The Project-Based Learning Approach on the Blended Teaching to Improve the Computational Thinking Ability*

Yuan Fang
School of Engineering Practice and Innovation Entrepreneurship Education
Dalian, China
fangy@dlpu.edu.cn

Xiuyan Zhao
School of Engineering Practice and Innovation Entrepreneurship Education
Dalian, China

Weizhen Wang
Human Factors and Intelligent Fashion Design Research Center
Dalian, China

***Abstract*—Computational thinking ability is the core problem faced by college computer programming courses. Facing the main teaching problems in the era of blended teaching, this paper puts forward a six-point blended teaching model based on project-based learning. According to the six-point of the model, teachers design teaching content and implement the teaching process. By comparing the forms of computational thinking ability before and after the implementation of project-based learning, the effectiveness of the proposed teaching model in improving computational thinking ability is confirmed.**

Keywords—computational thinking, PBL, blended learning, programming course

I. INTRODUCTION

The 21st century is an era of rapid technological development and educational innovation. In 2020, the global outbreak of COVID-19 led to the inability of teachers and students to carry out offline classroom teaching, and the Internet provided unlimited possibilities for online teaching. Blended teaching is the trend of future development, and the teaching mode of combining online and offline has gradually become the mainstream. Blended teaching makes up for the shortcomings of many face-to-face teaching. But there are also some problems, such as teaching information overload, students' learning motivation not lasting, and so on. Human beings are inseparable from thinking activities in the process of understanding and transforming the world. Scientific thinking refers to the way of thinking used in human scientific activities. There are three ways of scientific thinking: logical thinking, empirical thinking, and computational thinking (CT). Computer programming course is often regarded as the first CT course in universities, such as C programming, and Python. Its purpose is to cultivate students, CT ability and advanced language programming skills, so as to lay a solid foundation for students to learn the information application integrated with their major in the future. For the popular educational strategy, Project-based learning (PBL) is the key one that offers students opportunities to synthesize and apply knowledge, as well as become independent learners and thinkers.

In this paper, we propose a teaching mode for computer programming courses based on the integration of PBL and blended teaching. Through the practice of project teaching, this paper fundamentally improves the ability of computing thinking.

II. COMPUTATIONAL THINKING

Computational thinking was first proposed, which attracted the attention of the public. Some domestic scholars defined computational thinking as thinking activity [1]. In [2], the computational thinking is the thinking process involved in solving problems. Its solution can be expressed as calculation steps and algorithms. In this process, the most important thing is to find an appropriate calculation model to express the problem and output the solution. In 2013, Guoliang Chen proposed that the purpose of computing thinking education is to cultivate a thinking habit and proposed computational thinking 2.0 in 2020. Computational thinking 2.0 is a further excavation of the connotation of computational thinking. It is proposed that computational thinking focuses on the scientific and cultural connotation of computing, and provides a conceptual model to describe the adaptation of reality and engineering technology. At present, the research on computational thinking continues to deepen. In the stage of higher education, the cultivation of computational thinking starts with learning a programming language.

Based on the above definitions and research, this paper holds that computational thinking is a way of thinking to solve practical problems by using computer methods and the basic ability of information technology processing. Decompose computational thinking into the following six key abilities of the programming language course.

CT(1) Definition problem. Students have the ability to find, analyze and clearly define problems.

CT(2) Abstract modeling. Students can present mathematical models and computational models of problems. Students have the ability to abstract problems and express scientific problems.

*China National Light Industry Council Education Section Project (NO. QGJY2021008); Dalian Polytechnic University Reform of Education Project Foundation (NO. JGLX2021026).

CT(3) Algorithm design. Students can design corresponding algorithms according to the established models, and use computer programming to realize the algorithms.

CT(4) Critical feedback. Students bring critical thinking into the process of project design and constantly feed back to the design process.

CT(5) Reflective transfer. Students can flexibly apply their existing knowledge and ability accumulation to the current unsolved projects. Students can also transfer the development experience of this project to other application fields.

CT(6) Recollection. Students can have a memory to summarize the key points, difficulties, and error-prone points in the process of project implementation. Students can organize these memories to form logical and storable documents.

