Factors Influencing Students' Computational Thinking -- a Case Study of Chinese Vocational Colleges

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Abstract: The Internet era has created new challenges and opportunities for computational thinking (CT) and computer application. Primary schools are where programming courses normally taught, however, Chinese vocational colleges don't give sufficient attention to the CT of their students. 1213 students from Chinese vocational colleges were sampled for a qualitative and quantitative study. The findings show that vocational college students are more engaged in cognition and decomposition for resolving practical issues, but they are not conscious of the significance of generalization, which results in the uneven development of CT skills. Academic discipline significantly affect CT, while gender variations only exist in the generalization dimension. Also, there is a substantial gap between grades. Additionally, this paper addresses the feasible solutions to improve Chinese vocational college students' CT.

1. Introduction

The digital revolution in education and society has revolutionized the conventional ways we learn, work, and live. Computational thinking (CT), which is currently a benchmark for assessing worldwide information technology competency in the 21st century, is one of the issues that evolved from the growing influence of artificial intelligence and robotics. CT is one of the critical and necessary talents in the digital age, as said by information technology professionals [1]. According to the experts, CT is inspired by students' analytical coursework, including reading, writing, and mathematics [2]. Numerous fundamental investigations have shown that CT, which includes analysis, creativity, and algorithm development, is a form of recursive thinking [3]. CT has an impact on both the humanities and the natural science, based on the recent studies published in the literature [4]. Currently, CT is not only just a skill for programmers; rather, it incorporates thorough knowledge from a variety of other academic fields because it makes normal procedural activities like abstraction, focus, algorithm, and logical integrity easier to do. Moreover, CT abilities can be further integrated into higher-order competencies, improving self-control, academic success, interpersonal relationships, and metacognitive abilities [5].To be specific, CT's function is to broaden students' ability sets rather than to keep them constrained by their existing skills. In other words, CT is an engaging skill that the younger generation needs to possess. To encourage students' CT, the PRC Ministry of Education has recently made all-around requests for the integration of programming with practical, multidisciplinary teaching and learning. It has been determined that vocational students are more focused on refining their professional abilities than on CT, hence students in vocational colleges are currently falling behind in this area. Although vocational college students are positioned as talents with cross-disciplinary skills, it is crucial to exploit their CT abilities. Inadequate CT skills will hinder the development of vocational college students. As a result, to support the subsequent studies, this research aims to examine the current situation and the key variables affecting the CT of Chinese vocational college students.

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2. Research Questions

The prior researches on computational thinking have enriched to some extent. Although they are different from one another, they share the same goal. Particularly, there hasn't been a comprehensive review of CT level among Chinese vocational college students. There is a consensus among academics in the field of CT that gender has an influence on students' computational thinking [6]. With the goal to evaluate the CT levels of vocational college students, we propose the following hypothesis:

Hypothesis 1: Gender will have a significant effect on vocational college students' CT.

It's common that students in vocational colleges study in distinct academic disciplines and are required to master specialized courses in addition to the public basic curriculums. Therefore, it is sensible to divide the participants into different categories. We classify vocational college majors into two categories: science and technology, literature and history. We assume:

Hypothesis 2: Academic discipline (science and technology, literature and history) will have a significant effect on vocational college students' CT.

In order to experience cognitive shifts, it is more crucial for students to increase CT competency through the study of IT courses. Generally, vocational college students would like to have IT courses in the first year of college in China. When they become sophomores, they don't have any IT-related courses if they are not science and technology majors. IT courses may deepen students' parsing of media technologies. We address the grade functions significantly:

Hypothesis 3: Grade will have a significant effect on vocational college students' CT.

3. Definitions of Computational Thinking: Perceptions

According to theoretical research, the term CT could date back to 2000s, and was initially described as a type of analytical thinking that incorporates evaluative behavior, scientific thinking for understanding complex systems, and mathematical thinking for problem-solving [7]. The foundation for CT was established by this definition. Later, by illustrating CT as a process of thought, Guzdial(2008) and other computer science educators shed light on the evolution of CT [8]. CT has long been known to assist people to get better at addressing human problems and utilizing human ingenuity and critical thinking to tackle difficulties with the aid of computer programs [9]. Researchers focused on the past literature and consequently came up with five fundamental elements of CT (abstraction, decomposition, algorithm, evaluation and generalization) [10].

