: At least 8.
Interviewer: Can you be more specific?
PSJ: Well, what I thought was that ⑨ honesty is definitely included. There were temptations, of course. Should I copy a problem from somewhere else? Should I just slightly change the numbers? How about taking turns in finishing the assignment? I'm thinking that we all may have been tempted at one point. If the student was honest, then I think it would have had a good impact on character. In fact, we don't do that in a situation where we're involved in personal relationships. We talked to each other, split the roles in half, and ⑩ attempted to take responsibility for our duties.
Interviewer: Anything else?
PSJ: ⑪ We also need consideration. I think I felt that we really need consideration in selecting the topics, such as accepting, acknowledging, and considering our partner's ideas if they're better. We had to choose one of the two different topics we each presented, and that was when I experienced the sense of consideration.

Interviewer: I can tell that both members of your group participated very enthusiastically.

PSJ: ⑫ I think the good thing was that both of us attempted to be honest. If my partner Hyeonil suggested otherwise, I would have been tempted. I think we were a pretty good team.

Interviewer: Anything else?

PSJ: Then, there was ⑬ fairness. There is consideration in selecting the topic, but I think ⑭ we agreed on better ideas objectively and made rational choices with better topics in the objective view. ⑮ And there is cooperation. We collaborated by striving to produce the effect of posing better problems while applying our ideas to classroom situations. No problematic situation was given, but we had to consider the classroom situation, so we exchanged such ideas and set up a better situation, and then also thought the other way around.

### 3. PMTs' Suggestions for Efficient Use of CPP in Mathematics Class

To devise implications to more efficiently use CPP in training PMTs and secondary school mathematics education, this study examined the difficulties experienced by PMTs in Group A, and things that must be changed. Table Ⅲ-7 summarizes their opinions. Multiple responses were allowed because the questions were open-ended; thus, the frequency was calculated, and the rate of response was calculated as a percentage of all 49.

The biggest difficulty in performing CPP was scheduling the time to meet with their partners for problem posing (36.7%). Because PMTs chose different courses, it may have been difficult for them to schedule and spend extra time outside class to pose the problems together. The plan to operate CPP more efficiently by overcoming this limitation was based on the feedback of PMTs on things to change. First, the number of problems to pose in 1 semester should be adjusted, reflecting the opinion with the highest frequency among the things that must be changed. Because the hours in 1semester differ between a university and secondary school, adjusting the number of CPP tasks is necessary while considering each curriculum. Second, an amount of time in class can be set aside to perform the CPP tasks.

Difficulties experienced at a similar frequency were devising ideas about classroom situations and the unfamiliarity of problem posing. These difficulties can be overcome by using existing problems. For example, solving the existing problems in collaboration and modifying them by applying the same theory of mathematics education to a classroom situation with a different mathematical topic. In secondary school mathematics classes, they can continuously perform these activities, from collaborating and solving existing mathematical problems to using them and modifying them into new problems. More effective feedback can be naturally exchanged by having other teams solve the modified problems or having all the students solve them together. Moreover, they will have the opportunity to indirectly learn how to modify problems by sharing and solving the problems devised within the group with the others.

To overcome other difficulties such as coordinating opinions and sharing roles, teachers can consider providing an opportunity for PMTs to imitate other teams that efficiently perform CPP. In other words, giving a presentation on the coordination of opinions and role sharing in the process of problem posing and having a discussion might resolve this issue.

