

RESEARCH ARTICLE

A STEAM Experience Activity Task: Making and Experiencing Goods for the Disabled with Physical Computing Tools and 3D Printing Technology

Young Chun Jung¹ · Kyung Taek Lee²*

¹Yongmoon Middle School

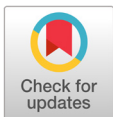
²Korea National University of Education

*Corresponding Author: ktleee@knue.ac.kr

ABSTRACT

The purpose of this study is to develop a STEAM experience activity task that can be applied to middle school students as the theme of 'making and experiencing tilt-compensation spoons for the disabled'. This study was conducted through preparation, development, execution, and evaluation phases according to PDIE model. In the preparation phase, 2015 revised curriculum was analyzed in terms of STEAM education, tilt-compensation spoons released in markets were investigated, and physical computing tools and 3D modeling software required for model design were also explored. In the development phase, a spoon model having tilt-compensation function was designed so that middle school students could easily make it. A STEAM experience activity tasks based on this spoon model, class topics, goals, and contents, centered on STEAM education and disability awareness improvement education, were selected. In the implementation phase, the 1st preliminary test with eight 2nd-year students of a maker club in Seoul Y middle school for finding some problems of the STEAM experience activity task, and expert verification by technology teachers also performed for improving the task. And then, fifty 3rd-year students of same school were put into the 2nd preliminary test. As the result of expert verification, average 4.56 point(4.8 point each in class goal, interest, and understanding questions, and average 4.33 point in three relevance questions) was obtained on a 5-point scale. In the evaluation phase, from the student satisfaction survey on this STEAM experience activity task, average 4.14 point(4.29 point in interest, 4.35 point in understanding, and 3.99 point in relevance) was obtained on a 5-point scale. Reflecting the opinions obtained in the above processes, the STEAM experience activity task was revised and changed to 14-hour course. From the series of procedures and results, it is expected that this STEAM experience activity task with the theme of 'making and experiencing tilt-compensation spoons for the disabled' has a positive effect on the level of interest and awareness for the disabled and also improve the levels of interest and understanding of physical computing tools and 3D printing technology.

Key words: STEAM experience activity task, tilt-compensation spoon, awareness improvement for the disabled



OPEN ACCESS

Brain, Digital, & Learning
2022, Vol. 12, No. 4, 675-692.

<https://doi.org/10.31216/BDL.20220042>

Received: December 05, 2022

Revised: December 22, 2022

Accepted: December 28, 2022

© 2022. Institute of Brain based Education,
Korea National University of Education



This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction

Research Background and Purpose

2015 revised curriculum (Ministry of Education, 2015) focuses on fostering creative convergence talents with upright character required by the future society. Based on science and technology literacy, STEAM education, which is configured by integrating with various subjects such as engineering, mathematics, and arts, is mentioned to be effective in fostering creative and convergent talents (Baek et al., 2012; Kim, 2012; Land, 2013; Yakman, 2008). Kim (2018) presented a maker-based STEAM class model, and he reported that students, joining to the maker-based STEAM class, got positive effects in fluency, originality which were sub-domains of creativity, and convergence, respect, and communication which were sub-domains of convergence talent cultivation. Kwon (2016) also said that the STEAM program was effective in cultivating creative capability, content fusion capability, and communication and personality capabilities.

In accordance with Welfare Act for Persons with Disabilities, daycare centers, schools, and public institutions provide education for students and employees to improve awareness of persons with disabilities at least once a year (Ministry of Health and Welfare, 2021). In connection with these educational efforts, by the research of Woo et al. (2008), most of the education for the disabled that takes place at school sites are focused on audio-visual class and lecture-style class, although disability experience class is more effective. Lee et al. (2013) said that disability awareness was raised when disability awareness improvement education was conducted in the form of a project in a daily environment such as regular curriculum rather than being taught by an external instructor during extracurricular time. Yang (2008) and Kim et al. (2019) showed respectively that students' disability acceptance attitude (disability sensitivity) was improved through classes on the use of inventions for people with disabilities and STEAM programs on the theme of visual impairment. If STEAM experience activity tasks includes classes for making and experiencing supplies for the disabled (Nopparat et al., 2022), therefore it is expected to improve the awareness of the disabled, class interest and understanding, and further be effective in the cultivation of creative convergence talents.

The purpose of this study is to develop a STEAM experience activity task having the theme of 'making and experiencing tilt-compensation spoons for the disabled' using 3D printing technology and physical computing tools to improve the disability awareness and improve interest and understanding of classes.

Background

Elements for STEAM Education in 2015 Revised Curriculum

From 2015 revised curriculum (Ministry of Education, 2015), the nature and purpose of science, technology, information, arts, social studies, and mathematics in relation to STEAM education can be summarized from the perspective of student interest and problem solving through convergent thinking.

- Science fosters the understanding of scientific concepts, an attitude cultivation, and the ability to solve problems creatively and scientifically.
- Technology fosters knowledge, attitude, skill as well as problem-solving ability and creativity through practical experience.
- Information interprets and solves real-life problems from the perspective of computer science.
- Arts make visual works and brings out aesthetic value.
- Social studies fosters community, participation and responsibility awareness.
- Mathematics helps solve real-life problems with mathematical knowledge and is the basis for learning other disciplines.

The STEAM experience activity task to be developed in this study needs to be designed with the above characteristics of individual subjects related to STEAM extracted from the curriculum.

