

## Analysis of Research Trends in Korea on Creative Problem Solving<sup>1)</sup>

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< ABSTRACT >

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The study aims to analyze research trends in Korea related to Creative Problem Solving (CPS) for elementary, middle and high school students and to provide basic data for finding future development. For this purpose, 186 journal articles published from 2000 to 2021 were collected using the Research Information Sharing Service (RISS) by the Korean Academy of Science and Research Information. Recently, CPS has been mentioned as important in the South Korean curriculum, so in this study, papers for elementary, middle and high school students were selected. The collected data were analyzed by year of publication, subject, method, the research field of an academic journal and research topic and keywords. To do this, we undertook a research trend analysis and keyword network analysis. The results are as follows. First, related research on CPS has been increasing every year since 2000, 34 studies in 2000~2007, 55 in 2008~2014, and 97 in 2015~2021. Second, by research methods, program development studies was the most common, followed by experimental study, survey study, qualitative study and literature review study. Third, the largest number of studies were about elementary school students. Fourth, education was the most common journal field, followed by engineering and arts. Among them, science education research was the most common, subsequently gifted education, biological education and engineering. Fifth, the topic related to studies on ‘the impacts on CPS and impacts of CPS’ was the most dominant, followed by ‘program development and application’, ‘effect analysis’. Sixth, the most frequently used keywords among all were ‘CPS’, ‘CPS ability’, ‘gifted student’, ‘STEAM’, and ‘science’. To analyze the trend of Creative problem solving will be meaningful in terms of reviewing the past research outcome and direction of future research.

**Key Words** : Creative problem solving, research trends, keyword analysis, research methods, research subject.

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## 창의적 문제해결에 관한 한국내 연구 동향 분석<sup>1)</sup>

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### < 요약 >

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본 연구의 목적은 초·중·고등학생 대상으로 이루어진 창의적 문제해결 관련 한국 내 연구의 연구 동향을 분석하여 향후 발전 방안을 모색하기 위한 기초자료를 제공하는 것이다. 이를 위해 2000년부터 2021년까지 발표된 국내 학술지 논문을 ‘창의적 문제해결’ 키워드를 학술연구정보서비스를 비롯한 유관 검색 서비스에 투입하여 한국연구재단 등재 및 등재후보 학술지에 출판된 총 186편의 창의적 문제해결에 관한 논문을 분석 대상으로 추출하였다. 최근 한국 교육과정에서는 창의적 문제해결이 중요하게 언급되고 있기에, 초·중·고등학생 대상의 논문을 선정하였다. 수집한 자료를 연구시기, 연구대상, 연구방법, 연구 분야 및 학술지 분야, 연구주제, 등에 따라 분석하였다. 분석 결과는 다음과 같다. 첫째, 창의적 문제해결 연구는 2000~2007년 34편, 2008~2014년 55편, 2015~2021년 97편 지속적으로 이루어지고 있으면 매년 증가하고 있다. 둘째, 연구방법별로는 창의적 문제해결 관련 프로그램 개발연구 연구가 가장 많고, 실험연구, 조사연구, 질적연구, 문헌연구 순으로 나타났다. 셋째, 연구대상별로는 초등학생(130편), 중학생(29편), 고등학생(17편) 순으로 나타났다. 넷째, 학술지 분야에 따라 살펴보았을 때 교육학 분야 연구가 가장 많았고, 그 다음으로는 공학, 예술학 분야순이었다. 이중 세부적으로 과학교육 분야의 연구가 가장 많았으며 영재교육, 생물교육, 공학이 그 뒤로 많았다. 다섯째, ‘CPS에 미치는 영향’에 관한 연구와 관련된 주제가 가장 많았고, 그 다음으로 ‘프로그램 개발 및 적용’, ‘효과분석’ 순이었다. 여섯째, 가장 많이 사용된 키워드로는 ‘창의적문제해결’, ‘창의적문제해결능력’이었다. 창의적 문제해결의 연구 동향을 살펴보는 것은 지금까지의 연구 성과를 돌아보고 앞으로의 연구 방향을 점검해 본다는 측면에서 의미가 있을 것이다.

**주요어** : 창의적 문제해결, 연구동향, 키워드분석, 연구방법, 연구대상

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## I . Introduction

Creativity is a phenomenon whereby something new and valuable is formed. The created item may be intangible (such as an idea, a scientific theory, a musical composition, or a joke) or a physical object (such as an invention, a printed literary work, or a painting). Scholarly interest in creativity is found in a number of disciplines, primarily psychology, business studies, and cognitive science. It can also be found in education, the humanities (philosophy, the arts) and theology, social sciences (sociology, linguistics, economics), engineering, technology and mathematics. Creativity is an integral part of any understanding of human education and psychology.

Problem solving is the process of achieving a goal by overcoming obstacles, a frequent part of most activities. In an increasingly challenging age and full of races to achieve goal, it is inevitable that human beings need to prepare themselves with problem solving competence because every time a human being will face problems. Modern society requires people to be able to solve problems in a creative way (Craft, 2011). Wilson et al. (2000) mentioned four main skills to master competence in the 21st century namely communication, problem solving ability, teamwork as well as the ability to produce something. In the era of the Fourth Industrial Revolution, in which artificial intelligence is continuously in development and jobs evolve at a rapid pace, creative human resources are needed in order to create new jobs and solve future problems. Creativity is required to find solutions to facing problems.