<Table III-7> Feedback from PMTs for efficient implementation of CPP

| Difficulties | Frequency (%) | Things that must be changed | Frequency (%) |
|---|---|---|---|
| - Scheduling time | 18 (36.7) | - Reduce of the number of problems to pose | 9 (18.4) |
| - Ideas for classroom situations | 6 (12.2) | - Detailed guidance on the problem-posing way | 9 (18.4) |
| - Unfamiliarity of problem posing | 5 (10.2) | - Sufficient time | 5 (10.2) |
| - Burden of multiple tasks | 5 (10.2) | - More feedback | 4 (8.2) |
| - Coordination of opinions | 2 (4.1) | - Increase the number of members | 2 (4.1) |
| - Insufficient of time | 2 (4.1) | - Increase the number of problems | 2 (4.1) |
| - Role sharing | 1 (2.0) | - Activities in class | 1 (2.0) |
| | | - Grouping for easy schedulin | 1 (2.0) |
| | | - Role assignment | 1 (2.0) |

## Ⅳ. CONCLUSION AND SUGGESTIONS

In this study, I attempted to propose the introduction of CPP at the stage of preparatory math teacher education as a means to reinforce the creativity and character education capacity of preservice teachers required. Next, I attempted to reveal that it would be an opportunity to actively utilize CPP in math teaching-learning in the school field for the education of students' creativity and character. To achieve objective, I encouraged the PMTs taking the 'Educational Theories for Teaching Mathematics' course, which a required in the second year of university, to experience CPP. Subsequently, over 3 years, I conducted an open-ended questionnaire survey and interviews on how the PMTs recognized CPP as a tool to cultivate students' creativity and character in secondary schools. The conclusions and suggestions that I derived by dividing the aspect of creativity and character education into subcategories based on the study findings are as follows.

First, the PMTs recognized that CPP might have a positive impact on improving students' ability to devise various ideas, regardless of their CPP experience. The perception difference between the two groups was not statistically significant. Even for the open-ended question on the merits of CPP for PMTs who had experienced CPP, their responses that they could share more ideas or see the problem from different perspectives were more supported than the other responses were. These results show that PMTs generally accept that math problem-posing activities not only require a variety of ideas but also provide an opportunity to seek problem solving methods from different perspectives.

Second, the experience of PMTs participating in the CPP makes them more positively aware that CPP is effective in improving students' ability to elaborate on ideas. The results of the survey demonstrate that the group that did not participate in the CPP activity recognized that the effect on the ability to elaborate on ideas was lower than that on the ability to devise various ideas, but the perception of the participating group was the opposite. Regarding the effect of improving the ability to elaborate on ideas, the CPP participants' perceptions were statistically significantly more positive than those that did not. In response to the open-ended questions, the second most frequent response was that CPP was helpful in complementing ideas and improving the quality of problems, and this demonstrated this perception change well.

Third, the PMTs acknowledged that regardless of their experience with CPP participation, CPP positively influences students' attitudes in building interpersonal relationships, including teamwork, respect, and consideration. Both the group that implemented CPP and the group that did not, evaluated that the effect on this attitude was the highest compared with the other subcategory of character education, and the perception difference between the two groups was not statistically significant. In addition, for the open-ended question on the merits of CPP for the PMTs who have experienced CPP, there were many responses related to teamwork and respect, among the elements of character education. In the interviews, some PMTs answered that CPP would help students build this attitude. These show that they generally recognize that CPP activities require teamwork, respect, and consideration among peers.

Fourth, the CPP experience of PMTsleads them to recognize that CPP positively influences the formation of students' inner attitudes of individuals, including honesty, fairness, and responsibility. Compared with the other two subcategories of character education, the degree of the positive perception of this attitude was lower, but the participating group perceived significantly more positively than the other group did. In the open-ended question, one PMT mentioned responsibility as an advantage of CPP, and in the interview, another answered that CPP helps students foster honesty, fairness, and responsibility. These findings implicate that although CPP's effectiveness is low compared with the other subcategories of character education, CPP might positively influence student's attitude regarding, namely, responsibility, honesty, and fairness. Activities to pose a problem by collaboration can be considered effective in nurturing students' sense of responsibility, especially because the performance of their role is important.