Disability Awareness Improvement Education

There is no community devoid of people with disabilities. Thus, awareness of disability is fundamental to creating equity for people with disabilities in any society (Madhesh, 2022). Through UN Agreement on the Rights of Persons with Disabilities adopted in December 2006 and the Act on the Prohibition and Remedy of Discrimination against Persons with Disabilities enacted in April 2007, the obligations of each member of society to guarantee the rights of persons with disabilities and antidiscrimination have been stipulated. Based on this, the necessity, target, and direction of disability awareness improvement education (Choi, 2018) were suggested. With the enactment of the Welfare Act for Persons with Disabilities (Ministry of Government of Legislation, 2021), disability awareness improvement education for elementary, middle, and high school students was begun to apply to schools. In accordance with Welfare Act for Persons with Disabilities, which was amended in 2020 with the aim of creating an integrated society for both the disabled and non-disabled by eliminating social prejudice and discrimination against persons with disabilities, daycare centers, schools, and public institutions provide education for students and employees to improve awareness of persons with disabilities at least once a year (Ministry of Health and Welfare, 2021). According to a study on disability awareness improvement education (Lee & Kim, 2013) based on the above efforts, as shown in Table 1, it is told that effective ways to teach elementary, middle, and high school students about improving disability awareness require a variety of innovative teaching methods in addition to traditional methods such as disability experience are necessary. In particular, it is effective to deal with it naturally during each subject rather than a one-off program outside of class, and it is necessary to apply new teaching methods such as project classes rather than lecture-style classes, or to integrate them with textbook content in regular curriculum to provide education for the disabled.

Woo et al. (2008) surveyed 332 primary and secondary school teachers who supervised students with disabilities and general students to find out the current status of education for the awareness improvement of the disabled and the teaching methods and their real conditions. Although the effective classes are in the order of disability experience class (52%), audio-visual class (31%), discussion class (15%), lecture-style class (1%), and survey report class (1%), most of the education for the disabled that takes place at school sites are focused on audio-visual class (50%) and lecture-style class (22%).

Table 1. Opinions of experts on education methods to improve awareness of people with disabilities

	Expert's opinion	Remarks
Methods of Education to Improve Awareness of Persons with Disabilities	Reflect in textbooks and implement in subject classes	
	Utilize extracurricular time such as creative experience activities and make separate programs	Practicing time
	Regular and continuous implementation	
	Practice designing programs, games, materials, etc.	
	Use of various indirect materials such as videos, photos, case materials, books, and news	Diverse and innovative teaching methods
	Using various and specialized teaching methods such as discussion class, dilemma situation method, project class, game, newspaper making, etc.	
	Reflecting the characteristics of each grade and school	
	On-the-job experience, experiences of people with disabilities	Expanding opportunities for direct contact
	Recognize the strengths, positives and great aspects of people with disabilities around us	
	Expansion of direct contact with the disabled and disabled neighbors	

Source: Lee & Kim (2013. p. 9), reconstruction.

Prior Research

Prior researches on the application of STEAM programs on the topic of improving disability awareness show that the programs affect disability acceptance attitudes, creativity, personality, communication, consideration, and interest as shown in Table 2.

Table 2. STEAM program preceding studies on disability

Researcher	Activity
Lim, S. C. (2012)	A STEAM-based project class was conducted under the theme of 'designing a product that can help people with disabilities in their real life' to confirm the effect on high school students' acceptance of disabilities.
Kwon, Y. J. (2016)	Through the 'Exhibition for the Visually Impaired Using 3D Printing' class, it was confirmed that the STEAM program had a significant effect on creativity, content convergence, and communication/personality.
Kim, H. B. et al. (2019)	By developing a middle school STEAM program with the theme of visual impairment, students' interest in science and mathematics, communication and consideration, admission to science and engineering, and interest in disabilities were increased.

According to Lim (2012), the reason why project-based learning is effective in improving students' acceptance of disabilities is because it is a class in which the learner actively participates. According to Kwon (2016), it was found that communication among students became active while using the 3D modeling program and the Padlet bulletin board. This is thought to be due to discussions and problem solving from a wide perspective due to the immediacy and openness that are characteristics of SNS. According to Kim et al. (2019), It is judged that the students were more active in the process of designing and experiencing creative products because this STEAM program is a subject that can easily feel the difficulties of the disabled through experiencing the visual impairment.

Research Methods

By carrying out a STEAM experience activity task with the theme of making and experiencing tilt-compensation spoons for the disabled, we tried to design it so that physical computing tools and 3D printing technology could be understood and to find ways to solve technological problems and to provide education on improvement of disability awareness. According to the procedure presented in the PDIE model of Kim (2012), this study was conducted in the order and content as shown in Fig. 1.

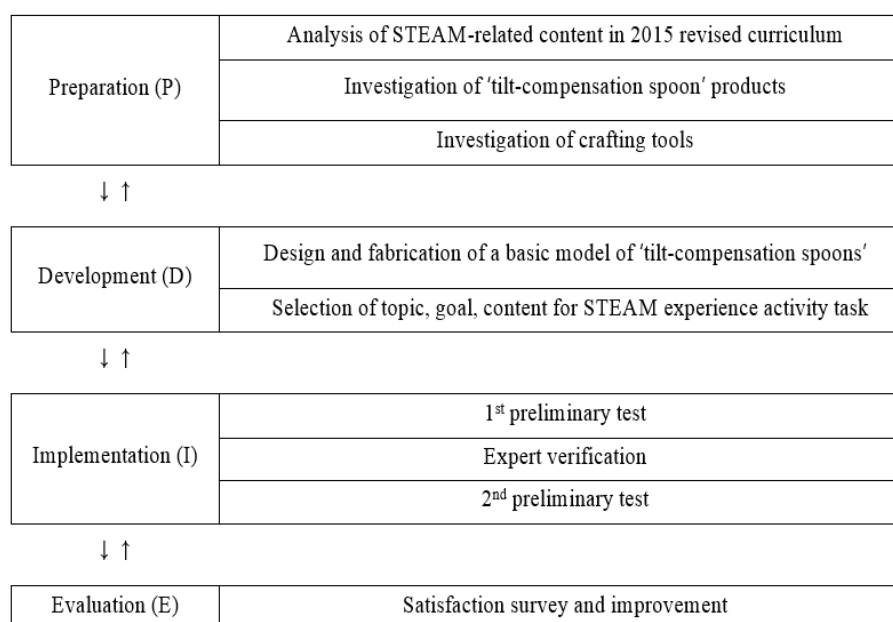


Fig. 1. Research procedure

In the preparation phase, many related subjects of 2015 revised curriculum with the topic on the disabled and the technology for them were analyzed. In order to devise a basic model of 'a tilt-compensation spoon' that can be managed at middle school student level, the 'tilt-compensation spoon for the disabled' products introduced on the market was investigated, also various manufacturing tools such as physical computing tools and sensors, actuators, and 3D printers were compared, and micro:bit (including accelerometer), servomotor, and Tinkercad (3D modeling software) as tools for composing tilt-compensation spoon models were determined.

