Literature Review

Project-based learning (PBL) is a teaching method that arranges learning by doing projects. Projects are works that takes many steps, which causing difficult questions or problems, that make participants do design, problem-solving, decision making, or investigative activities. This teaching methodology suggests participants the chance to work comparatively separately over long time, and finishes in authentic results or presentations (Jones, Rasmussen, & Moffitt, 1997). PBL is the one of the teaching methodologies, and PBL is known that it has advantages but few disadvantages. PBL leads to a deep understanding of students' subjects with direct participation and strengthens the supportive learning community with productive educational zeal (Eckardt, Craig, & Kraemer, 2020). Since PBL is an effective method for gaining deep understanding and participations about the subject, PBL can be a good choice when people want to develop their useful skills. Among the existing skills, computational thinking skill(CTS) is argued as "the mental skills and practices for designing computations that get computers to do jobs for us, and explaining and interpreting the world as a complex of information processes" by Peter and Matti (2019). Also, ISTE (2015) divided the factors of CTS into creativity, algorithmic thinking, critical thinking, problem solving, cooperative thinking and communication skills.

To develop computational thinking skill (CTS) by participating project-based learning (PBL),

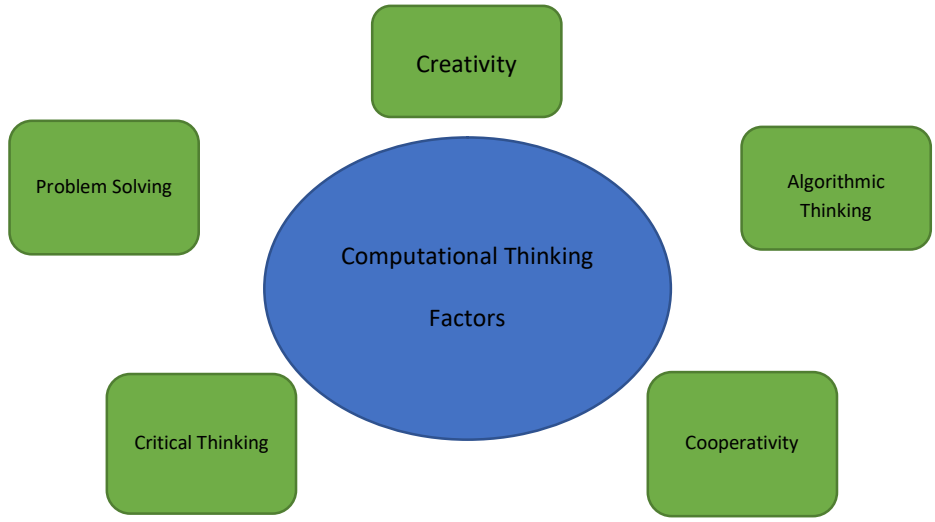


Figure 1. Computational Thinking Factors (according to ISTE, 2015).

project toolkits are required. According to Arduino, Arduino is "an open-source electronics platform based on easy-to-use hardware and software" (Arduino, 2020). Their features are

inexpensive, cross-platform, simple and clear programming environment, and open source and extensible software and hardware. For another toolkit, according to Raspberry Pi, Raspberry Pi is a cheap credit card-sized computer designed to teach young people programs (Raspberry Pi, 2015). Their features are inexpensive cost, compact size, portability, programmability, and connectability.

Table 1. Features of two toolkits

Name	Features				
Arduino	Inexpensive Cost	Cross-Platform	Simple, Clear Programming Environment	Open source, extensible software	Open source, extensible hardware
Raspberry Pi	Inexpensive Cost	Compact Size	Portability	Programmability	Connectability

Through all, this study focuses on computational thinking skills development in a "project-based course where student use either Raspberry Pi or Arduino".

Research Questions

How a project-based course can contribute to university freshmen's computational thinking skills?

Hypothesis

1st Null Hypothesis	There is no difference in gender in learning the computational thinking skills.
1st Alternative Hypothesis	There is a difference in gender in learning the computational thinking skills.
2nd Null Hypothesis	There is no difference in toolkits in learning the computational thinking skills.
2nd Alternative Hypothesis	There is a difference in toolkits in learning the computational thinking skills.
3rd Null Hypothesis	There is no difference in nationality in learning the computational thinking skills.
3rd Alternative Hypothesis	There is a difference in nationality in learning the computational thinking skills.

Method

The methods of this study are used both quantitative and qualitative methods by surveying with questionnaire and conducting interviews. Questionnaire is used purposive sampling. Two time conducted to identify the difference of before and after of the computational thinking course. Interviews are conducted in two sessions; one is Arduino group, and another is Raspberry Pi group. Each group has at least one female, and have same gender portion, and almost same people.

Questionnaire

Korkmaz et al (2017). Have the right of this questionnaire.

* Required

Demographics

Please tell us about yourself

Gender*

Mark only one oval.