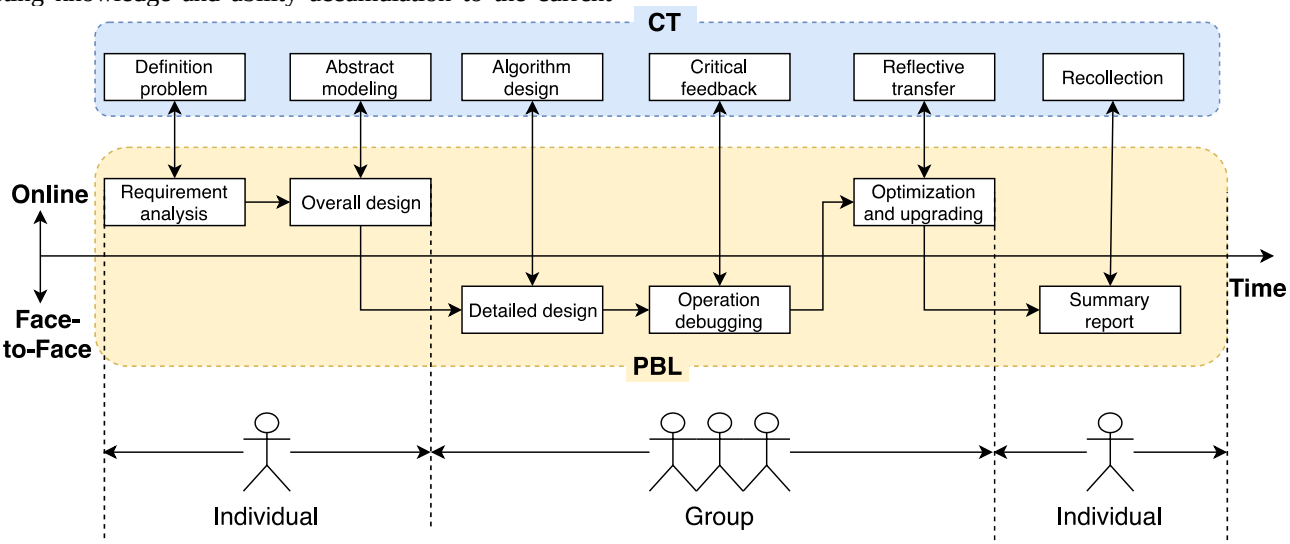


Fig. 1. PBL model of blended learning.

III. Blended Teaching Approach

Blended teaching is a combination of online and face-to-face activities to optimize learning. With the progress of technology and the continuous innovation of educational ideas, the concept of hybrid teaching gradually shifts the focus from the field of technology to both sides of teaching, and makes more discussions from the perspective of teachers and students. There are two meanings in the blended teaching, one is "teaching", the other is "learning". It pays attention to both teachers' design of teaching and students' learning experience. The concept of hybrid teaching has also developed into a teaching mode that combines information technology, innovative teaching methods and various learning methods for the purpose of cultivating students' autonomous learning ability, and constructs a teaching situation based on multiple communication equipment, network learning environment.

In blended teaching, there is the main contradiction between information overload and the maladjustment of human learning process. Students need to face a large number of learning content, information, data screening, reconstruction and memory. In addition, influenced by the continuous switching of learning space in mixed teaching, how to maintain students, long-term learning motivation is also the main problem to be solved in mixed teaching.

In this research, PBL is used to solve the problem of mismatch between information overload and the learning process. The teaching content takes the project as the core, including three dimensions: knowledge elements of project development, thinking training elements, and ability training elements. In order to solve the problem of maintaining long-term learning motivation in mixed teaching, the way of overlapping individual and group tasks is adopted and implemented. Aiming at the problem that the abstract characteristics of the computer programming course itself may cause the disappearance of students' motivation for long-term learning, the application project cases of different majors are reconstructed into the course project, to stimulate students' interest in new knowledge fields and maintain their learning motivation.

IV. Project-Based Learning

Computer programming courses, such as C language and Python, are offered to first-year non computer majors. This paper studies the teaching project design with reference to the Waterfall Model [4] of the project development process of software engineering.

A. PBL Model of Blended Learning

In carrying learning out, the teacher prepared a validated plan, so it meets the learning objectives for computational as shown in Fig.1 used project-based learning.

PBL(1) Requirement analysis. Teachers publish projects on the smart teaching platform. After students obtain the basic information of the project, they conduct demand analysis.

PBL(2) Overall design. In this step, students need to analyze the process, draw the flow chart and investigate the corresponding data.