In the development phase, the basic model of the tilt-compensation spoon was designed and fabricated, and the theme, goals, and contents for the lesson with the theme of 'making and experiencing tilt-compensation spoons for the disabled' were determined and a STEAM experience activity task was organized by including them.

In the implementation phase, two preliminary tests were conducted over October and November 2021 to improve this STEAM experience activity task, and expert verification was also conducted. First, eight 2nd-year maker club students at Y middle school in Seoul were taken into the 1st preliminary test as 8-hour course, and after checking the problems by expert verification, the teaching methods and materials were revised. 2nd preliminary test was conducted with fifty 3rd-year students as 10-hour course.

In the evaluation phase, learners' satisfaction rate with this STEAM experience activity task was surveyed. In addition to the results of expert verification, the STEAM experience activity task was revised to 14-hour course by supplementing the lesson plan, student materials (portfolios), and assessment plans.

Result

Preparation Phase

Analysis of STEAM-related Content in 2015 Revised Curriculum

Disability is a problem that can arise from congenital or acquired reasons, and is not well recognized by normal people, and at least has the perception that it is not 'my' problem. However, as the average life expectancy increases due to the development of medical technology, the number of elderly people suffering from Parkinson's disease, a neurological disease, is increasing (Min, 2020). Therefore, Parkinson's disease is a disease that can be found in many cases where someone close to us, including 'me', a normal person, can get it in the future or has already got it. If students recognize that it is not a problem experienced by people with congenital or special accidents, but a problem that anyone can experience, they will actively participate in solving the problem. Therefore, Parkinson's disease, which even normal people can get from aging, was selected as the subject of disability.

Parkinson's disease is a disease in which motions and mental functions are impaired because nerve transmission is not performed well due to nerve cell damage (Khatri et al., 2020). This makes it difficult to eat because fingers tremble and spoon shakes. To apply this to the STEAM class, a class on the subject of making a tilt-compensation device for Parkinson's patients was conceived.

The topic of disability is a topic that spans various subject areas. Therefore, it is considered desirable to apply this topic to STEAM classes.

Table 3. STEAM learning elements related to 'disability, tilt compensation device' (based on 2015 revised curriculum)

STEAM	Area	Element	Subject
S	Force and movement	Gravity, kinetic energy	Science
	Electricity	Electric circuit, electric motor	
	Energy conversion	Work, energy conversion	
T	Technology system	Manufacturing technology system (3D printing technology)	Technology
E	Usage of technology	Computing Systems and Programming	Information
		Control structure (servomotor)	Technology
		Sensor-based program implementation (coding)	
		Troubleshooting of communication technology	
A	Experience	Art and various fields	Art
	Relationship with society/community	Becoming part of a community	Ethics
	Individual and social life	Socialization, role conflict, and social groups	Social studies
M	Geometry	Properties of three-dimensional shapes	Mathematics

STEAM learning elements that can be applied to subject-convergence classes with the themes of disability and tilt-compensation devices include disability-related content, design thinking produced from the user's point of view, and science and technology content related to tilt compensation. It is also necessary to understand the principles of physical computing tools, accelerometer, servomotors, and 3D printing technology. In addition, as disability-related contents, education for improving the system and social awareness for the disabled or socially underprivileged should be included. Table 3 summarizes these learning elements.

Investigation of Tilt-compensation Spoon Products

Patients with Parkinson's disease have great difficulty holding and using tools with their hands due to hand tremor. There are many studies to control hand tremors in patients with Parkinson's disease, and efforts to make tools are also active, because it can be of great help to patients' lives (Ayana et al., 2019).

Stepoon in Fig. 2 is a tilt-compensation spoon that won the grand prize at 2015 social venture contest. A gyroscope sensor that recognizes the tilt of the spoon is installed, and a small motor is installed to keep the spoon horizontal without shaking (HANKOOKILBO, 2015). The Liftware Level product is a spoon used by cerebral palsy, spinal cord injury, and stroke patients, which remains horizontal without being affected by the direction and tilt of the hand, as shown in Fig. 3. The control circuit and accelerometer sense the change in hand movement, and two servomotors inside the handle keep the spoon horizontal.

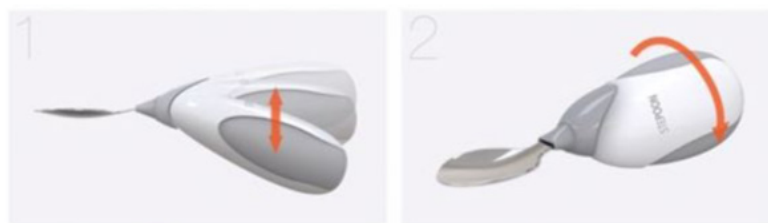


Fig. 2. Stepoon

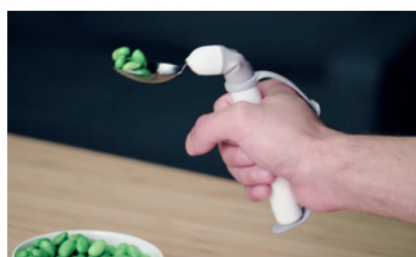


Fig. 3. Product of Liftware Level

Both products have a structure, which the control circuit and accelerometer built into the handle, detect the tilt of the handle and operate the servomotor in the reverse direction to compensate the tilt of the spoon and keep horizontal.