- Male
- Female

International Age* :

What toolkit are you working on?*

Mark only one oval.

- Raspberry Pi
- Arduino

After reading each questions, please rate on the scale of 1 – 5 of how much you can relate on each questions. 1: never, 2: rarely, 3: sometimes, 4: mostly, 5: always

Creativity*

Mark only one oval per row.

	1	2	3	4	5
1. I like the people who are sure of most of their decisions.					
2. I like the people who are realistic and neutral.					
3. I believe that I can solve most of the problems I face if I have sufficient amount of time and if I show effort.					
4. I have a belief that I can solve the problems possible to occur when I encounter with a new situation.					
5. I trust that I can apply the plan while making it to solve a problem of mine.					
6. Dreaming causes my most important projects to come to light.					
7. I trust my intuitions and feelings of "trueness" and "wrongness" when I approach the solution of a problem.					
8. When I encounter with a problem, I stop before proceeding to another subject and think over that problem.					

Algorithmic thinking*

Mark only one oval per row.

	1	2	3	4	5
1. I can immediately establish the equity that will give the solution of a problem.					
2. I think that I have a special interest in the mathematical processes.					

	1	2	3	4	5
3. I think that I learn better the instructions made with the help of mathematical symbols and concepts.					
4. I believe that I can easily catch the relation between the figures.					
5. I can mathematically express the solution ways of the problems I face in the daily life.					
6. I can digitize a mathematical problem expressed verbally.					

Cooperativity*

Mark only one oval per row.

	1	2	3	4	5
1. I like experiencing cooperative learning together with my group friends.					
2. In the cooperative learning, I think that I attain/will attain more successful results because I am working in a group.					
3. I like solving problems related to group project together with my friends in cooperative learning.					
4. More ideas occur in cooperative learning.					

Critical thinking*

Mark only one oval per row.

	1	2	3	4	5
1. I am good at preparing regular plans regarding the solution of the complex problems.					
2. It is fun to try to solve the complex problems.					
3. I am willing to learn challenging things.					
4. I am proud of being able to think with a great precision.					
5. I make use of a systematic method while comparing the options at my hand and while reaching a					

decision.	

Problem solving*

Mark only one oval per row.

	1	2	3	4	5
1. I have problems in the demonstration of the solution of a problem in my mind.					
2. I have problems in the issue of where and how I should use the variables such as X and Y in the solution of a problem					
3. I cannot apply the solution ways I plan respectively and gradually.					
4. I cannot produce so many options while thinking of the possible solution ways regarding a problem.					
5. I cannot develop my own ideas in the environment of cooperative learning.					
6. It tires me to try to learn something together with my group friends in cooperative learning.					

Interview Schedule

Researcher, and lead professor created this interview schedule together.

Hello,

First of all, thank you very much for accepting this interview. I am conducting a study on computational thinking skills. Your personal information and answers will be kept totally confidential and your answers will only be used for that study. In the records, the codes will be used rather than the names. The results of the interviews will be given totally. If requested, interview records will be shared by you and asked for your feedback. You will be informed when the study is completed. This interview will take nearly one hour and whenever you want, you can stop this interview.

After all this information, do you let me use your interview records in my dissertation study?

Do you mind if I record that interview?

Ok, and then let me start with first question.

1. It is nearly the end of your first semester in a university, how do you think about?
    a. Do you think you have changed this semester?
        i. If yes, how?
2. Is there any special point in freshmen capstone course in comparison to other lectures?
    a. What have you learnt from freshmen capstone course?
3. How did you feel at the beginning of this course?
    a. Did your feeling change as you finish the semester?
4. How do you evaluate project approach of this course?
    a. Was it difficult to find a project idea?
        i. How did you find your project's topic?
    b. Was it difficult to design your project?
    c. Was it difficult to make your project?
    d. Are you satisfied with the result of your project?
        i. Out of 10, what grade would you assign your project?
        ii. What was missing in your project?
    e. Have you ever wanted to change your project topic while working on your project?
        i. If yes, why?
        ii. If yes, did you change it? What did you do?
        iii. If yes, is new project after changes go as well as you thought compared to the previous project?
    f. If you were the professor of the course, what would you change?
5. Which toolkit were you given? Arduino or Raspberry Pi?
    a. Are you happy with your toolkit? Or what would you prefer the other one?
    b. Do you think you could do two projects with these two toolkits in the semester?
    c. Tell me your ideas on your toolkit?
        i. Was it difficult to learn?
        ii. Was it complicated?
        iii. Was it user friendly?
6. Before, you take this course, did you know any programming?
    a. Did you do any programming in this course?
        i. If yes, how did you manage coding problems?
    b. Did you learn any programming in this course?
    c. Did you do any mathematical calculations in your project?

d. Do you think programming is easy?
e. Do you think you could be successful in programming?
f. Do you want programming as your future job?