Fifth, the CPP experience of PMTs makes them more positively recognize that CPP is effective in fostering an attitude of students to logically present their opinions and make rational decisions. In the survey, the group that did not participate in the CPP activity perceived that the effect on the attitude when presenting opinions and making decisions was lower than that on the attitudes in building interpersonal relationships, but the participating group evaluated the effect on the attitude when building opinions and making decisions. In the survey, the group that did not participate in the CPP activity perceived that the effect on the attitude when presenting opinions and making decisions was lower than that on the attitudes in building interpersonal relationships. Additionally, the participating group evaluated the effect on the attitude when presenting opinions and making decisions the highest. This change of perception may because they presented their opinions and experience regarding the importance of decision making in the process of completing one problem by proposing and elaborating ideas during CPP activities. This suggests that CPP activities can be a powerful strategy that encourages students to present their opinions based on logical grounds and promotes an attitude of rational decision making through discussion.

By contrast, there were many responses to the positive aspects of learning effectiveness in the open-ended question. This finding reveals that it is effective not only in creativity and character education but also in supporting students' math learning. This CPP activity, which is effective in various aspects of education, can be utilized not only in face-to-face teaching and learning situations but also in non-face-to-face education environments online. In particular, considering the shortcomings of having the greatest difficulty in scheduling time for CPP or limited time in an offline environment, the online environment may be more beneficial in solving such difficulties. Therefore, I suggest a follow-up study to design CPP activities in an online environment and to verify its effectiveness.

# REFERENCES


Bae, S. & Hwang, W. (2015). Changes in students' awareness of a creativity-personality enriched mathematics program. *Journal of Research in Curriculum and Instruction*, **19(1)**, 23-45.

배성철 · 황우형 (2015). 창의 · 인성 수학교육 프로그램과 수학적 창의성과 인성에 대한 인식 변화. 교과교육학연구, **19(1)**, 23-45.

Berkowitz, M. W. & Bier, M. C. (2005). W*hat works in character education: a research-driven guide for educators*. Retrieved from http://www.rucharacter.org/file/practitioners_518.pdf

Bialik, M., Bogan, M., Fadel, C., & Horvathova, M. (2015). *Character education for the 21st century: what should students learn? Center for Curriculum Redesign.* Retrieved from http://curriculumredesign.org/wp-content/uploads/CCR-CharacterEducation_FINAL_27Feb2015.pdf

Cho, N., Choi, E., & Eun, J. (2015). Teachers's capacity for character education during teaching each subject. *Proceedings of for The Korean Society for the Study of Teacher Education*, **16**, 135-180.

조난심 · 최의창 · 은지용 (2015). 교과교육에서의 인성교육과 교원의 역량. 한국교원교육학회 학술대회자료집, **16**, 135-180.

Kim, H., Kim, Y., & Kim, H. (2008). The effects of a program applied with learning portfolio style to enhance the capability of reflective thinking of pre-service teachers. *Journal of Korean Practical Arts Education,* **21(3),** 257-276.

김희필 · 김영용 · 김효심 (2008). 예비 교사의 반성적 사고 능력 강화를 위한 학습 포트폴리오 적용 프로그램의 효과. 한국실과교육학회지, **21(3),** 257-276.

Kim, K. H. (2006). Can we trust creativity test? A review of the Torrance tests of creative thinking (TTCT). *Creativity Research Journal*, **18(1)**, 3-14.

Kim, N. (2014). Performing mathematics teacher training for a professional development - focusing on thought experiment activities by Socratic method -. *Journal of Educational Research in Mathematics,* **24(4)**, 537-554.

김남희 (2014). 교사 전문성 신장을 위한 수학 교사 연수 실행. 수학교육학연구, **24(4)**, 537-554.

Kohn, A. (1997). *How not to teach values: a critical look at character education*. Retrieved from http://www.alfiekohn.org/article/teach-values

Korean Educational Development Institute (2012). *The study on teachers' professional development for spreading creativity and character education* (Rep. 2012-43-1). Seoul: KEDI.