PBL(3) Detailed design. In the detailed design stage, students need to cooperate with team members, fully discuss

the individual needs analysis and outline design results, and formulate a set of feasible schemes.

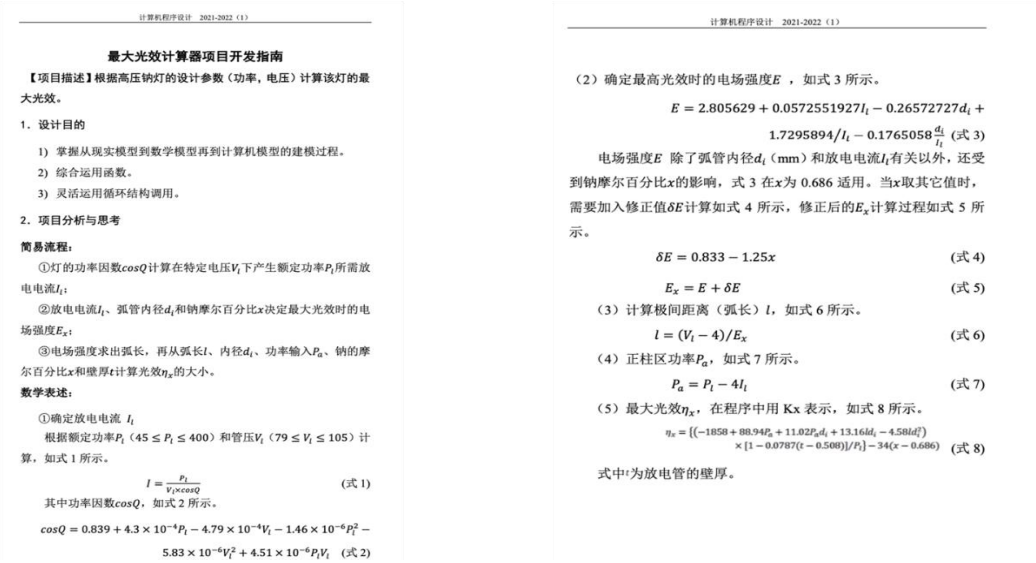
PBL(4) Operation debugging. In the operation debugging stage, students carry out the actual development of the project in groups. Students will fully interact in this step. Teachers are ready to help students as off-site assistance.

PBL(5) Optimization and upgrading. In the optimization and upgrading stage, the teacher guides students to refer to similar high-level resources. Through the query and comparison of online resources, students put forward corresponding optimization or upgrading schemes in combination with the thinking of this project.

PBL(6) Summary report. At this stage, students should not only write project reports, but also make project presentation.

B. A *Case* Study

C programming is a compulsory core course of computer basics in colleges and universities, offered in the first year of college. Due to the apparent differences in students' learning sources, basic abilities, and personalities, the teaching of traditional computer programming courses has problems such as insufficient accuracy of course content and methods, and a low degree of integration with applied undergraduate disciplines. In the function comprehensive application project. The teacher designed the project of the Maximum Luminous Efficiency Computation System, as Fig. 2shown.



计算机程序设计 2021-2022（1）

最大光效计算器项目开发指南

【项目描述】根据高压钠灯的设计参数（功率，电压）计算该灯的最大光效。

1．设计目的

1）掌握从现实模型到数学模型再到计算机模型的建模过程。
2）综合运用函数。
3）灵活运用循环结构调用。

2．项目分析与思考

简易流程：

①灯的功率因数$cosQ$计算在特定电压V_l下产生额定功率P_l所需放电电流I_l；

②放电电流I_l、弧管内径d_l和钠摩尔百分比x决定最大光效时的电场强度E_x；

③电场强度求出弧长，再从弧长l、内径d_l、功率输入P_a、钠的摩尔百分比x和壁厚t计算光效η_x的大小。

数学表述：

①确定放电电流 I_l

根据额定功率P_l（$45 \le P_l \le 400$）和管压V_l（$79 \le V_l \le 105$）计算，如式 1 所示。

$$I = \frac{P_l}{V_l \times cosQ} \quad \text{(式 1)}$$

其中功率因数$cosQ$，如式 2 所示。

$$cosQ = 0.839 + 4.3 \times 10^{-4}P_l - 4.79 \times 10^{-4}V_l - 1.46 \times 10^{-6}P_l^2 - 5.83 \times 10^{-6}V_l^2 + 4.51 \times 10^{-6}P_lV_l \quad \text{(式 2)}$$

