Fourth, we developed a questionnaire to analyse the problems in the physical computing education that informatics teachers perceive. Finally, the results of the questionnaire were analysed in terms of educational perception of physical computing, the degree of usability of physical computing tools, the degree of connectivity of physical computing tools, configurability of circuits and lessons, and debuggability.

F. Development of Survey Tools

Based on the results of the keyword classification in Table 5, the development of the questionnaire tool was conducted by developing items corresponding to the keywords. We developed the items that correspond to keywords such as tool selection, input / output device, circuit configuration, system configuration, language selection, and control programming. The developed questionnaire consisted of 25 items in terms of basic information, recognition, hardware, and programming. To analyze the questionnaire contents, we divided the hardware and programming related items into four parts: usable degree, connectable degree, configurable degree, and debuggable degree. The composition of the reclassified questionnaire is set forth in Table 6.

TABLE VI
DEVELOPMENT OF SURVEY TOOLS

	Contents	**Contents Number**	
		in-service teacher	**pre-service teacher**
Basic Information	gender	1	1
	school type	2	-
	ages	3	2
	final education	4	3
	education/training experience	7	5
	work/teaching experience	5	8, 9
Recognition	the degree of knowing	6	4
	why do you want to be educated?	8	6
	why do you not want to be educated?	9	7
	priority of education	23	
	the need for education	24	
	effect of education	25	
Usable Degree	physical computing board usability	10	
	classification and usability of physical computing devices	12	
	breadboard availability	14, 15	
	the degree to which the physical computing programming environment can be used	17	
	arduino IDE operation control function usability degree	21	
Connectable Degree	the degree to which you can connect with the Arduino board from the Arduino IDE	13	
	the degree to which the S4A and the physical computing board can be connected	19	
	entry and physical computing board connectivity	20	
Configurable Degree	choosing the board, you want to use in your class and why	11	
	ability to read, write, and modify schematics	16	
	choosing the programming language, you want to use in your class and why	18	
Debuggable Degree	error checking and fixing	22	

III. RESULTS AND DISCUSSION

A. Educational Recognition of Physical Computing

The educational recognition of physical computing was analysed by the questionnaire about the degree of knowing about physical computing, the reason for wanting to be educated, the reason for not being educated, priority, necessity, and effect.

The results are as follows. First, 87.5% of the in-service and pre-service informatics teachers said they know about physical computing. 87.5% of in-service teachers and 57.1% of the pre-service teachers responded that they had to attend the physical computing education. 83.3% of in-service teachers responded that they did not have time because of lack of physical computing education, and 50% of pre-service teachers answered that they could not find appropriate courses. Second, 100% of the in-service teachers and 93.8% of the pre-service teachers answered that they need physical computing education. For reasons of necessity, 62.5% of the in-service teachers and 25% of the pre-service teachers answered that it is helpful to the program education. 37.5% of the in-service teachers and 27.5% of the pre-service teachers were found to help improve creativity.

B. Problems in Physical Computing Education

The problems in the education of physical computing were analysed by classifying the questionnaires conducted by the in-service and pre-service teachers of secondary school into the usability, connectivity, configurability, and debuggability. The overall results of the problem analysis are set forth in Table 7

TABLE VII
PROBLEMS OF PHYSICAL COMPUTING EDUCATION

UNIT: M(SD)

	Contents	**In-service teacher**	**Pre-service teacher**
Usable Degree	Physical Computing Board	2.59(0.61)	2.32(0.67)
	Input/Output Device	3.38(0.21)	3.77(0.32)
	Breadboard	2.78(0.73)	3.00(0.89)
	Programming Language	3.13(0.23)	3.25(0.29)
	Arduino IDE Control Fuction	2.91(0.29)	3.25(0.10)
Connectable Degree	Arduino	3.40(0.19)	3.98(0.20)
	S4A	2.38(1.06)	2.94(1.44)
	Entry	2.62(1.19)	2.19(1.33)
Configurable Degree	Circuit Design	3.09(0.32)	3.23(0.28)
	Board Selection	Arduino Board	
	Programming Language Selection	Block-based	Block-based, Text-based
Debuggable Degree	Debugging	3.13(1.25)	3.88(0.81)