한국교육개발원 (2012). 창의·인성교육 확산을 위한 교사 전문성 제고 방안 연구 (연구보고서 No. CR 2012-43-1). 서울: 저자.

Lee, B. (2012). The analysis of mathematics teachers' teaching behavior for fostering creativity. *The Korean Journal for History of Mathematics*, **25(3)**, 77-95.

이봉주 (2012). 초 · 중등학교 수학교사의 창의성 신장 교수 행동에 대한 분석. 한국수학사학회지, **25(3)**, 77-95.

Lee, E. (2014). *A study on the learning environment for the activation of the creativity and character education*, Unpublished Doctoral dissertation, Korea National University of Education.

이은주 (2014). 창의와 인성교육 활성화를 위한 교수·학습 방법 및 미래형 교실 환경 연구. 박사학위논문, 한국교원대학교.

Lee, G. & Hwang, D. (2007). Correlation between gifted and regular students in mathematical problem posing and mathematical creativity ability. T*he Mathematical Education,* **46(4)**, 503-519.

이강섭 · 황동주 (2007). 수학 영재학생과 일반학생의 수학 창의성과 문제설정과의 상관 연구. 한국수학교육학회지 시리즈 A <수학교육>, **46(4)**, 503-519.

Ministry of Education (1992). *The Middle School Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (1992). 중학교 교육과정. 서울: 저자.
Ministry of Education (1997a). *The School Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (1997a). 교육과정 총론. 서울: 저자.
Ministry of Education (1997b). *The School Mathematics Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (1997b). 수학과 교육과정. 서울: 저자.
Ministry of Education (2009). *Fostering talented people via balance between creativity consideration - Basic for creativity and character education-*. Seoul: MOE.
교육부 (2009). 창의와 배려의 조화를 통한 인재 육성 - 창의·인성교육 기본 방안 -. 서울: 저자.
Ministry of Education (2010). *Basic methods for creativity and character education - Fostering talented people via balance between creativity consideration-*. Seoul: MOE.
교육부 (2010). 교과부 '창의·인성교육 기본 방안' 발표 - 창의와 배려의 조화를 통한 인재 육성 추진 -. 서울: 저자.
Ministry of Education (2011a). *The School Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (2011a). 교육과정 총론. 서울: 저자.
Ministry of Education (2011b). *The School Mathematics Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (2011b). 수학과 교육과정. 서울: 저자.
Ministry of Education (2015a). *The School Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (2015a). 교육과정 총론. 서울: 저자.
Ministry of Education (2015b). T*he School Mathematics Curriculum of the Republic of Korea.* Seoul: MOE.
교육부 (2015b). 수학과 교육과정. 서울: 저자.
Moon, Y., Choi, I., Kwak, Y., & Lee, H. (2010). *A study on activating creativity and character education for fostering creative talented people who practice considering and sharing in their life* (Rep. 2009-019). Korea Foundation for the Advancement of Science and Creativity.
문용린·최인수·곽윤정·이현주 (2010). 배려와 나눔을 실천하는 창의 인재 육성을 위한 창의·인성교육 활성화 방안 연구 (연구보고서 No. 2009-019). 한국과학창의재단.
Park, J. & Kim, P. (2014). A study of teachers' perception of humanity education through mathematics education in elementary school. *Teacher Education Research*, **53(4)**, 581-595.
박지숙·김판수 (2014). 수학교육을 통한 인성교육에 대한 초등학교 교사의 인식 연구. 교사교육연구, **53(4)**, 581-595.
Resnick, M. (2007). *Sowing the seeds for a more creative society. Learning and Leading with Technology.* Retrieved from https://web.media.mit.edu/~mres/papers/Learning-Leading-final.pdf
Runco, M. A. & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, **24(1)**, 92-96.
Seo, Y. & Park, M. (2021). Effects of open-ended mathematical problem solving learning on mathematical creativity and attitudes of elementary students. *Communications of Mathematical Education,* **35(3)**, 277-293.
서영민·박만구 (2021). 개방형 문제해결학습이 초등학생들의 수학적 창의성 및 수학적 태도에 미치는 영향. 한국수학교육학회지 시리즈 E <수학교육논문집>, **35(3),** 277-293.
Sheffield, L. (2009). Developing mathematical creativity—Questions may be the answer. In R. Leikin, A. Berman, & B. Koichu (Eds.), *Creativity in mathematics and the education of gifted students* (pp. 87-100). Rotterdam: Sense Publishers.
Silver, E. A. (1997). Fostering creativity through instruction rich in mathematical problem solving and