Creative problem solving (CPS) is a way of using your creativity to develop new ideas and solutions to problems. The process is based on separating divergent and convergent thinking styles, so that you can focus your mind on creating at the first stage, and then evaluating at the second stage. CPS derived from three words: creative means a lot of new and unique ideas to create solutions, problem means a condition that provides challenges and interrelated opportunities, solution means designing ways to answer or find solutions to a problem (Mitchell & Kowalik, 1999). CPS requires both creativity and problem-solving skills, and the difference from general problem solving is that it involves devising various alternatives to solving problems and finding a pathway to the best solution. This is especially required when general problem-solving methods do not work, as this is closer to

choosing the best alternative among several solution alternatives rather than looking for only one answer (Ki & Kwon, 2021). CPS is a way of solving problems or identifying opportunities when conventional thinking has failed. It encourages you to find fresh perspectives and come up with innovative solutions, so that you can formulate a plan to overcome obstacles and reach your goals.

Educational systems also need to produce creative problem solvers that try to understand everyday challenges, generate multiple creative ideas and select the most creative ones to put into practice (Isaksen et al., 2011). In the future, thinking ability, thinking and creativity, and problem-solving ability will become individual core competencies and competitiveness (World Economic Forum, 2016). In order to reach the goal of education, it is important to expose students to various problem situations and to experience problem-solving through classes. However, the problem is how to narrow the distance between the current state and the target state to be processed and reached, and how to overcome the obstacle between the initial starting state and the goal state. Therefore, problem solving refers to the process of overcoming these obstacles and removing the distance between the initial starting state and the goal state.

CPS, first introduced by Osborn (1953) in his pioneering book *Applied Imagination*, has undergone more than 60 years of research and development. Furthermore, Isaksen and Treffinger (1985) continued to develop CPS and described the steps. The steps are 1) understanding a problem, 2) finding ideas, and 3) the plan to solve the problem. Moreover, the Osborn - Parnes CPS process (Kandemir & Gür, 2009) is classified into six forms, namely (1) finding object, (2) finding facts, (3) finding problem, (4) finding ideas, (5) finding solution, and (6) finding acceptance. CPS needs both convergent and divergent thinking (Kandemir & Gür, 2009). While each step involves specific cognitive and affective skills, all steps feature a balance between divergent thinking, a search for many original options, and convergent thinking, the selection and development of the most promising options.

The learning process in the 21st century aims to master the student's critical thinking skill and it is able to solve problems, be creative, be innovative, as well as capable to communicate and collaborate (Hobri, 2016). This is in line with Greiff (Scherer & Gustafsson, 2015) who states that one of abilities in 21st century need to be mastered by the students. These abilities refer to students' ability to solve complex problems based on real-life situation and require the interaction with an unknown environment. Therefore, it

can be stated that the problem-solving ability is very important for the students (Hobri et al., 2020).

Students often struggle to solve difficult problems because they lack the creative tools necessary. However, the development of students' creative thinking plays an important role in their academical success (Onda, 1994). Therefore it affects their problem solving skills. Creativity is not an in born, unchangeable trait. Scott et al. (2004) have shown that CPS programs can develop creative and creative thinking skills. Puccio & Murdock (2001), think creative thinking can be developed using creativity and CPS techniques. CPS starts with two assumptions: everyone has creative potential and creative skills can be learned and improved (Treffinger & Isaksen, 2005). CPS needs to be supported by a learning environment that can empower students to learn actively (Kashefi et al., 2012).

Recently, CPS has been mentioned as important in the Korean curriculum. The Korean national curriculum, revised in 2007, includes seven core skills: creativity, problem solving, self-management, citizenship, basic literacy, preparation for future jobs sensibility to multiculturalism (Ananiadou & Claro, 2009). The goal of the Korean school curriculum in 2009 included nurturing creative talents who practice consideration and sharing, and since 2010, the curriculum has been operated based on creativity and character. In 2011, South Korea introduced STEAM education focused on convergent literacy and CPS abilities in elementary, middle, and high schools to foster creative and convergent talents (Sim et al., 2015). The Korea Institute of Curriculum and Evaluation (2013) presents self management ability, communication skills, civic awareness, inter personal skills, problem-solving ability, information processing and utilization skills, and emphasizes the cultivation of creative thinking and positive personality traits through school education (Yang, 2017).

Recognizing the importance of cultivating students' creativity and CPS skills, the Korean Intellectual Property Office has been hosting the South Korea Student Creativity Championship since 2002 with the aim of cultivating students' core competencies such as problem solving, cooperative, challenging and creativity (Yang, 2017). Based on some of the papers and opinions above, it is found that CPS is a competency should be emphasized in the construction of the curriculum in schools in the 21st century because of the urgent needs of human beings in general and students in particular to face an increasingly unpredictable world.

Over the past years, researches related to CPS is increasing in South Korea. According to

previous studies, findings show that an increased interest, especially in the development and effectiveness verification of programs to improve CPS abilities (such as: ‘The development and application of maker environmental education program on creative problem solving abilities of elementary school students’ (J. Y. Kim & S. W. Lee, 2021); ‘Developing and applying an online based creative problem-solving program for gifted children’ (Kim et al., 2021). Notwithstanding notable literature research on creative problem-solving in South Korea such as ‘The meta-analysis of variables in creative problem solving’ (Jeong, 2016), the number of such literature research is significantly smaller than that of all research on CPS.

Despite an increased interest in CPS, there is difficult to find research conducted on the analysis of trends and issues of CPS. Therefore, it is one of the urgent tasks to find the direction of future research activities by looking at the research trends in the CPS field that will play an important role in the education department in the future. Accordingly, it is necessary to collect CPS research data and comprehensively examine previous domestic research on CPS.