计算机程序设计 2021-2022（1）

（2）确定最高光效时的电场强度E ，如式 3 所示。

$$E = 2.805629 + 0.0572551927I_l - 0.26572727d_l + 1.7295894/I_l - 0.1765058\frac{d_l}{I_l} \quad \text{(式 3)}$$

电场强度E 除了弧管内径d_l（mm）和放电电流I_l有关以外，还受到钠摩尔百分比x的影响，式 3 在x为 0.686 适用。当x取其它值时，需要加入修正值δE计算如式 4 所示，修正后的E_x计算过程如式 5 所示。

$$\delta E = 0.833 - 1.25x \quad \text{(式 4)}$$

$$E_x = E + \delta E \quad \text{(式 5)}$$

（3）计算极间距离（弧长）l，如式 6 所示。

$$l = (V_l - 4)/E_x \quad \text{(式 6)}$$

（4）正柱区功率P_a，如式 7 所示。

$$P_a = P_l - 4I_l \quad \text{(式 7)}$$

（5）最大光效η_x，在程序中用 Kx 表示，如式 8 所示。

$$\eta_x = \{(-1858 + 80.94P_a + 11.02P_ad_l + 13.16Id_l - 4.58Id_l^2) \times [1 - 0.0787(t - 0.508)]/P_l\} - 34(x - 0.686) \quad \text{(式 8)}$$

式中t为放电管的壁厚。

Fig. 2. Project requirements document.

Table 1 Instructional Design of the Maximum Luminous Efficiency Computation System

PBL	Content	Activity	CT
Before Class	online project investigation arrange the project	teacher guidance student self-study	CT(1)
PBL(1)	analyze requirements set goals	situational introduction	CT(1)
PBL(2)	practical problems mathematical model computer model	modeling	CT(2)
PBL(3)	process planning different function	draw flow chart	CT(3)
PBL(4)	programming, debugging long expression	group discussion	CT(4)
PBL(5)	extended application	exchange	CT(5)
PBL(6)	write report	presentation	CT(6)

Before the class, the teacher publishes the basic requirements document of the project and the corresponding questionnaire on the teaching platform. The problem-guided teaching method is used to guide students to carry out pre-research on the needs of the project, as shown in Fig. 2, Fig. 3.

Teachers use software engineering methodological steps to guide the project development process according to the PBL(1), as shown in 0.

Teachers and students analyze realistic models together, build mathematical models, and convert mathematical models into computer models of PBL(2), as shown in 0.

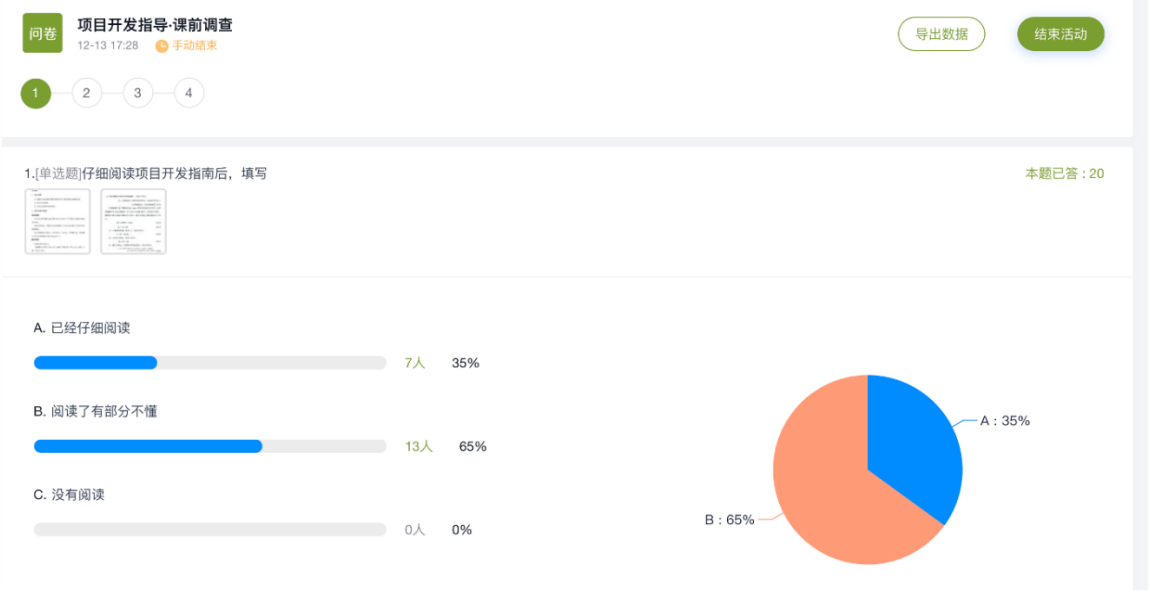


Fig. 3. Questionnaire of the project.