7. You worked alone in your project. Would you like do the same or similar project in group?
    a. If no, why you don't?
    b. If yes, why do you?
        i. How many students do you want to cooperate with in that project?
    c. Although you worked alone for this project, have you shared your project related problems and opinions with someone else?
        i. If yes, with who and why?
            1. How did you felt about the problem after sharing opinions with others?
        ii. If not, why not?
8. What was/were the biggest problem(s) you had during your project development?
    a. If not mentioned, did you have any mechanical problem with the toolkit?
        i. How did you manage these mechanical problems?
    b. How did you feel when you had project related problem?
    c. Did you ever think about quitting the project?
        i. If yes, what happened?
            1. How did you solve that quitting?
    d. Did you ever feel that you will fail from this course?
        i. If yes, why?
        ii. If no, what kept you motivated?
    e. Do you think group work would help you find better solutions to project problems?
        i. Do you think you could share your ideas easily in a group project?
        ii. Do you think you are a problem solver?
        iii. Do you think your future job will require problem solving skills?
    f. Do you like challenges?
        i. If yes, do you think challenges contribute to your development?
        ii. If no, why not?
9. How do you evaluate yourself in this project?
    a. Are you successful enough?
        i. If no, what stopped you being successful?
    b. Out of 10, how do you evaluate your achievement in this class?
    c. Do you think you followed an organized way in your project?

i. If no, what made you unorganized?

d. Do you think you are a creative person?
   i. If yes, can you please give me an example from your life?
   ii. If no, why not? What prevents you?

e. Are you a dreamer? Do you like dreaming?
   i. If yes, what do you dream about?
      1. How it reflects to your school life?
   ii. If no, why not?
   iii. Do you think dreaming is an important skill for this century?

f. When you compare before and after the capstone lecture, would you willingly proceed if someone ask you to do new project then before?

g. When you compare before and after the capstone lecture, would you ask other's opinions more than before when you feel stuck?

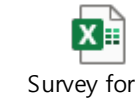
h. When you compare before and after the capstone lecture, do you think the course developed your problem solving skills?

i. When you compare before and after the capstone lecture, do you think the course made you more creative?

10. This semester started as online then shifted to hybrid (online and offline together). How did you feel yourself taking the class online?
    a. Do you think online courses affected your success?
       i. How? Positively or Negatively? Why?
    b. Did you become an offline student later?
       i. If yes, how was it to be in classroom?
       ii. If no, why not?
    c. What do you think about hybrid option?

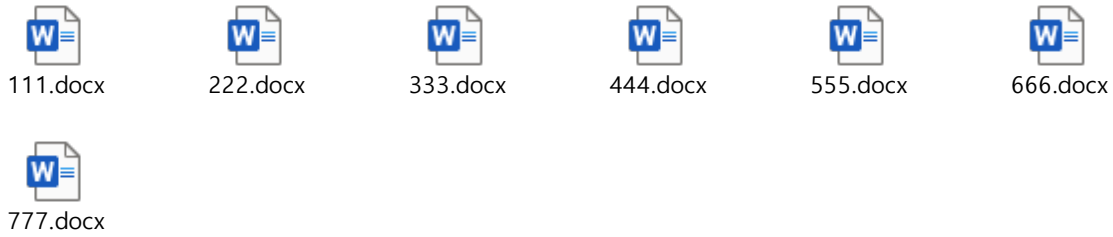
IS THERE ANYTHING THAT YOU WANT TO ADD?

Results

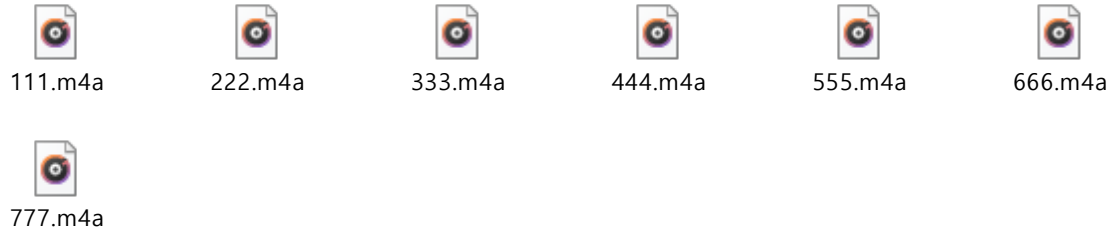


International questionnaire answer sheet.

Domestic questionnaire answer sheet.



7 interviews' transcript which taken from domestic students.



7 interviews' raw recordings.

Assumptions

The first assumption is that samples are had the freshmen capstone course.
The second assumption is that samples chose either Arduino or Raspberry Pi.

Limitations

The first limitation is that samples might not be representative on freshmen in whole world.
The second limitation is that female samples are very few, so it might not be representative on female group.

Delimitations

The first delimitation is that all samples are freshmen in Korea.

The second delimitation is that all samples are studying in Woosong University.

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