The usable degree is the usability of board, I/O device, breadboard, programming language, and Arduino IDE operation control function. The connectable degree is enough to connect the Arduino board to the PC, the degree to which the S4A and the Arduino board can be connected, and the connection between the entry board and the board. The configurable degree is the degree of configurability of the circuit diagram creation, modification, circuit diagram implementation, and the choice of the tools used in the class. The debuggable degree is about whether a programming error can be detected and corrected. The responses to the questionnaires were as follows: 'not at all (1)', 'not (2)', 'normal (3)', 'can do (4)', Likert 5 point scale and Likert 4 point scale of 'not at all (1)', 'not (2)', 'can do (3)' and 'can do well (4)' And the results of the analysis were unified to the Likert 5 point scale.

IV. CONCLUSIONS

The concept of 'physical computing' has been added to the 2015 revised informatics curriculum, and physical computing education will be conducted in 'informatics' of secondary schools from 2018. The purpose of this study is to present the implications for effective programming education by analysing the problems in the physical computing education that the in-service and pre-service informatics teachers are aware.

The results of the study are summarized as follows.

- First, in recognition, the necessity and effect of physical computing education are recognized, but the problem is the time to receive education and the lack of proper education program.
- Second, in terms of usability level, the degree of usability of hardware tools and programming environment was asked with Likert 5 point scale. As a result, it was analysed that the average of the in-service and pre-service informatics teachers was insufficient to carry out the class with 3 point scale.
- Third, in terms of connectability, we asked the degree of connection between the programming environment and the physical computing board with a Likert 5 point scale. As a result, it was analysed that the average of the in-service and pre-service informatics teachers was not enough to carry out the less than 3 or 3 point scale.
- Fourth, in terms of configurability, we asked the degree of likelihood of creating and modifying a schematic to implement physical computing with a Likert scale of 5 points. As a result, it was analysed that the average of the in-service and pre-service informatics teachers was insufficient to carry out the class at the early stage of 3 points. For both in-service and pre-service informatics, teachers prefer the Arduino board for the choice of boards, while in-service teachers prefer block-based programming languages, while pre-service teachers prefer both block-based and text-based programming languages Respectively.
- Fifth, the average of pre-service teachers was higher than that of in-service teachers in terms of debugging ability. Because the block-based programming

environment does not show error messages, the debugging average of in-service teachers preferring block-based is lower than the pre-service teacher. However, it was analysed that the average of the pre-service teachers is 4 points or less, which is insufficient to carry out the class.

Based on the results of this study, we will reconsider the education of physical computing in the following four aspects.

- First, various training programs for teachers should be organized. In order to facilitate the education of physical computing, teachers should be able to recognize the contents of physical computing contents and communicate them to students.
- Second, an instructional design that can improve thinking ability should be supported. It is necessary to be able to apply real-life examples to lessons by simply avoiding the lessons of the following formula. Students should be able to select topics that can interest and motivate them, and be able to choose appropriate physical computing tools for the topic.
- Third, we need to consider the linkage and sequence of physical computing education. Elementary, middle, and high schools should have a spiral curriculum to ensure that the elementary, middle, and high school education is linked.
- Fourth, debugging ability should be improved. Informatics brings creativity through various thinking. Because there are various solutions according to recognition even with the same problem, the verification and implementation of the algorithm is a process of constant thinking. Physical computing can visualize actual programming results and enhance debugging capabilities. There is a need for research on physical computing education in a text-based programming environment that outputs error messages.

This study has implications for the effective programming education by analysing the problems in the physical computing education recognized by in-service and pre-service informatics teachers. More research is needed to find out more informatics teachers are involved in.

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