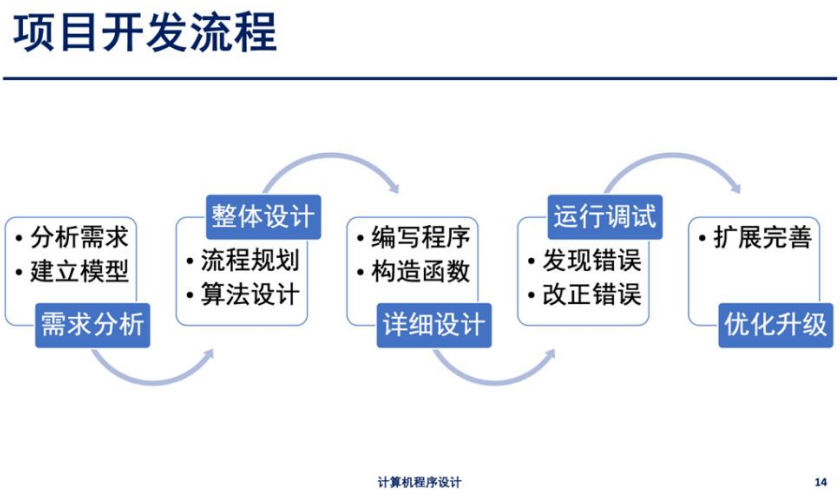


Fig.4 Software engineering methodological steps.

Fig 5 Modeling.

In PBL(3), the flow chart will be draw, as shown in 0.

In PBL(4), the group work will done, included the programming, debugging, summarize and prepared the presentation slides, as shown in 0. During that time, the teacher will give them support for the difficult problems and give them recommendation for good presentation.

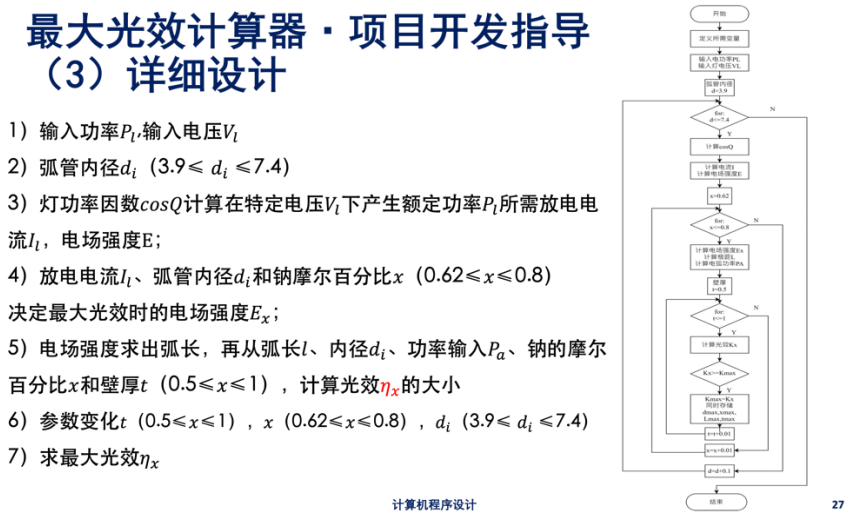


Fig 6 Flow chart of the project.