Consequently, regarding all the above facts the purpose of this study was to analyze research trends in South Korea related to CPS for elementary, middle and high school students in the last two decades and to provide basic data for finding future development. Also, by means of keyword network analysis, we explored the relationship between keywords and research contents that are important in the relevant field. Analysis of trends in existing research helps identify where further research and development is needed and in suggesting directions for future research (Wong et al., 2005). Keyword network analysis focuses on which other keywords appear in proximity to a given keyword this theory offers the advantage of revealing semantic association among keywords (Choi & Park, 2011). Keywords identified as high frequency likely represent a field’s most significant topics.

Through this process, we attempted to analyze the trends and scope of the research field of CPS establish basic concepts, overcome the fragmentation of the research, lay the academic foundation for research about future CPS in South Korea, and attempt to answer the following:

Research questions:

1. What is the trend by year of research on CPS for elementary, middle, and high school students in South Korea?

2. What is the trend by research subject of research on CPS for elementary, middle, and high school students in South Korea?
3. What is the trend by research method of research on CPS for elementary, middle, and high school students in South Korea?
4. What is the trend in research fields of journals in research on CPS for elementary, middle, and high school students in South Korea?
5. What is the trend in research topics in research on CPS for elementary, middle, and high school students in South Korea?
6. What are the core keywords presented in research on CPS for elementary, middle, and high school students in South Korea?

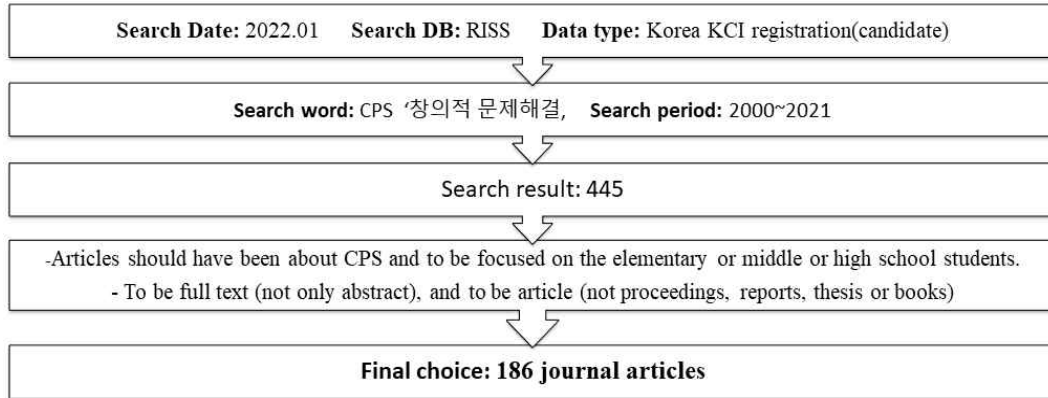
## II. Methodology

### 1. Data collection

In this study, domestic research trends were analyzed focusing on academic papers published in South Korean academic journals. This study has been used to research trend analysis and keyword network analysis. A trend analysis is a useful method to unearth the hidden recurring patterns within a rapidly changing field, and it facilitates anticipating the likelihood of future needs, events and behavior.

Keyword network analysis can be effective in identifying major research topics and overall research characteristics in a discipline (Kim et al., 2017).

To answer the research questions, a literature gathering of relevant research and studies was conducted in the following database: Korean Academy of Science and Research Information (RISS). The reasons for the selection of this database is that it contains many well-known and leading magazines also most well known database of South Korea. The search was based on the specified words, ‘문제해결(problem solving)’ or ‘창의적 문제해결(creative problem solving)’ .



[Figure 1] Research Procedure

<Table 1> Categories for Trend Analysis

Criteria	Content
year of publication	2000-2021
research subjects	elementary school students middle school students high school students
research methodology	development research experimental research survey research qualitative research literature research mixed research
research field of journal	education arts engineering
detailed field of journal	general education science education biological education gifted and Talented education arts engineering
research topic	a studies on the impact CPS/ CPS' s impacts program development and application effect analysis comparative studies theoretical review a studies on the relationship with CPS

In addition to the search words, to be full text (not only abstract), and to be article (not proceedings, reports, thesis or books) were used. Also, all articles for analysis should have been about CPS and to be focused on the elementary or middle or high school students. If the title was confusing, the abstract was reviewed to identify whether the article discussed creative problem solving. At the end of this search 186 journal articles published from 2000 to 2021 were chosen to be analyzed.

In order to see the trend of publications, all gathered publications have been categorized and analyzed under five categories (see Table 1) such as: 1) Year of publication, 2) research subjects, 3) research methodology, 4) research field of journal, 5) research topic. This research methodological categories, which had already been established in previous papers (Hwang, 2020; Park & Lee, 2021).

## 2. Keyword Network Analysis

Given that texts constitute the main data in this study, the keyword network analysis technique was applied, and keywords were therefore collected for the network analysis.