Investigation of Crafting Tools

Popular physical computing tools include arduino, spike prime, and micro:bit. The strengths and weaknesses of them are shown in Table 4. In this study, the micro:bit was selected as a control unit because of block coding and various compatible sensors and servomotors.

Among various 3D-CAD (3D modeling) softwares, Tinkercad can be run on the Internet (<https://www.tinkercad.com>) without installation and payment, and we can easily make a desired shape by combining various three-dimensional shapes supplied by Tinkercad. It is less difficult for students to learn and use it. Above all, the 3D shape of micro:bit is in the library of Tinkercad and it is convenient to design something with the micro:bit. Therefore, in this study, it was decided to use Tinkercad as the 3D-CAD software for 3D modeling.

Table 4. Physical computing tools

Tool	Strength	Weakness
Arduino	- Various compatible sensors and servomotors - Low price compared to competing products	- Text-based coding - Output device, sensor cost - Complicated sensor and servomotor connection
Spike Prime	- Various shapes can be assembled with Lego block type - Block coding possible - Easy to connect sensors and servomotors	- High price compared to competing products - Lack of compatible sensors, servomotors - Detailed motion, small production difficulty
Micro:bit	- Various compatible sensors and servomotors - Output value can be checked - Block coding possible	- Internet-based coding

Development Phase

Basic Model Design for ‘Tilt-compensation Spoon’ and Making It

The accelerometer built into the micro:bit measures the inclination angle of the micro:bit board. External 4.5V or higher power is required to operate the servomotor. As shown in Fig. 4, an external power supply is connected to the servomotor by using an expansion board for micro:bit. Block coding has the role to control the spoon part to be horizontal by operating the servomotor to compensate inclination of the micro:bit with the accelerometer. An example of block coding for this is shown in Fig. 5.

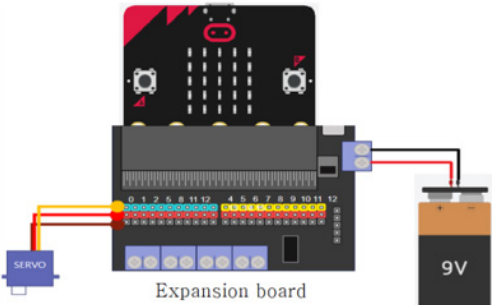


Fig. 4. Servomotor using micro:bit expansion board (9V power connection)

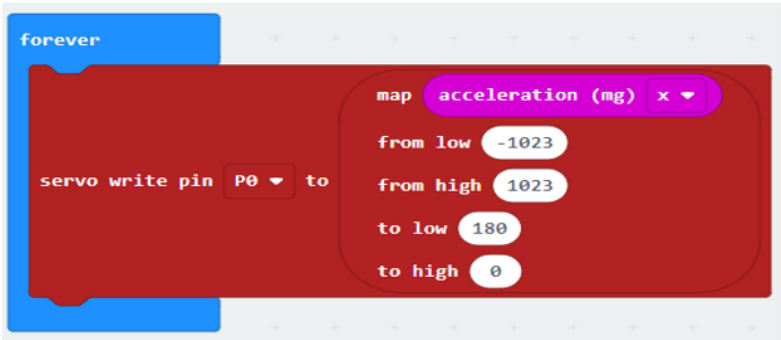


Fig. 5. Block coding for tilt compensation

A case for external appearance, that contains a micro:bit, an expansion board, a 9V battery, and a servomotor, was modeled by Tinkercad. Fig. 6 is a 3D model of the tilt-compensation spoon. The spoon part was modeled separately.

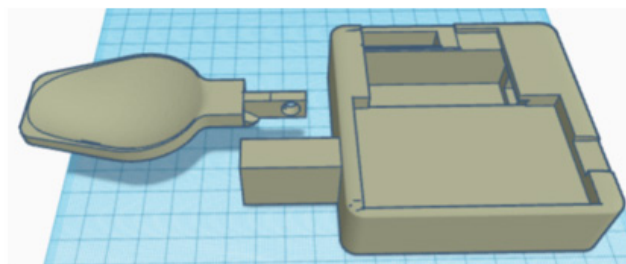


Fig. 6. A tilt-compensation spoon model designed with Tinkercad

Fig. 7 is the basic model for a tilt-compensation spoon for the disabled. The X-axis of the micro:bit-built accelerometer in the handle shows 0, +, - values, when handle is in a horizontal, + direction inclination, and – direction inclination states, respectively. In Fig. 5, ‘-1,023 ~ +1,023’, which are the detection values of the X-axis of the accelerometer, correspond to ‘0~180°’, which are the operating range of the servomotor. When the handle is tilted, the servomotor operates to the reverse direction of the accelerometer detection value to keep the spoon horizontal.



Fig. 7. Tilt-compensation test on the x-axis of the ‘Tilt-Compensation Spoon’ model

Selection of Topic, Goal, Content for STEAM Experience Activity Task

Based on the results obtained in the preparation phase and the tilt-compensation spoon model, the activity topics of the STEAM experience activity task were determined as shown in Table 5. Based on the achievement criteria of 2015 revised curriculum, the goals of the STEAM experience activity task with the theme of ‘making and experiencing tilt-compensation spoons for the disabled’ were determined as shown in Table 6. The course content and the course plan were configured for the STEAM experience activity task which has the length of 8 hours.

