



초등학생의 창의적 문제해결력 신장을 위한 Novel Engineering 기반의 SW융합교육 프로그램 개발 및 적용

홍지연

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Development and application of SW program based on Novel Engineering for improving creative problem solving ability of elementary students

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[요 약]

2015 개정 교육과정은 새로운 지식을 창조하고, 다양한 지식을 융합하여 새로운 가치를 창출할 수 있는 ‘창의융합형 인재’를 양성하고자 인문학적 상상력을 키우는 독서교육, 그리고 과학적 창의성을 키우는 소프트웨어교육을 강화하고 있다. 특히 Tufts대학의 CEO에서 소개한 Novel Engineering교육이 국내에 소개되면서 새로운 SW융합 교육 방법으로서 관심이 높아졌다. Novel Engineering은 책을 읽고, 그 속에 있는 생활 속 문제를 찾아 해결해 가는 과정 속에서 사고력을 키울 수 있다고 본다. 따라서 본 연구에서는 Novel Engineering을 적용한 소프트웨어교육 프로그램을 개발하여 실제 수업에 적용하고 학생들의 창의적 문제해결력 향상에 도움이 되는지 교육적 효과성을 검증하고자 한다.

[Abstract]

The 2015 revised curriculum aims to cultivate a 'creative fusion talent' that can create new knowledge and create new value by fusing various knowledge. So, in the curriculum, it's strengthening the reading education to raise humanistic imagination. In addition, it conduct software training to promote scientific creativity. Especially, Novel Engineering education introduced by Tufts University CEO has been introduced in Korea, and it has attracted attention as a new SW fusion education method. Novel Engineering thinks that you can develop your thinking skills in the process of reading books and finding and solving problems in your life. Therefore, this study develops a software education program using Novel Engineering and applies it to actual classroom, and it is examined whether it is helpful to improve creative problem solving ability or educational effect.

색인어 : 노벨 엔지니어링, 소프트웨어 교육, 융합 교육, 문제해결력

Key word : Novel Engineering, Software Education, Convergence Education, Problem Solving Ability

<http://dx.doi.org/10.9728/dcs.2018.19.12.2315>



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Received 16 November 2018; **Revised** 04 December 2018

Accepted 23 December 2018

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I . Introduction

The 2015 revised curriculum aims to cultivate a 'creative fusion talent' capable of creating new knowledge and fusing various knowledge to create new value. As a basic education, we are strengthening Korean language education, reading education for developing humanistic imagination, and software education for raising scientific creativity.[1] As an education to develop computing thinking skills, software education is being emphasized as a core competence for learners in the 21st century. Accordingly, software education, coupled with the worldwide craze for coding education, is waiting for full-scale implementation on the school scene amid high interest in Korea.

According to the 2015 revised curriculum, elementary schools offer 17 hours of software training in practical subjects in grades 5 and 6. In middle schools, software education is mandatory for more than 34 hours in information classes. In addition, high schools are expanding their scope from more advanced optional subjects to general optional subjects, allowing more students to take software lessons.[2] This is meaningful in that software education is conducted as compulsory education. In elementary schools, it is doubtful whether software education can raise students' computational thinking at a time that is only 17 hours a year.

The 17 hour, 34 hour minimum time assigned to elementary and junior high school is also a problem, but there are also bigger problems. It is doubtful whether the following software classes can help students develop creative problem solving skills

As an alternative to this point, the curriculum states that "Computational thinking is not limited to software education, but is reflected in various subjects such as Korean language, social studies, mathematics, and science." This means that it is possible to do software education linked to other subjects as a fusion education. [3] In this way, we are trying various SW convergence education centered on themes connected with other subjects. For example, public institutions such as the Ministry of Veterans Affairs also hold "SW Convergent Patriot Instruction Competition" which combines the vocational lesson with software. This means that interest in SW convergence education is increasing. [4]

Especially, as the Novel Engineering education method introduced by in CEO of Tufts University was introduced in Korea, software education applying Novel Engineering as a new SW convergence education method centering on the Jeonju National University of Education was often applied to the school site.