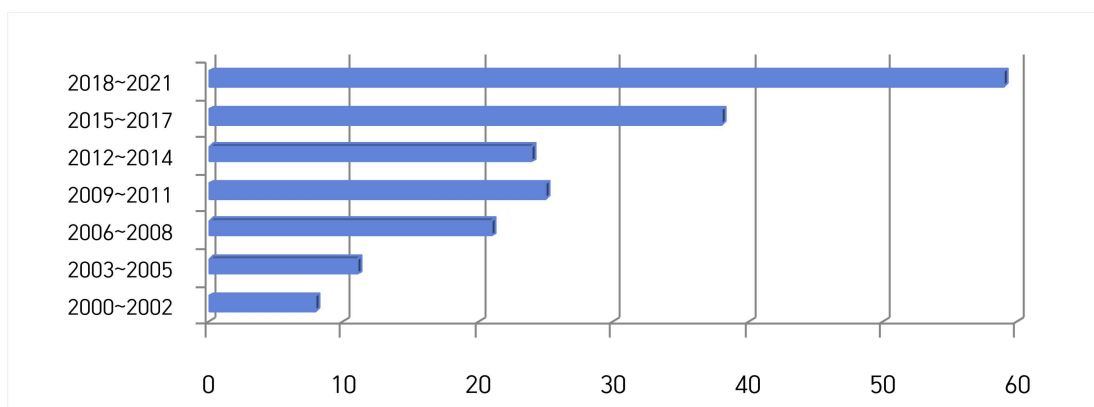
We analyzed the keywords of papers from 2000 to 2021. The study identified 735 keywords, and deleted nodes(words) with unclear meanings and words that occurred fewer. By means of this process, 489 keywords were extracted that appeared frequently. We used Gephi 0.10 an open-source software program for keyword network analysis. The word cloud is one of the representative text mining techniques used in big data analysis, and is characterized by intuitively showing the frequency of the corresponding keyword in the text by determining the size of the character according to the frequency. Keyword networks analysis, one of the social network analysis methods, was used to explore trends and the relationship between research topics in many study fields, including information science (Leydesdorff & Vaughan, 2006), medical research (Zhang et al., 2012), computer science (Chen et al., 2016), and science research (Bornmann et al., 2018). Before constructing the keyword network, refinement of the keywords was required, because individual keywords can be expressed in different ways by the authors; e.g. in abbreviated. Therefore, similar keywords such as ‘창의적문제해결능력’, ‘창의적문제해결력’ were changed to ‘창의적문제해결능력’. ‘교육공학프로그램’ were changed to ‘교육프로그램’. ‘SW교육’ were changed to ‘소프트웨어 교육’.

In this study, keyword network analysis includes the process of constructing the network using the relationship of the collected keywords within research articles, and analyzing their structure. Our analysis consists of two methods: degree centrality and betweenness degree, which are useful to identify the role of words in the overall network map. Centrality analysis measures the importance of a node (word) and has the potential to interpret its structures and express the key properties. Betweenness analysis measures the number of times the shortest link between nodes and explained words acted as bridge between nodes: a node with a high betweenness value may have a significant impact on the overall network (Radhakrishnan et al., 2017). These analyses express trends in the latest studies with the centrality degree, and relevance to other studies with the betweenness degree (Abilhoa & de Castro, 2014; Jung & Park, 2015) and are useful in understanding the properties of words.

### III. Results

#### 1. Distribution of Studies by the Year of Publication

For this study, a total 186 domestic academic researches published by RISS published from 2000 to 2021 were analyzed according to the research period.

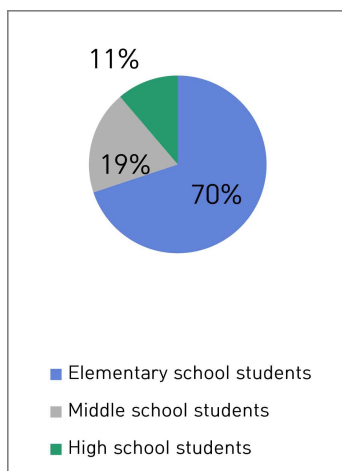


[Figure 2] Number of Publication Year

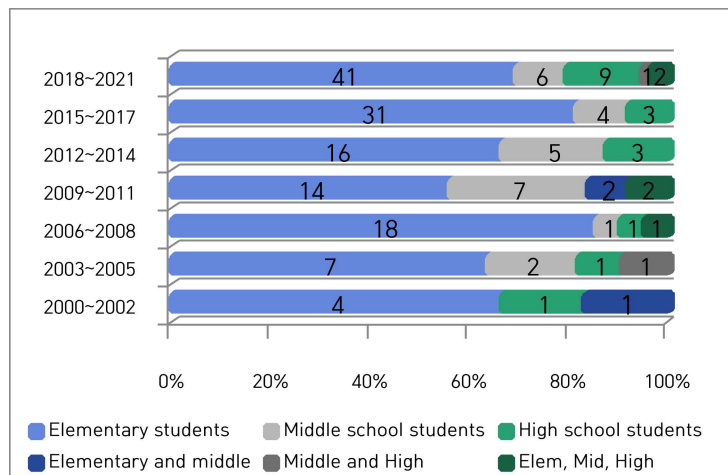
The research trend of ‘CPS focusing on elementary, middle and high school students’ was analyzed in 3~4 years cycles (2000~2002, 2003~2005, 2006~2008, 2009~2011, 2012~2014, 2015~2017, 2018~2021). The publication research from 2000 to 2021 is shown in Figure 2. During the passed decades CPS papers of elementary, middle and high school students on research produced from 8 in 2000~2003 to 59 in 2018~2021. The annual number of publication growing, indicating that the research had aroused more attention recently.

## 2. Research trend of research subjects

In this study, papers for elementary, middle and high school students were selected. Figure 3 and Figure 4 present the research trend of research subjects. The largest number of studies were about the elementary school students(70%) followed by middle school students(19%) and high school students(11%). This results (see Figure 3 and Figure 4) shows that there are relatively few papers of middle and high school students and research on this seems to need to be actively conducted.