Table 5. Topics for each area of STEAM experience activities

Subject	Topic
Science	Understanding and using electric circuits and motors
Technology	Understanding and using 3D printing technology
Engineering	Understanding and using physical computing tools
Art (Ethics)	Understanding the socially underprivileged

Table 6. Goal of STEAM experience activity task

Goal	
Understanding the inconveniences in the life of the disabled, and integrating knowledge of science, technology, engineering, art, and mathematics to design, manufacture, and experience using 'tilt-compensation spoons for the disabled' to improve awareness of the disabled and to improve interest and understanding on physical computing tools and 3D printing technology.	
Science	One can explain the working principle of electric circuits and electric motors.
Technology	One can design the shape one wants with 3D modeling software, and one can print out the designed parts using a 3D printer.
Engineering	A physical computing system using the micro:bit can be configured.
Art (Ethics)	Know the meaning of the socially underprivileged and think about problems in our society from the perspective of the socially underprivileged.

Implementation Phase

1st Preliminary Test

From October 4th to 7th, 2021, eight 2nd-grade students of maker club at Seoul Y middle school participated in 1st preliminary test with an 8-hour STEAM experience activity task. For 4 days, this test has been practiced for 2 hours daily. These eight students have experienced arduino as a physical computing tool but not micro:bit before joining this preliminary test. They also experienced Tinkercad for 3D modeling in a technology class in 1st year. The class proceeded in the following order. "Understanding the socially underprivileged and Parkinson's disease → Understanding physical computing tools and micro:bit → Utilizing micro:bit built-in accelerometer → Utilizing expansion board and servomotor → 3D modeling using Tinkercad → Model printing → Assembling and testing → Evaluation". Each group modified the shape of the handle in the basic model(Tinkercad file) provided by the teacher. One group used two servomotors to configure a spoon that compensates the inclinations of the x and y axes at the same time. Students' opinions from 1st preliminary examination are as follows. "It is not necessary to follow the fabrication ways suggested by the teacher. Homepages are necessary for portfolio recording."

Expert Verification

On October 9 and 10, 2021, ten technology teachers with more than 10 years of experience or master degree in technology education, that they also have a experience on physical computing tools and 3D printing technology, participated in the verification of this STEAM experience activity task. The questionnaire for the verification consists of 6 items in the areas of goal, interest, understanding, and relevance. The average score in goal, interest, and understanding is 4.8 point, and average score in relevance is 4.33 point. The average score for all areas is 4.65 point.

Table 7. Expert verification results on STEAM experience activity task

Area	Number	Question	M	SD
Goal	1	Class materials are structured appropriately for class objectives.	4.8	0.40
Interest	2	Instructional materials are structured to arouse learners' interest.	4.8	0.40
Understanding	3	Class materials help learners understand physical computing tools and 3D printing technology.	4.8	0.40
Relevance	4	Class materials are organized in appropriate quantities.	4.5	0.40
	5	The content of the instructional materials is appropriate for the learner's level.	4.3	0.64
	6	The tools and materials used in class activities are appropriate and easy to apply.	4.2	0.87
※ N=10, relevance M (Avg.) 4.33, All area M (Avg.) 4.65				

The opinions of the survey are as follows. “Combining disability topics with STEAM education are good attempt. Using various examples, it is necessary to notify the socially underprivileged and introduce various disability goods. It is expected that the time to print parts with a 3D printer is not enough. It would be nice to share the spoon modeling file(STL format) supplied by the teacher in online so that students can easily and quickly refer to and modify the spoon modeling file. When making homepages for each group, it would be good if the teacher's homepage is released as a platform so that other groups' homepages refer it.”

2nd Preliminary Test

Reflecting the opinions from the 1st preliminary test and expert verification, the STEAM experience activity task was modified to a 10-hour course. As shown in Table 8, as each stage of STEAM education, the 2-hour 1st session, 4-hour 2nd session, and 4-hour 3rd session were designated as presenting situation, creatively designing, and emotional experience sessions, respectively. The 2nd preliminary test was conducted from October 11, 2021 to November 2. Due to COVID-19, 1st session was conducted as a non-face-to-face class, and other sessions were conducted as face-to-face classes.

Table 8. Configuration of 2nd preliminary test (10-hour course)

Session	Time	Style	Topic
1 Presenting situation	1	Non-face-to-face class	Understanding the socially underprivileged and Parkinson's disease
	2		Forming a group, making a homepage for each group
2 Creatively designing	3	Face-to-face class	Understanding physical computing tools and the micro:bit
	4		Utilizing micro:bit accelerometer
	5		Utilizing expansion board and servomotor
	6		3D modeling using Tinkercad
3 Emotional experience	7		Ideation
	8		3D modeling and printing
	9		Assembling and testing
	10		Discussing and comment

Presenting Situation

The 1st time is the class with the topic of ‘understanding the socially underprivileged and Parkinson’s disease’ and it corresponds to STEAM’s arts area. A lecture and discussion were given to students by using the teaching materials extracted from ethics textbooks. Teachers showed instructional materials and video materials related to disabilities. And then students investigated and presented Parkinson's disease related to hand-shaking to all students.

The 2nd time is the class with the topic of ‘compositing group and making group homepage’, Padlet (<https://ko.padlet.com/>) was used to form a group by receiving students' opinions. Every group made their homepages by discussing and co-working with each other in the ZOOM small meeting room.

Creatively Designing

The 3rd time is the class with the topic on ‘physical computing tools and micro:bit understanding’, and the practice corresponding to engineering area(information) in STEAM was conducted as a non-face-to-face class. Students participated in the teacher's class remotely and coded hex-files in the micro:bit editor, and checked whether the micro:bit was working properly in a simulator.

The 4th to 6th times are the classes with the topic on 'use of accelerometer for micro:bit, use of expansion board and servomotor, and 3D modeling using Tinkercad' as shown in Fig. 8. These times correspond to STEAM's technology area. It was conducted as a face-to-face practice class.