With the development of information technology such as artificial intelligence and 5G, more and more researchers emphasized the importance of CT as an integrated skill that includes algorithm, collaboration, creation and critical thinking [11, 12]. CT education shouldn't rely on IT-related courses alone, but rather a blend of interdisciplinary integration, anyone can develop their CT skills through programming activities [13]. With regard to the factors influencing CT skills, Chongo et al.(2017) yielded that males had significantly higher level of CT than females [14]. However, Yadav et al.(2014) discovered that gender was found to affect the motivation of learning in CT, but had no connection with other dimensions [15].

4. Research Design

A quantitative and qualitative approach was utilized because it allowed us to gain a deeper understanding of the study.

4.1 Participants

The survey was conducted from June 2021 to December 2021, and the participants were students aged 17 to 20 years from some Beijing vocational colleges. In view of COVID-19 pandemic, the questionnaires were distributed online. An effective rate of 89.9% was achieved with 1213 valid questionnaires. The description of the study participants is shown in Table 1 below.

Table 1 Description of Participants

Gender	Male	52%
	Female	48%
Academic Discipline	Science and Technology	63%
	Literature and History	37%
Grade	Freshman	67%
	Sophomore	33%

Table 1 shows the descriptive statistics of the participants, 52% of the participants were male, while the female participants were 48%. 63% of the participants majored in science and technology, while the rest of the participants were studying literature and history. Concerning grades, we had 67% freshmen and 33% sophomores as our participants.

4.2 Questionnaire Selection

The CT Scale was adopted from Tsai, M. J., Liang, J. C., & Hsu, C. Y. (CTS), which consisted of 15 questions covering four dimensions: (1) cognition and decomposition, which was to assess the capacity to identify key information and break down a problem into small parts; (2) algorithm, which was to assess the capacity to solve problems step by step; (3) creativity, which was to assess the capacity to generate new ideas and find the best solution; and (4) generalization, which was to assess the capacity to draw connections between problems [16]. The scale gauged students' capacity for introspection and task-based learning. Using a five-point Likert scale, the scale has been updated to be suitable for students in vocational colleges. Reliability alpha results of the subscale and overall scale was from 0.825 to 0.923. Amos was conducted for model fit test, all indicators were within the required range. The common method bias was not serious by Herman's single factor test.

4.3 Qualitative Research

Under the research questions, we randomly selected 100 students for online interviews. Transcripts of the interview were sorted, coded, refined and summarized.

5. Presentations, Analysis and Interpretation of Data

5.1 Characteristic of the Participants

Table 2 Participants' Computational Thinking Level

Item	Contents	N	M	SD
Cognition and Decomposition	I usually deliberate a question as a whole. I usually examine the relationship between details. I usually give thoughts on the structure of the problem. I usually try to identify the key points of the problem. I usually build models to solve problems.	1213	3.34	0.42
Algorithm	I have a better grasp of mathematical symbols and concepts. I can use mathematical methods to solve problems in daily life. I usually try to list the steps of a solution. I usually predict the way a computer executes code.	1213	3.16	0.24
Creativity	When I am looking for a solution to a problem, I trust my intuition and feelings. I usually look for an optimal solution procedure. I usually hunt for a quick solution to a problem.	1213	3.14	0.59
Generalization	I am willing to make plans to solve complex problems. I attempt to apply generic solutions to a variety of issues. I usually contemplate how to apply the solution to other problems.	1213	3.08	0.32
CT		1213	3.21	0.16

Under the data collection techniques (SPSS 22.0) used, we observed that the cognition and decomposition dimension had the highest mean score (M=3.34, SD=0.42), indicating the majority of the participants had a moderate perception of the CT. And the mean score in the algorithm and creativity dimensions, as well as the whole CT were M=3.16(SD=0.24), M=3.14(SD=0.59), and

M=3.21(SD=0.16) respectively, reflecting to a certain extent that the level of CT of vocational college students was not very satisfactory. With respect to generalization dimension, the mean score was the lowest (M=3.08, SD=0.32) as shown in Table 2, demonstrating a gap in the previous study. For the vocational college students, CT as a technique was not well developed and not sufficiently motivated.

This finding numbers resembled that vocational college students, to some extent, generally had no awareness of technology application, and didn't realize the significance of developing CT and at the same time, they were not conscious of how crucial CT was, as tallied in Sands et al.(2018) [17].