[Figure 3] Research trend of research subjects

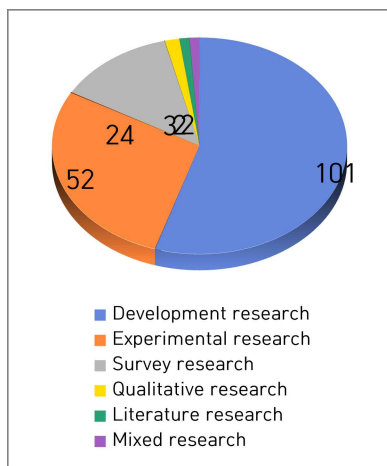


[Figure 4] Research trend of research subjects by years

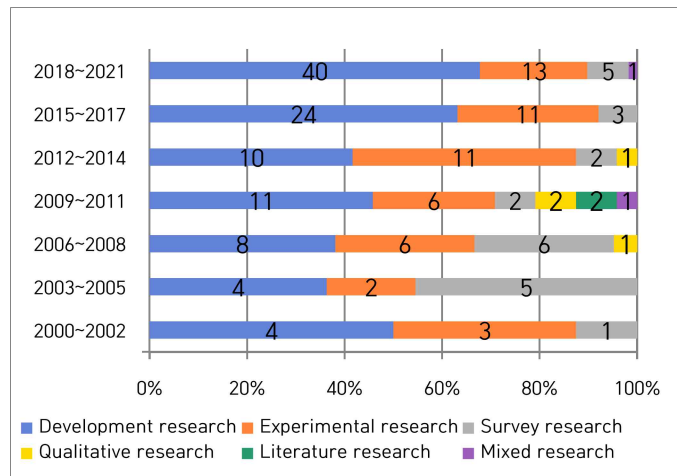
## 3. Research trend of research methodology

Figure 5 and Figure 6 shows the results of analyzing research trend of research methodology. The results of analyzing trend on ‘research methodology’ showed that

majority of the research articles utilize a ‘developmental research’ (54.3%) compared to ‘experimental study’ (27.9%), ‘survey study’ (12.9%), ‘qualitative study’ (1.6%). Based on Figure 5 below, ‘quantitative analysis’ (such as development research, experimental research, survey research)” was the most preferred analysis in publications from 2000 to 2021 compared to other methodologies appearing.



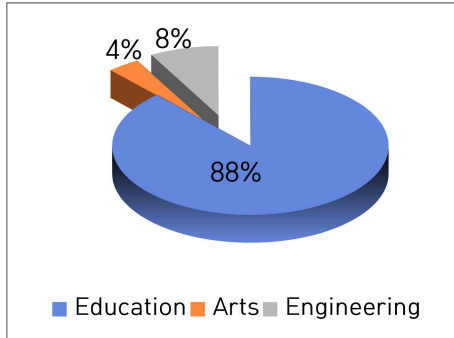
(Figure 5) Research trend of research methodology



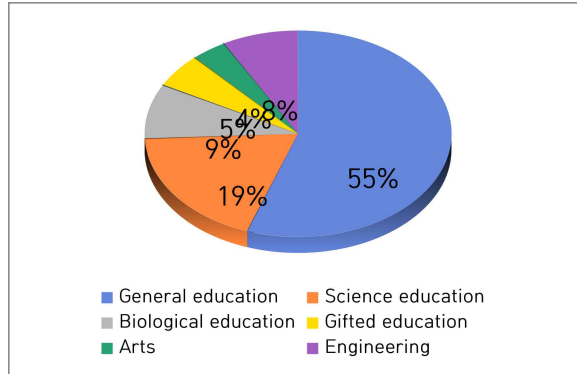
(Figure 6) Research trend of research methodology by period

#### 4. Research trend by research field of journal

Figure 7, shows the results of analyzing how research related to research trends has been conducted by research field of journal. The education field has the largest frequency with 164(88%) articles, followed by 15 (8%) articles on engineering studies and 7 (4%) articles on arts. It can be considered that in Korea, research on CPS of elementary, middle and high school students is mainly being studied in the fields of academics related to education. Among them, science education research was the one of the most common with general education, subsequently gifted education, biological education and engineering (see Figure 8).



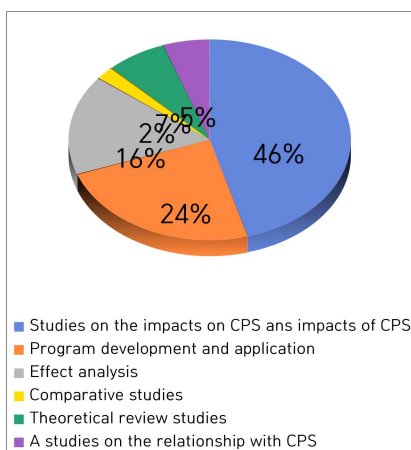
[Figure 7] Frequency by field of journal.