Fig. 8. Class activity in 4~6 times

Emotional Experience

In the 7th time is the class with the topic of 'creating ideas for solving problems. Each group tries to obtain design ideas for the tilt-compensation spoon model and records the design ideas on each group's homepage. In the 8th time, each group modeled the case for external appearance and printed it with a 3D printer as shown in Fig. 9. In the 9th time, the micro:bit, expansion board, servomotor, and battery are connected and assembled into the case, and the tilt-compensation performance of the spoon is tested after downloading the coding to the micro:bit. The students modify the coding several times and checked the calibration performance when the tilt-compensation of the spoon did not work well. In the 10th time, students upload the production process on the homepage for their groups. A group students who participated in the presentation class operate other group's spoons and evaluate the function and design, and then gave advises.

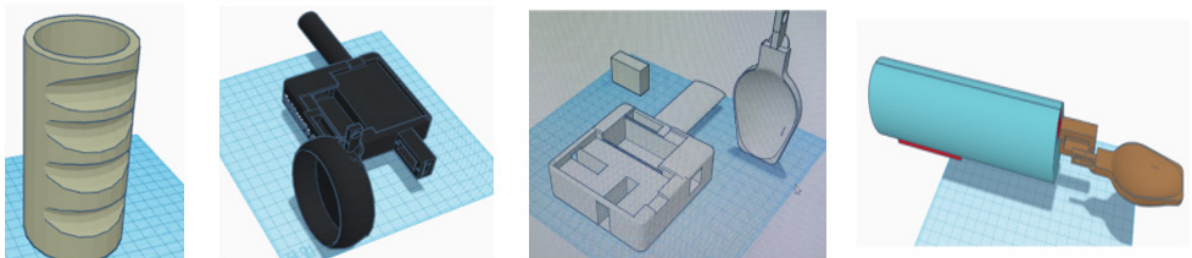


Fig. 9. Examples of 3D modeling results for each group

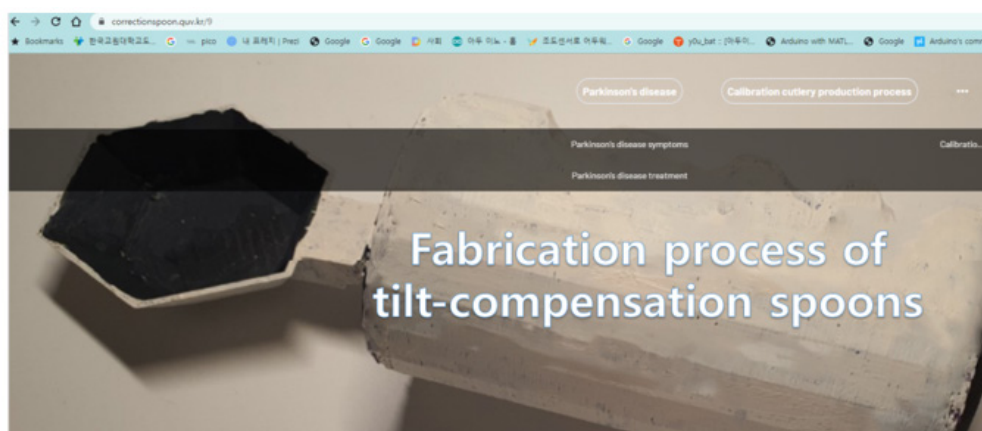


Fig. 10. A homepage example

Evaluation Phase

Student Satisfaction Survey

A satisfaction survey was conducted by 3rd-year students who participated in the 2nd preliminary test of the STEAM experience activity task on the subject of making and experiencing tilt-compensation spoons for the disabled. Fifty students responded. These students had an experience on Tinkercad but not micro:bit. In Table 9 for questionnaire, No. 1 to 4 are about interest. No. 5 to 7 are about understanding. No. 8 to 15 are about relevance. No. 1, 5, 8, 12 are about class materials. No. 2, 7, 9, 13 are about 3D printing. No. 3, 6, 10, 14 are about physical computing tools. No. 4, 11, 15 are about prototyping. It was investigated on a 5-point Likert scale.

According to Table 9, the average score of interest is 4.29 point, the average score of understanding is 4.35 point, and the average score of relevance is 3.99 point. Grouping by class content, the average score of class materials is 4.22 point, the average score of 3D printing is 4.11 point, the average score of physical computing tools is 4.34 point, and the average score of prototyping is 3.83 point. The overall average score of the satisfaction survey is 4.14 point, and the survey opinions are summarized as follows.

First, most of students answered that they were interested in the class materials and were able to understand the difficulties of the disabled and patients with Parkinson's disease thanks for the class materials. However, the score on class materials is relatively low as 3.62 point.

Second, most of students were interested in physical computing tools and 3D printing technology, and answered that the level was appropriate.

Third, they responded that they had a interest in prototyping and enhanced their understanding of disabilities through this STEAM experience activity task. They answered that spoon making time had appropriate length. But some students responded that the time to manufacture parts and assemble them was not enough.

From this STEAM experience activity task on the theme of 'making and experiencing tilt-compensation spoons for the disabled', Most of students answered positively on improvement of awareness of the disabled, increase of self-efficacy to use knowledge to help someone. They answered that it was important to communicate and share through collaboration rather than competition, They also answered positively to the understanding of 3D printing technology and physical computing tools.