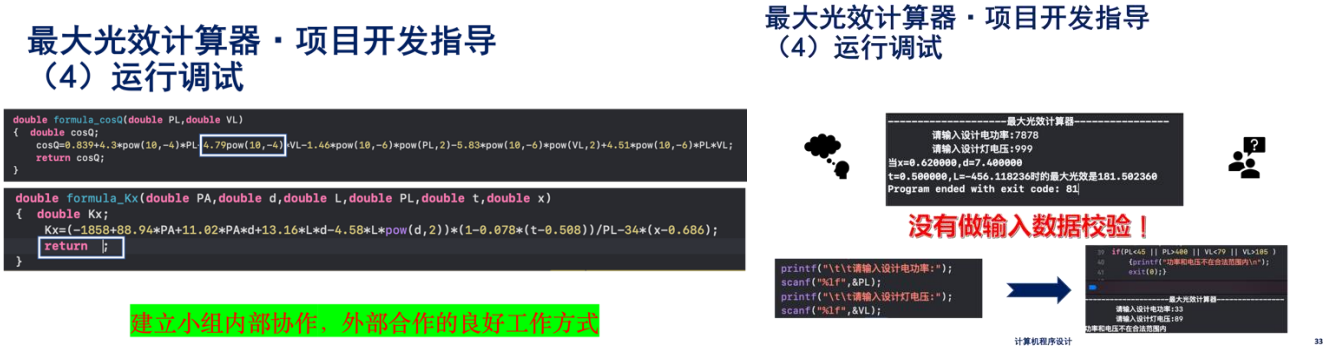


Fig 7 Group works.

V. Computational Thinking Ability Evaluation

The research object of this paper selects 31 first-year non computer majors to test the Computational Thinking Ability Scale [5] improved based on this study before and after PBL. This paper analyzes the level of learners' Computational Thinking Ability from six dimensions: CT(1) Definition problem, CT(2) Abstract modeling, CT(3) Algorithm design, CT(4) Critical feedback, CT(5) Reflective transfer and CT(6) Recollection. There are 18 questions in total. This paper uses reliability test to verify the scientifically of the questionnaire and test Cronbach's α using Python program in six dimensions. The coefficients are 0.73, 0.75, 0.81, 0.79, 0.82 and 0.79 respectively, indicating that the questionnaire in this paper is properly set.

Through the analysis of the questionnaire, the results are shown in the 0. The result of CT (3) Algorithm design is the largest increase in data before PBL and after PBL. This also shows that PBL helps to provide more accurate learning objectives and knowledge and avoids the problem of information overload in the process of mixed teaching.

The result data of CT (2) Abstract modeling shows that the number of students who believe that "I can use mathematical models and computer models to describe problems in daily life" is in line with their actual situation has increased, indicating that the number of students who can abstract their ideas into models has increased. Students' abstract modeling ability in CT is gradually improved in teaching practice.

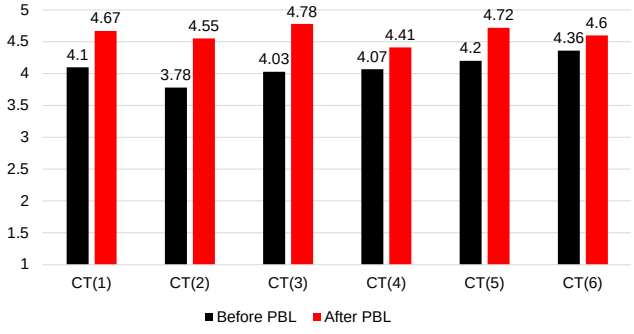


Fig 8 Result of evaluation.

VI. Conclusion and Future Works

Under the background of blended teaching and facing the problems of information overload and long-term learning enthusiasm, this paper uses PBL to carry out teaching practice during computer programming. The basic six modules implementation model and case study are proposed, a questionnaire survey is made on improving the

ability of computing thinking. The comparison results show that the new teaching mode of using PBL combined with blended teaching is conducive to improving the ability of computing thinking.

The design and practice of teaching projects with computational thinking as the core is the key direction of future work.

REFERENCES

[1] Wing J M . “Computational thinking,” Communications of the ACM, vol.49(3), pp.33-35, 2006.

[2] Aho,A.V..“ComputationandComputationalThinking,”TheComputer Journal, vol.55(7), pp. 832-835, 2012.

[3] Kintu, M.J., Zhu, C. , Kagambe, E. “Blended learning effectiveness: the relationship between student characteristics, design features and outcomes,” Int J Educ Technol High Educ 14, 7, 2017.

[4] H. D. Benington, ”Production of Large Computer Programs,” in Annals of the History of Computing, vol. 5, no. 4, pp. 350-361, Oct.-Dec. 1983, doi: 10.1109/MAHC.1983.1010

[5] Korkmaz, Ozgen,Cakir, Recep,Ozden, M. Yasar. “A validity and relia- bility study of the computational thinking scales (CTS),” Computers in Human Behavior,vol.72, pp.558-569, 2017