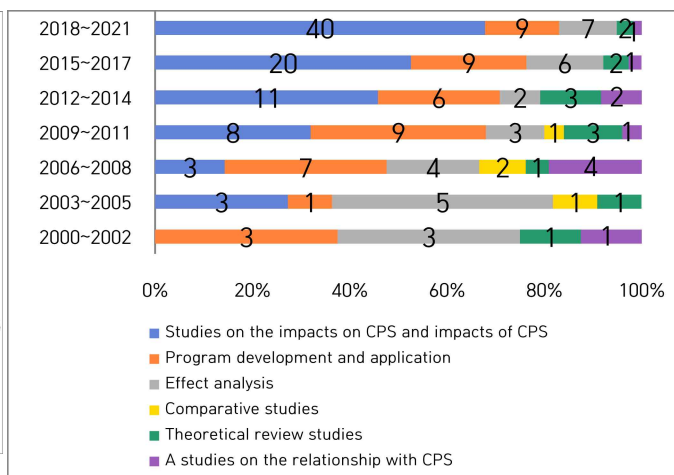
[Figure 8] Frequency by detailed field of journal

### 5. Research trend of Research Topic

The research topic was analyzed by examining the prior research and analysis target dividing it into a studies on the Impacts on CPS and impacts of CPS, program development and application, effect analysis, comparative studies, theoretical review studies, a studies on the relationship with CPS(see Figure 9, 10). As in illustrated in Figure 9, the topic related to ‘studies on the Impacts on CPS and impacts of CPS’ (46%) was the most dominant, followed by many studies on ‘program development and application’ (24%), ‘effect analysis’ (16%). In additional, a number of studies related to ‘theoretical review’ (7%) were conducted.



[Figure 9] Research trend of research topic



[Figure 10] Research trend of research topic by period

## 6. Keyword network analysis

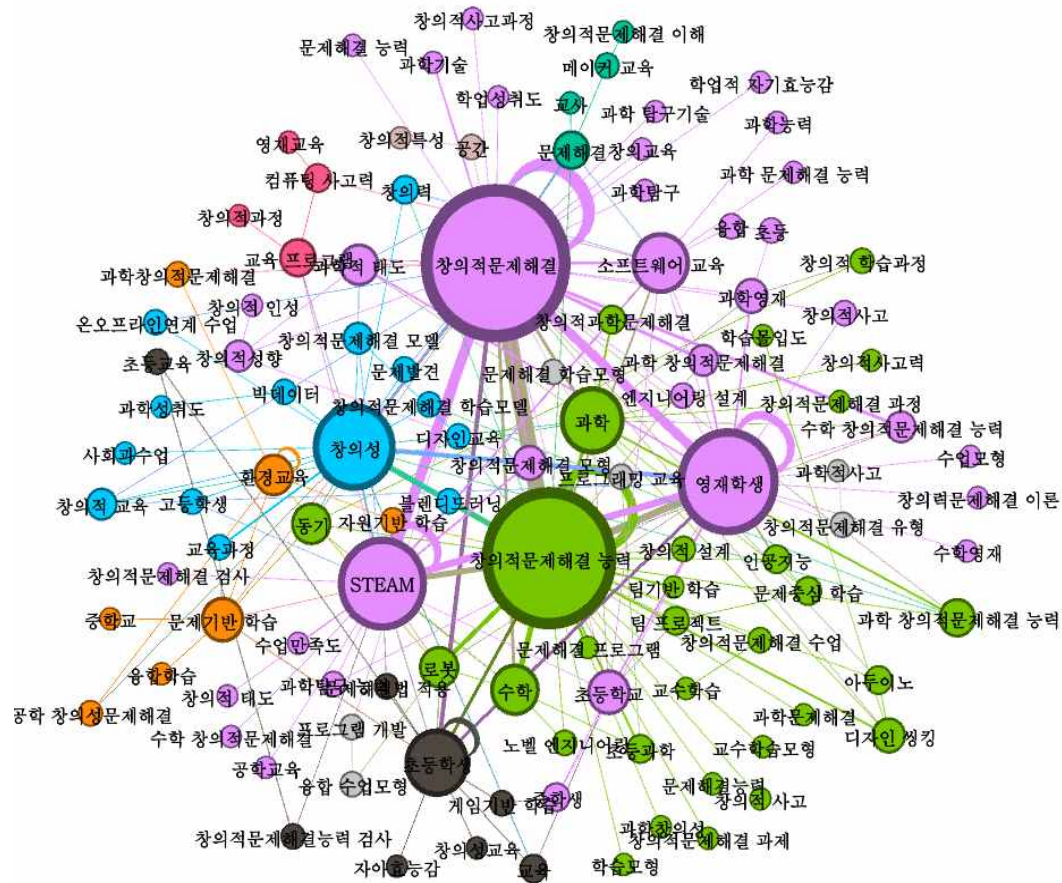
We analyzed the keywords of papers from 2000 to 2021. Keywords were identified via degree and betweenness centrality analysis. Table 2 shows the degree and betweenness centrality of occurrence of important keywords among the keywords included in the analyzed.