Novel Engineering is a new engineering education method that integrates humanities, software education, and STEAM education, and it can be said that students can develop their thinking skills in the process of finding and solving problems in their lives. It is not merely learning according to the function. The problem solving is aiming to help students to think for themselves so that it helps students to improve their problem-solving ability.

However, there are not many SW fusion education programs applying Novel Engineering. In addition, it is too early to confirm the possibility of the new SW convergence education method because the objective educational effectiveness of it is hardly verified. The purpose of this study is to develop a software education program using Novel Engineering and to apply it to actual classroom and to verify the effectiveness of students in improving creative problem solving ability and educational effectiveness.

II . Main subject

2-1 Theoretical Background and Related Research

In this chapter, Novel Engineering, which is a teaching method used to develop SW education programs for improvement of problem solving ability of elementary students, will be discussed first, and research examples applied there will be examined.

1) Novel Engineering

Novel refers to literary works, and Engineering refers to engineering that transforms existing ones into new ones. Novel Engineering is a combination of reading and engineering. Tufts University in the state of Massachusetts, USA, has been developing and applying this program. [5] Novel Engineering consists of 7 steps of Picking a Book, Identify Problems, Design Solution, Building, Feedback, Upgrade Solution, Reconstruct stories.

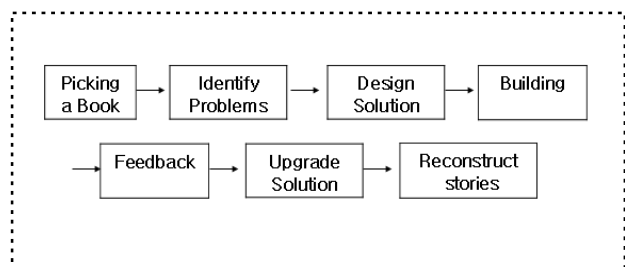


Fig. 1. Teaching-learning stage of Novel Engineering

As shown in Table 1, Novel Engineering is similar to

computational thinking, which is the goal of software education. [6]

Table 1. Novel Engineering and Computational Thinking

Novel Engineering	Computational Thinking
Identify Problems	Abstraction
Design Solution	Decomposition Algorithm
Building	Algorithm Abstraction
Feedback	Abstraction Logical Analysis
Upgrade Solution	Abstraction Generalization
Reconstruct stories	Logical Analysis

2) A study on SW convergence education applying N.E

Park Seon-jung et al. (2018) [7] conducted a lesson to create a recycled song to solve garbage problems around the school by applying Novel Engineering class model. I have seen the effect that the concentration of students is enhanced through the process of solving the problem of fairy tales by linking the engineering works using 'Beat the Earth' and 'Beat Music', a type of Makey board. This study was expected to improve students' creativity and problem-solving ability. However, we did not provide objective verification of how students' problem-solving abilities improved.

Eom Tae-geon (2018) [8] introduced a case study of convergence with fifth grade Korean language using Novel Engineering instructional model. As a result of a semester class that solves the problem of the book's main character in the Mine-Craft game, students' participation in class, interest, and writing ability improved. However, this study did not test the students' creative thinking ability or problem solving ability.

Joe Young-Sang (2018) [9] conducted a book on the understanding of disability by using Novel Engineering to solve the problems that can be found in the contents of the book by reading the book "Gregoire speaks with eyes.". As a result, students could make a meaningful change, but the problem-solving ability test is suggested as a future research project.

Novel Engineering is used as a new method of SW convergence education in connection with various subjects and subjects, but there is not yet enough verification of its educational effectiveness. Therefore, this study develops an SW convergence education program based on Novel Engineering and applies it to elementary school students. The purpose of this study is to examine the effectiveness of educational activities by examining the change of their pre- and post-problem solving ability.

2-2 Research content and method

In this study, the development and application method of SW convergence education program based on Novel Engineering is as follows.