problem posing. *Zentralblatt für Didaktik der Mathematik*, **29(3),** 75-80.

Stein, M. I. (1953). Creativity and Culture. *The Journal of Psychology,* **36(3)**, 311-322.

Sternberg, R. J. & Grigorenko, L. E. (2001). Guilford's Structure of intellect model and model of creativity: contributions and limitations. *Creativity Research Journal,* **13(3)**, 309-316.

Torrance, E. P. (1965). Scientific views of creativity and factors affecting its growth. *Daedalus*, **94(3)**, 663-681.

Van Harpen, X. Y. & Sriraman, B. (2013). Creativity and mathematical problem posing: an analysis of high school students' mathematical problem posing in China and the USA. *Educational Studies in Mathematics*, **82(2)**, 201-221.

# 창의성과 인성 교육 방안으로서 협력 문제 만들기에 대한 수학 예비교사의 인식

**이봉주**
경북대학교 수학교육과
E-mail : leebj@knu.ac.kr

이 연구는 수학 예비교사가 수학교육에서 학생들의 창의성과 인성을 함양하기 위한 방법으로 협력 문제 만들기를 어떻게 인식하는지 고찰하는 것을 목적으로 수행되었다. 이를 통해 수학 예비교사의 창의성 교육과 인성 교육 역량을 강화할 수 있는 방안의 하나로 수학 예비교사 교육 단계에서 협력 문제 만들기를 도입하는 것은, 이후 학교교육에서도 창의성 교육과 인성 교육을 위해 협력 문제 만들기를 좀 더 적극적으로 실천할 수 있는 계기가 될 것임을 밝히고자 하였다. 대학교 2학년 과정에 필수 과목으로 개설하는 '수학교육론' 강좌를 수강하는 수학 예비교사를 대상으로 협력 문제 만들기 과제를 수행하게 하고 3년에 걸쳐 설문조사, 면담 등의 방법으로 자료를 보완·수집하였다. 연구 결과는 다음과 같다. 첫째, 수학 예비교사는 협력 문제 만들기 경험과 상관없이 협력 문제 만들기가 학생들의 다양한 아이디어 산출 능력 함양 및 협동심, 존중, 배려를 포함한 학생의 대인 관계 형성 태도 등에 긍정적인 영향을 미친다고 인식하였다. 둘째, 협력 문제 만들기 과제를 수행한 수학 예비교사의 경험은 협력 문제 만들기가 학생의 아이디어 정교화 능력 향상에 효과적이라는 것을 더 긍정적으로 인식하게 하였다. 셋째, 수학 예비교사의 협력 문제 만들기 경험은 협력 문제 만들기가 아이디어 정교화 능력, 개인의 내적 태도(정직, 공정성, 책임감), 논리적인 의견 제시와 합리적인 의사 결정 태도 등에 미치는 영향에 대해 보다 긍정적인 인식으로 이어졌다. 마지막으로 대면 환경의 단점을 온라인 환경이 보완해 줄 수 있을 것으로 기대하고 제언하였다.

* MSC2000분류 : 97C70
* 주제어 : 수학 예비교사, 협력 문제 만들기, 학생의 창의성과 인성, 창의성 교육, 인성 교육
* 이 논문은 2020학년도 경북대학교 연구년 교수 연구비에 의하여 연구되었음.