<Table 2> Keywords degree and centrality

Keywords	Degree	Betweenness centrality	Keywords	Degree	Betweenness centrality
창의적문제해결 (CPS)	43	2356.80	과학영재 (science gifted student)	5	134.63
창의적문제해결 능력 (CPSAbility)	38	1960.43	창의적문제해결 모형 (CPSshape)	5	31.73
영재학생 (gifted student)	27	934.25	디자인 씽킹 (design thinking)	5	110.2
STEAM	23	851.71	수학창의적문제해결능력 (mathematics CPS)	4	2.21
창의성 (creativity)	21	822.23	과학 창의적문제해결 (science CPS)	4	0
과학 (science)	15	362.99	창의적문제해결 모델(CPS model)	4	15.60
초등학생 (elementary student)	15	491.89	창의적성향 (creative tendency)	4	109.33
소프트웨어 교육 (software education)	13	527.49	창의적 교육 (creative education)	4	2.21
수학 (mathematic)	10	97.726	초등과학 (elementary science)	3	53.40
문제기반 학습 (question based learning)	8	276.95	문제중심 학습 (problem based learning)	3	3.81
초등학교 (elementary school)	8	91.55	인공지능(AI)	3	22.20
동기 (motivation)	7	89.320	교육 (education)	3	7.40
환경교육 (environment education)	7	19.37	창의적과학문제해결 (science CPS)	3	4.37
로봇 (robot)	7	111.26	팀 프로젝트 (team project)	3	15.70
과학적 태도 (scientific attitude)	7	63.85	중학생 (middle school student)	3	12.17
과학 창의적문제해결 능력 (science CPS)	6	33.50	컴퓨팅 사고력 (computational thinking)	3	111.66
교육 프로그램 (education program)	6	183.05	창의력 (creativity ability)	3	5.142
문제해결 (problem solving)	6	328.27	아두이노 (Arduino)	3	0

According to the centrality analysis presented in Table 2, the result for ‘창의적문제해결(CPS)’ was the highest. In addition, the results were confirmed in the order of ‘창의적문제해결능력(CPS ability)’, ‘영재학생(gifted student)’, ‘STEAM’, ‘창의성(creativity)’, ‘과학(science)’, and ‘초등학생(elementary school students)’.

Figure 11 presents a network map created by applying the connection centerline to keywords. The study identified 326 connecting lines between 111 keywords. The size of the node shown in the picture means that the keyword appears frequently at the same time. In addition, the more neighbors it has, the more important the node seems to be. Connections of special significance are ‘창의적문제해결-창의적문제해결능력’, ‘창의적문제해결능력-창의성’, ‘창의적문제해결-영재학생’, ‘STEAM-CPS’, ‘창의성-영재학생’ etc.



[Figure 11] Keyword network map

The keyword is used more frequently as the circle gets larger. The connections between the circles indicate how far apart two keywords are from one another. The relation size decreases in proportion to the strength of the association between the terms. Similar-colored keywords describe groups of keywords that are closely connected (see Figure 11). There are seven clusters in the diagram, and each one is represented by a distinct hue.

Figure 12a/12b visualizes the keywords related to CPS in a word cloud. The aim of using a word cloud for the papers is to examine the most frequent terms, meaning that the bulk of the analysis is performed in those fields (Mulay et al., 2020). A word cloud, also known as a Tag Cloud, transforms the text data into identifiers, which are typically single words whose relative value is visualized in the cloud by their color (Depaolo & Wilkinson, 2014). The ‘Word Cloud Generator’ (<http://wordcloud.kr>) application was used to keywords excluding all keywords and major search terms in the literature. The result shows that ‘창의적문제해결능력(CPS Ability)’, ‘창의적문제해결(CPS)’, ‘STEAM’, ‘영재학생(gifted student)’, and ‘창의성(creativity)’ in descending order, are 5 of the most influential nodes.



(Figure 12a) Words cloud for all keywords (Figure 12b) Words clouds excluding main keywords

Figure 12a visualizes the results of applying all keywords, and Figure 12b visualizes the keywords, excluding ‘창의적문제해결능력(CPSA)’, ‘창의적문제해결(CPS)’, ‘STEAM’, ‘영재학생(gifted student)’, ‘초등학생(elementary school students)’, ‘과학(science)’, ‘창의성(creativity)’, ‘과학적태도(scientific attitude)’, and ‘문제해결(problem solving)’, which were used as major keywords. Looking at the word cloud (Figure 12b) in which the main search words were deleted, keywords such as ‘소프트웨어교육(software education)’,

‘수학(Math)’, ‘로봇(Robot)’, ‘환경교육(environment education)’, ‘과학창의적문제해결(science CPS)’, ‘초등학교(elementary school)’ and ‘동기(motivation)’ were identified as the main topics, indicating that these are important factors in the field.

#### IV. Discussion

This study analyzed the trends in creative problem solving(CPS) by subdividing 186 academic papers published in South Korean academic journals from 2000 to 2021 into research year of publication, research subjects, research methodology, research field of journal, research topic and keywords. Overall, the general research trend shows an increase in the quantity of publications on CPS of elementary, middle, and high school students in South Korea. Year by year publications also shows an increase in CPS of elementary, middle, and high school students in South Korea since 2000 to 2021. Research related to CPS of elementary middle and high school students had only 8 papers for 4 years from 2000 to 2003, but 21 papers were published in 2006 to 2008, start showing a sharp increase. This seems to be because, since the revised The Korean national curriculum was revised in 2007, includes seven core skills: creativity, problem solving, self-management etc have been emphasized and related research has increased.

This study shows that in Korea, most research of CPS was about elementary school students(Hwang & Tae 2021; Jho & So, 2019; Kim, 2020; K. T. Kim & C. H. Lee, 2021; Song & Park, 2019). It shows that in Korea, interest in CPS is mainly focused on elementary school students. On the other hand, ‘middle school students’ and ‘high school students’ has seen to have less interest from researchers in South Korea. This result is similar to Park & Lee (2021) explained that researches about creativity were conducted the most at the elementary school level. But CPS can also be applied in the middle and high school students. Ninety-seven percent of educators and ninety six percent of policymakers in a global research study from Adobe said CPS is important for today’ s students, and they said they believe students who excel at CPS will have higher-earning jobs in the future. In fact, CPS Ability are in high demand today for senior level and higher paying careers (<http://cps.adobeeducate.com>). It can be said that is necessary pay more attention to and to conduct more research targeting middle and high school students. Another reason

is that, CPS is a learning model that is able to train and increase student creativity. Also, CPS can be applied in various conditions and all ages (Isaksen & Treffinger, 1985). The purpose of each CPS step is to: understand conditions, understand objectives, formulate ideas, formulate solutions, implement, and evaluate. CPS has been applied in learning at several levels of education. CPS is considered effective in helping students achieve their learning goals. Then, CPS can also be used as a basis for developing valid, practical and effective learning tools (Widya et al., 2020).