1) Contents of Research

First, we extracted learning elements that students must learn according to the software education achievement standards of the 2015 revised curriculum, such as Sequence and Repetition. And the curriculum was created by combining the Novel Engineering teaching and learning stage with software education. At this time, one book each student needs to read for each weekly activity was decided, so that SW fusion education applying Novel Engineering was smoothly performed. The contents of the weekly curriculum are as follows.

Table 2. Curriculum

Division	Step of Novel Engineering	Learn ing element	Related Book	
1 week	M	introduction video	Sequ ence	Who is the real Snow White?
	P.B	read e-book		
	I.P	select a scene for animation (find a problem)		
	D.S	watch learning video and do coding worksheet		
	B	coding -using sequence related blocks		
	F	submit work and feedback		
	U.S	improvements and submit		
	R.S	deepening activity		
2 week	M	introduction video	Repe tition	"Music box" School of Music
	P.B	read e-book		
	I.P	select a scene for animation (find a problem)		
	D.S	watch learning video and do coding worksheet		
	B	coding -using repetition related blocks		
	F	submit work and feedback		
	U.S	improvements and submit		

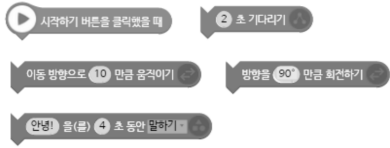
3 week	R.S	deepening activity	Condition	The day smartph one eats!
	M	introduction video		
	P.B	read e-book		
	I.P	select a scene for animation (find a problem)		
	D.S	watch learning video and do coding worksheet		
	B	coding -using condition related blocks		
	F	submit work and feedback		
	U.S	improvements and submit		
	R.S	deepening activity		
4 week	M	introduction video	Event	The bean mask teacher laughed again!
	P.B	read e-book		
	I.P	select a scene for animation (find a problem)		
	D.S	watch learning video and do coding worksheet		
	B	coding -using event related blocks		
	F	submit work and feedback		
	U.S	improvements and submit		
	R.S	deepening activity		

Based on this, we developed the teaching and learning process and 12 activities of 4 weeks so that the systematic SW convergence education can be achieved.

Table 3. Teaching and learning process (example)

Division		Learning contents and method	
C	NE	Step	Details contents and method
Intr odu ctio n	Moti vati on	■ Intro	▮ Introduce what you learn
		■ Goal of this activity	▮ Check the goal of this activity ▮ (Goal) In the process of creating an animation that solves the problems found in the book you read, you can learn about the "sequential" structure and develop problem-solving skills.
		■ Watching video	▮ Watching the video <How to make Animation> : https://www.playsw.or.kr/repo/bbc/178
		■ Doing	▮ Doing worksheet : Simply write down an introduction to my

Dev elo pm ent	Pick ing a boo k	works heet ①	favorite anime and draw a simple picture of the most memorable scene - How do I make a character appear to move? - What is the title of my favorite animation? - Why do you like the animation?
		■ Reading a book	▮ (Reading a book) Reading a Free eBook in Cyber Library - Book title: Who is the real Snow White?
	Ide nti fy pro ble ms	Doing works heet ②	▮ After reading the book : After reading the book, look at what changed my feelings. - Who is the main character? - What happened to the protagonist? - What did you think as you read this book? If there was an angry or sad scene, why did you feel such an emotion? - What if you had a funny or happy scene in reading this book, and you felt that feeling?
		■ Finding a problem	▮ (Awareness of the problem) What is the problem of the main character in reading the book? - example : Why did Princess Lucia have to do makeup?
	Des ign solu tion	■ Searching for Reference Works	▮ (Searching for Reference Works) Exploring Coding Works on the theme of Snow White https://playentry.org/all#!/?sort=updated&rows=12&page=5&name=%EB%B0%B1%EC%84%A4%EA%B3%B5%EC%A3%BC&role=teacher
		Doing works heet ③	▮ (Designing the algorithm) Divide the operation, order the expression of the action, etc. - Character, background - Expressing the scene that starts the story - Expressing scenes in which story events appear - Expressing the scene to finish the story
Buil din g	Experi ence Block coding	■	▮ (Suggested solution 1) Block coding 2 episode: Sequential, sequential, sequential video viewing https://www.playsw.or.kr/repo/ebs_software2/222 ▮ (Solution Presentation 2 / Practice) Solving the Mission Directly: Learning / Going Further Solving Mission Problems - https://playentry.org/ebs_2015#/1/1 - https://playentry.org/le#!/55dff4a798ef40c00475e0b