Table 9. Class satisfaction results of STEAM experience activity task

Area	Number	Question	M	SD
Interest	1	The class material was interesting.	4.2	0.80
	2	The process of making parts using a 3D printer was interesting.	4.48	0.70
	3	The process of making prototypes using a micro:bit board and a servomotor was interesting.	4.14	0.82
Understanding	4	The process of making the tilt-compensation spoon was interesting.	4.32	0.86
	5	The class materials helped us understand the difficulties of patients with Parkinson's disease.	4.86	0.40
	6	The use of micro:bit and servomotor helped us understand physical computing tools.	4.16	0.78
	7	Making supplies for patients with Parkinson's disease helped to understand 3D printing technology.	4.02	0.84
Relevance	Time	8 The class time using the class materials was appropriate.	3.62	1.02
		9 The time was enough for 3D modeling.	3.22	0.90
		10 The time was enough for micro:bit coding.	4.38	0.66
		11 The time was enough for prototyping.	3.24	0.79
	Level	12 There was no difficulty in understanding the class material.	4.18	0.74
		13 There was no difficulty in using 3D modeling software.	4.70	0.46
		14 There was no difficulty in micro:bit coding.	4.66	0.47
	Tool	15 I guess, I can make the product. if I want with appropriate materials and tools.	3.94	1.01
	All area Avg. 4.14			

Improvement of STEAM Experience Activity Task

Based on the opinions disclosed in the expert verification and student satisfaction survey, this STEAM experience activity task was modified with a 14-hour course. the details were also changed.

In the 1st time of 1st session, 'understanding the socially underprivileged and Parkinson's disease' was changed to 'techniques for the socially underprivileged and the technology for them, Parkinson's disease and tilt-compensation spoons'. As the result, 1 hour was added to the 1st session. In the 8th time of 3rd session, which was referred not to be enough time, '3D modeling and printing' was changed to 'model design and modeling file conversion to G-code and printing'. In the 14th time of 3rd session, new jobs such as 'making exhibition pamphlets and displaying works to show other teachers and students' were included. As the result, 3 hours were also added to the 3rd session.

Reflecting the suggested opinions, the teaching-learning course plan was improved as shown in Table 10.

Table 10. Teaching-learning course plan

Related section	[Ethics 1] III. Relationship with society/community, 1-2. How to treat the socially underprivileged? [Technology·Home-economics 1] IV. Technology and invention, 2-1. Technological problem solving and invention [Information] IV. Computing system, 2-2. Physical computing programming		
Achievement Criteria	[9Ethics 03-01] ① Understand that human dignity, human rights, and gender equality are universal values in a moral context, and can sympathize with and consider all human beings as beings with human rights from a universal perspective by controlling social prejudice against others. ② How to treat the socially underprivileged? [9Technology·Home-economics05-06] Find problems in life, come up with ideas, and creatively solve them using divergent and convergent thinking techniques. [9Information 05-02] Implement data processing and motion control programs using sensors.		
Session	Time	Activity	Related subject
1 Presenting situation	1	Socially underprivileged and Technology for them	Social studies, technology
	2	Parkinson's disease and a tilt-compensation spoon	Social studies, technology
	3	Forming groups and making a homepage for each group	Technology
2 Creatively designing	4	Understanding physical computing tools and the micro:bit	Information
	5	Utilizing micro:bit accelerometer	Information
	6	Utilizing expansion board and servomotor	Information
	7	3D modeling using Tinkercad	Technology
3 Emotional experience	8	Ideation	Technology
	9	Model design	Technology
	10	G-code conversion of modeling file and printing	Technology
	11	Making of a tilt-compensation spoon	Technology, Information
	12	Operation test of the tilt-compensation spoon	Technology, Information
	13	Evaluation (mutual evaluation by group, self and peer evaluation)	Technology
	14	Sharing (making pamphlets for exhibition)	Technology

Discussion

First, since STEAM education deals with problems in the real world and takes the form of convergence of multiple disciplines, it is important to select a subject that can be naturally connected with the content elements of each discipline. Moving away from the focus on simple making and using, which has been pointed out as a limitation of math, science, and technology-centered STEAM learning programs (Ju et al., 2022), by combining the topics of ICT use and disability awareness with Parkinson's disease. Breaking away from the subject bias of the previous study (Lim, 2012), which bundled disability awareness experience education with subjects with high relevance, such as social studies and special education, it appropriately linked subject areas that could be somewhat heterogeneous to develop technology, engineering, social studies, and ethics. Since the class can be conducted in the form of subject-convergence class, it is expected that the degree of immersion will be improved compared to when the subject is taught individually. According to the results of the satisfaction survey after class, it is possible to expect improvement in learning interest and understanding, and equipment use capability.

Second, by combining the classes, which are divided into face-to-face classes centered on group activities and non-face-to-face classes focused on individual learning, with stages such as situation presentation, creative design, and emotional experience according to the STEAM learning criteria (Son et al., 2019), Attempts from the methodological aspect were presented.

Third, physical computing tools and 3D printing technology, which are used in information communication and manufacturing technology areas of technology subjects, were put into the 'creative design' stage, one of the stages of STEAM. By doing this, the original purpose of technology classes using advanced equipment was emphasized.

Forth, the whole process was organically connected by presenting appropriate situations to understand the situation of Parkinson's patients with hand tremor, designing and manufacturing tilt-compensation spoons for the patient, and then composing the process of experiencing it from the patient's point of view. This is thought to be the factor that made the overall understanding and interest scores for the class come out high.

Conclusion

The purpose of this study is to develop a STEAM experience activity task with the theme of 'making and experiencing tilt-compensation spoons for the disabled' using 3D printing technology and physical computing tools. The results can be summarized as follows.

First, focusing on disability and tilt-compensation devices, 2015 revised curriculum was analyzed to search STEAM-oriented subjects. Existing commercial products and physical computing tools were also investigated to enable middle school students to apply to the tilt-compensation spoon for the disabled and design it simply. micro:bit with a built-in accelerometer that can apply block coding was selected as a physical computing tool in this study, and a tilt-compensation spoon model was designed and made using Tinkercad software, a 3D printer, and a servomotor.

Second, this STEAM experience activity task was formed to enhance disability awareness improvement education, physical computing, and 3D printing technology capabilities by converging the knowledge required for the making process of the tilt-compensation spoon with knowledge extracted from multiple subjects. It consists of 14-hour course and includes the teaching-learning process plan, class materials, and student materials.