This study result of analysis by research methodology shows that the majority number of papers was quantitative studies such as developmental research (Ki & Kwon, 2021; Lee & Lim 2021; Shin, 2016), experimental study (Hong & Kim, 2019; Hwang & Tae, 2021; Lee & Yi, 2021) compared to qualitative study and mixed study. In the literature study, only two research papers were conducted in the last twenty years. It can be seen that there is a lack of literature research on CPS of elementary, middle and high school students. In the research method of CPS, there are insufficient studies using qualitative and mixed research methods. This result is similar to Jeong (2016) mentioned that most volume of papers was about quantitative researches. Research on CPS in various contexts needs to be more actively conducted (Cho et al., 2011; Park & Lee, 2021). To gain insight in whether students really appreciate all aspects of creativity or not, a more qualitative approach zooming in on how these solution finding processes take place would be worthwhile (Van Hooijdonk et al., 2020). Although specific research methods are not recommended because research methods are determined by research problems, mixed research needs to be more active given that there are advantages and disadvantages of qualitative and quantitative research (Kim et al., 2007). Moreover, the qualitative research should be integrated in future research to investigate the empirical learning context that would enhance CPS performance. It is necessary to conduct both CPS on qualitative methods, quantitative methods, literature and mixed methods.

The result of the analysis by publishing journal field was confirmed that the largest number of articles were published in education field. Also it shows that students' CPS researches conducted and increasing in education field. However, papers have been published through academic journals in different fields also many studies related to CPS of elementary, middle and high school students have been conducted in various detailed fields of education. Therefore it can be said that researchers in the non-education field need to

make more efforts in this regard.

The topic that occupied the most part was ‘studies on the Impacts on CPS and impacts of CPS’ (K. T. Kim & C. H. Lee, 2021; Lee & Yi 2021; Park & Jung, 2021; Shin & Yoo, 2021; Song & Park, 2019) followed by ‘program development and application’, and ‘effect analysis’. However, the small number of studies related to ‘theoretical review’ were conducted. It shows that is necessary to conduct both theoretical interest in CPS and research on practical methods, especially need more interest in theoretical review study. In the future, more research methods should be used.

Keyword analysis presented that core keywords revealed ‘창의적문제해결(CPS)’, ‘창의적문제해결능력(CPS Ability)’ to be the most frequently used keyword among all collected words. This indicates that many of the researchers attempted to find both useful and meaningful implications. The keyword network of this field is very sparse because the field has changed quickly, adopting many new technologies and concepts. However, the keyword network also shows a high clustering coefficient. This implies that research themes with a set of closely related keywords continue to be selected by researchers and contribute to the evolution of the network.

Focusing on the centrality scores of each keyword, there were keywords with a relatively high degree of centrality in the core keyword network based on the frequency of the keywords: CPS, CPS Ability, 영재학생(gifted student), 창의성(creativity), STEAM, 과학(science), and 수학(math). Results showed that the words associated with Science and Gifted students had greater relevance than the other words in the CPS category in Korea. In the other hand, although 동기(motivation), 소프트웨어교육(software education), 중학생(middle school student) keywords did not appear as much in core keywords, they were closely connected to other core keywords. These keywords with a high degree of centrality can be potential themes in future CPS research. It is considered that there has been few studies about these keywords so far, so further research is needed.

Lastly, since in recent years, CPS has been mentioned as important in the Korean curriculum, it is expected that many research related to CPS for elementary, middle and high school students will continue to be conducted in the future. In this study, it is meaningful to explore the core keywords related to the CPS by using keyword network analysis and to grasp specific tendencies of integration of CPS.

## V. Conclusion

Based on previous chapters, I would like to briefly suggest potential future directions for CPS of elementary, middle and high school students. There has a limit to grasping the reality of domestic research using only domestic literature as the subject of research. In the follow-up study, it will be necessary to make an effort to investigate what differences there are from overseas research where CPS has developed by extending the analysis scope to overseas literature.

As our findings show that researches of CPS increases in just a small number of areas and usually used quantitative methods. In the sense that CPS needs to be strengthened in South Korean society as a whole and in various specialized fields, it is necessary to continue in-depth research in various fields. Since, CPS provides the chance for students to improve problem solving ability as the students were given an opportunity to develop their ideas and choose the most appropriate and effective ideas to solve problems (Rahman, 2015). As well as, in the future, not only quantitative methods but also studies using qualitative and mixed research methods studies need to be followed. If various research methods will be used and more convincing research results will be possible to draw.

For students, more experience in participating in CPS projects should be provided so that they can highlight problems and solve them through education. These experiences help students to grow as democratic citizens who participate and practice, and to grow as leaders who solve diverse problems caused by rapid changes in the industry. Furthermore, until now, CPS has been mainly implemented in primary education, but it should be extended to secondary and high school education. CPS education in high school will help students develop the CPS, collaborative, and creative talents required for future jobs and careers.

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