	Doing worksheet ④	<p>■ (Solution Presentation 3 / Practice Activity Sheet)</p> 
	Block coding	<p>■ (Coding) Express the scene you want to express yourself</p> <ul style="list-style-type: none"> - Look back at your own algorithmic design - Fix the part of Algorithm that needs to be fixed - Perform scene block coding that you want to express yourself
Wrap-up	Feedback and Feedback	<p>■ (Share) Submitting your completed footage as a program file or share link</p> <ul style="list-style-type: none"> - (Option 1) Save as an ent file and submit your work as a file - (Option 2) Share Share your work on the board and submit the created share link <p>■ (Feedback) Online tutor, get feedback to students</p> <ul style="list-style-type: none"> - Feeding feedback to a friend's work - Feedback to student work
	Upgrade Solution	<p>■ (Improve) Check online feedback and make any necessary corrections, submit modified program files or share links</p> <ul style="list-style-type: none"> - Check your friends' feedback and improve your work - Submit your improved work
	Reconstruction Stories	<p>■ (Reconstruction / deepening of the story) Reconstructing a scene of the story to express it as a new story, submitting the deepening task as a program or a shared link</p>

2) Method of Research

In this study, we try to verify the improvement of students' problem-solving ability by putting the previously developed Novel Engineering based SW convergence education program into students. In order to do this, I set up a group of 1 class (27 students) in 00 elementary school in Gyeonggi province as the experimental group and conducted 12 classes during 3 weeks in July, 2018.

Table 4. Experimental Design

Experimental group(27)	O1	X1	O3
Comparison group(27)	O2	X2	O4

O1, O2: Problem-Solving Ability pre-test
 O3, O4: Problem-Solving Ability post-test
 X1: N.E based SW convergence class
 X2: X2: General SW class

In order to verify the effectiveness of the study, this study used

the 'Research on the Development of Simple Creative Problem Solving Ability' developed by the Korea Educational Development Institute. In addition, a computerized problem solving ability evaluation model developed by the Korea Institute of Curriculum and Evaluation (RRE 2011-5) was conducted. The SPSS 18 version was used for statistical analysis. As a result of the pre-test, independent sample t-test and covariance analysis were performed on the mean difference of students in each group. In order to test the degree of improvement of the problem solving ability of the experimental group, a corresponding sample t-test was conducted. The significance level used for the test was $P < .05$.

III. Results of the study

In order to verify the effects of the Novel Engineering based SW convergence education on students' problem solving ability, we applied the Novel Engineering based SW convergence education program developed by the present researcher to the 6th grade elementary school. Also, general SW education was applied to the comparative class. The results of the study are as follows.

3-1 Result of Pre-test

In order to see if there is a significant difference in the creative problem solving ability of the experimental group and the comparative group before the experiment, the independent sample-t test was performed. As a result, the average of the total of the experimental group and the comparative semester was 109.81 and 109.29, respectively, which were not statistically significant. In other words, since the probabilities of P and .05 for each region are $P > .05$, the two groups are homogeneous groups.

Table 5. Pre-test result

Division	N	Average	Standard Deviation	t	p
E.G	27	109.81	16.916	.115	.920
C.G	27	109.29	16.294		

3-2 Result of Post-test

1) Result of Independent sample t-test

After implementing the SW fusion education program based on Novel Engineering, the creative problem solving ability test was conducted again. the results are as follow. The mean scores of the two groups were 122.48 and 113.21, respectively. The t value of the test statistic of both groups was -3.157 and the

significance probability was .003. $p < .05$, which is a statistically significant difference. This means that the convergence education program based on Novel Engineering is effective in enhancing students' creative problem solving ability.