Third, the goal, interest, understanding, relevance, and validity of the content and composition of the class material for the STEAM experience activity task were confirmed again by expert opinions and the student satisfaction survey. Freely dictated opinions were also obtained and reflected in the improvement of the task.

Judging from the results of the preliminary test and expert verification of the STEAM experience activity task on the subject of 'making and experiencing tilt-correcting spoons for the disabled', the awareness improvement of the disabled, self-efficacy that knowledge can be used to help others, communication through collaboration and sharing, 3D modeling, and understanding of physical computing tools received positive responses. It is expected that it can be applied to subject convergence classes across social, engineering, and technology areas, such as improving awareness of people with disabilities and increasing understanding and utilization of various tools.

Suggestion

Based on the results of this study, suggestions are as follows.

First, it is necessary to verify the effectiveness such as improving awareness of people with disabilities, improving creativity, and fostering convergence talents by this STEAM experience activity task.

Second, in order to expand disability awareness improvement education in technology education, the effort, that disability awareness improvement education can be carried out in regular subjects by linking with existing areas such as information and communication technology and manufacturing technology in technology education, are necessary.

Acknowledgement

This article was revised and summarized by using Young Chun Jung's 2022 master's thesis.

References

- Ayana, E. K., Yasar, C. F., & Engin, S. N. (2019). Studies on a robotic device that minimizes end-point vibrations for Parkinson tremor. *Procedia Computer Science* 158, 338-345.
- Baek, Y. S., Park, H. J., Kim, Y. M., Noh, S. G., Lee, J. Y., Jeong, J. S., & Choi, J. H. (2012). A Study on the Action Plans for STEAM Education. Seoul: Korea Foundation for the Advancement Science & Creativity.
- Choi, W. S. (2018). The legislation, revision progress and plan for legal improvement to the education system for the promotion of disability awareness – Focusing on ‘the disabled welfare act’ –. *Studies of Social Security Law*, 34, 237-269.
- HANKOOKILBO (2015, November 9). Undergraduates invent a hand-shake spoon 'for grandmothers'. Retrived from <https://m.hankookilbo.com/News/Read/201511091681094931>.
- Ju, H., Park, H., Jung, E. Y., & Paik, S. (2022). Proposal for a STEAM education program for creativity exploring the roofline of a hanok using GeoGebra and 4Dframe. *Thinking Skills and Creativity*, 45, 1-15.
- Khatri, D. K., Choudhary, M., Sood, A., & Singh, B. (2020). Anxiety: An ignored aspect of Parkinson's disease lacking attention. *Biomedicine & Pharmacotherapy*, 131, 1-13.
- Kim, H. B., Hwang, U. W., Lim, Y. J., Hwang, H. J., & Cha, J. H. (2019). Development and application of middle school STEAM program about visual impairment. *Journal of Special Education & Rehabilitation Science*, 58, 139-161.
- Kim, J. O. (2018). Development of An Instructional Model for Maker-based STEAM Education (Unpublished Doctoral Dissertation). Korea National University of Education, Chungbuk, Republic of Korea.
- Kim, J. S. (2012). Education Theory of STEAM. Paju: Yangseowon.
- Kwon, Y. J. (2016). A Study on the Development of STEAM Program Based on Arts by Using 3D Printing (Unpublished Master's Thesis). Seoul National University of Education, Seoul, Republic of Korea.
- Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts Into STEM. *Procedia Computer Science*, 20, 547-552.
- Lee, D. S., & Kim, S. Y. (2013). What are special education professionals' opinions on the contents and directions of disability awareness programs? *The Journal of Education*, 33, 113-136.
- Lim, S. C. (2012). The Effects on Changing Attitudes Toward Student with Disabilities by Project Based Learning in Specialized High School Class. - STEAM-centered Education (Unpublished Master's Thesis). Dankook University, Chungnam, Republic of Korea.
- Madhesh, A. (2022). Awareness of disability among saudi university graduates. *Heliyon*, 8, 1-15.
- Min, I. (2020). The Study of Development, Implementation and Effectiveness of Lifelong Education G.P Laughter Therapy Program to Improve the Quality of Life of Parkinson's Patients (Unpublished Doctoral Dissertation). Westminster Graduate School of Theory, Gyeonggi-do, Republic of Korea.
- Ministry of Education (2015). General Summary of Elementary and Secondary School Curriculum. Sejong:

Ministry of Education.

Ministry of Government Legislation (2021. December 21) Welfare Act for persons with disabilities 25. Retrived from <https://www.law.go.kr/LSW/lsSc.do?dt=20201211&subMenuId=15&menuId=1&query=%EC%9E%A5%EC%95%A0%EC%9D%B8%EB%B3%B5%EC%A7%80%EB%B2%95#undefined>.

Ministry of Health and Welfare (2021). 2021 Disability Awareness Improvement Training Guide. Sejong: Ministry of Health and Welfare.

Nopparat, N., & Motte, D. (2022). The influence of business model on the development of 3D food printing technology for dysphagia patients in elderly care. *Materials Today: Proceedings*, 70, 242-247.

Woo, J. H, Kim, Y. G., & Lee, C. S. (2008). A comparative study of elementary and secondary school teachers' realities, perception and demand on education about understanding disabilities. *Journal of Special Education: Theory and Practice*, 9, 359-386.

Yakman, G. (2008). STEAM Education: an overview of creating a model of integrative education. Paper Presented at the Proceeding of PATT on 9th ITEEA conference.

Yang, Y. S. (2008). The Effects of Teaching the Background about the Inventions for Disabilities on Changing Children's Attitude Toward their Friends with Disabilities (Unpublished Master's Thesis). Dankook University, Chungnam, Republic of Korea.

Authors Information

Jung, Young Chun: Seoul Yongmoon Middle School, Teacher, First Author

Lee, Kyung Taek: Korea National University of Education, Professor, Corresponding Author