Table 6. Post-test result

Subregion	Div.	N	A	S.D	t	p
Self Confidence and Independence	E.G	27	22.58	3.027	-3.7	.000
	C.G	27	19.44	3.117	64	.000
Divergent thinking	E.G	27	22.28	3.871	-2.7	.010
	C.G	27	20.02	1.931	14	.009
Critical/logical thinking	E.G	27	21.75	1.677	-4.3	.000
	C.G	27	19.28	2.414	20	.000
Problem-solving thinking	E.G	27	36.06	7.635	-5.1	.612
	C.G	27	35.14	5.510	1	.612
Motivative Thinking	E.G	27	19.77	2.136	-7.7	.441
	C.G	27	19.28	2.414	76	.441
Total	E.G	27	122.48	11.603	-3.1	.003
	C.G	27	113.21	9.877	57	.003

2) Corresponding sample statistics

The results of the pre-test and the post-test were analyzed to see if the Novel Engineering - based SW fusion education affected the experiment group. There was no significant difference between the synchronic thinking and the problem-solving thinking subscale. However, in the total, it appears that there is a statistically significant difference in the creative problem-solving ability within the significance level of 5%. The mean of the total score increased from 109.81 to 122.48 and $t = -3.198$ ($p = .004$). In the degree of freedom 26, the t value was -3.198 and the significance was .004, $p < .05$. Therefore, it can be seen that there is a meaningful difference in the level of significance 0.05.

Table 7. Correspondence specimen statistic

Subregion	Div.	N	A	S.D	t	p
Self Confidence and Independence	pre	27	18.67	3.397	.654	-4.1
	post	27	22.58	3.027	.581	71
Divergent thinking	pre	27	18.17	3.088	.594	-3.5
	post	27	22.28	3.871	.744	40
Critical/logical thinking	pre	27	19.47	3.796	.730	-2.9
	post	27	21.75	1.677	.321	81
Problem-solving thinking	pre	27	34.54	6.778	1.304	-.81
	post	27	36.06	7.635	1.469	4
Motivative Thinking	pre	27	18.95	3.143	.605	-1.1
	post	27	19.77	2.136	.411	60
Total	pre	27	109.81	16.916	3.176	-3.1
	post	27	122.48	11.603	2.233	98

V. Conclusion

The purpose of this study is to investigate how SW

convergence education based on general SW education and Novel Engineering influence students' creative problem solving ability. In particular, we tried to find out the possibility as a method to cultivate creative convergent talent with humanistic character which is pursued in the 2015 revised curriculum. In order to verify the objective educational effectiveness of the SW convergence education based on Novel Engineering, which is being tried in the school field, the creative problem solving ability test was divided into the experimental group and the comparative group.

In summary, the results of this study show statistically significant differences in the significance level $p < .05$ from the pre-test and post-test of the experimental group. In other words, it can be said that SW convergence education based on Novel Engineering is effective in improving students' problem solving ability.

The rapid development of information and communication technology is leading the fourth industrial revolution era, and creative problem-solving ability is an essential capability to live in this age. In particular, the SW convergence education based on Novel Engineering which uses SW as a way to solve the problem and find out the problem of the main character in the book is an education to raise this capacity. In other words, I found out that it is useful to develop creative problem-solving ability as an essential competence to solve many problems that students may encounter while living. Nonetheless, the following efforts are needed to make this study more general.

First, the results of this study are limited to a limited number of students in a specific area.

Second, there is a need for prior research on books with more diverse topics and problems. Depending on the book that contains the problem, the problem-solving strategies that students establish may be different. Therefore, it is necessary to study what kind of book is more effective in improving students' problem-solving abilities and to develop a program that reflects them.

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