5.2 Influencing Factors

We verified the influence of gender on the CT of vocational college students by a one-way analysis of variance (ANOVA). Data revealed the gender variable had a significant impact on the generalization dimension (p<0.05), and had no significant effects on other dimensions, which could be seen from Table 3.

Table 3 Anova of Gender

Variable		Cognition and Decomposition		Algorithm		Creativity		Generalization		Computational Thinking	
		F	p	F	p	F	p	F	p	F	p
Gender	Male Female	1.67	0.292	1.78	0.242	1.69	0.054	1.54	0.037	3.33	0.166

An independent-sample T-test reported different academic disciplines had significant effects on CT(p<0.01), while grades had a significant impact on the overall CT(p<0.001). This resulted in the obscure and slow development of CT in vocational college students. Under these findings, developing CT required much practice and wasn't feasible in a short period of time. Short-term gains in CT did not show their consequences directly.

Table 4 Independent t-Test of Academic Discipline and Grade

variable		Cognition and Decomposition		Algorithm		Creativity		Generalization		CT	
		t	p	t	p	t	p	t	p	t	p
Academic Discipline	Science and Technology Literature and History	2.02	0.373	3.24	0.321	1.89	0.156	1.78	0.134	2.78	0.002
Grade	Freshman Sophomore	3.12	0.334	4.51	0.313	0.62	0.253	0.34	0.168	1.87	0.000

5.3 Findings from the Interview

During the online interview, students frequently mentioned that CT was a skill that programmers would have and that not everyone has access to it.

I don't know how to program, and computers aren't really a big part of my curriculum.(Number 23)

I don't have any computer courses when I became sophomore. It's impossible to boost my CT. (Number 35)

The other interviewees stated:

I will teach young children in the future, have nothing to do with computers.(Number 10)

It seems classmates would like to be independent when doing jobs. I want to be collaborate and sharing, but it's hard. (Number 44)

The girl participants themselves lacked confidence in CT and believed that computers belong to boys.

Playing computer games is interesting, but solving programming problems is not easy. Sometimes I need help. (Number 66)

Girls are not as clever as boys. Boys are good at computing and logic.(Number 71)

I think girls are not as competitive as boys in computing and programming. (Number 88)

But, some suggestions were also observed:

We could have more courses to better explore the computer skills. This could help in the future works.(Number 26)

It could be interesting to design a learning application, I would like to try many times.(Number 39)

The results of the interviews coincide with the quantitative data. Both of these indicate that students do not understand the significance of CT in learning and that the development of CT in vocational college students appears to have been influenced by stereotypes. Furthermore, it seems that they are careless of technological advances. Their poor comprehension of CT restricts personal advancement, whether in terms of academic or technical skill development.

6. Conclusions

This study displays the current degree of CT among Chinese students attending vocational colleges, followed by the factors influencing that development. By analysing the data, we can conclude that vocational college students are more engaged in cognition and decomposition for resolving practical issues, but they are less conscious of the importance of generalization, which results in a lower level of CT and uneven growth of CT abilities overall.

When it comes to the influencing variables, the gender variable only significantly differs in the generalization dimension, which is likely brought on by the social division of work or the stereotypical interpretation of working circumstances. The first hypothesis is verified. In the course of getting technical education, men typically receive greater assistance and encouragement, while women face challenges and are not generally favoured by society. People automatically assume that girls have lower levels of interest in technology and are weaker innovators and adventurers. In short, sociocultural and demographic constraints limit girls' ability and desire to learn. The gender variable test results refute the ideas of "economic determinism" and "gender determinism" in CT.

The CT of students in vocational colleges is significantly influenced by academic disciplines. The second hypothesis is verified. While students specializing in literature and history take more fundamental technical courses, those majoring in science and technology can take technical courses relating to professional training (such as computer technology, multimedia technology, and programming languages). Knowledge connections is a challenge for the literature and history majors.

Our updated grade analysis reveals a significant difference between grades, which is similar to the findings of Ardito et al. (2020) [18]. This may be because CT involves long-term accumulation and cannot be attained quickly. The third hypothesis is valid.

The aforementioned studies demonstrate that CT is a cultivable trait, and that the growth of each of its sub-abilities is similarly non-linear, with qualitative changes taking place as a result of the application and accumulation of cumulative knowledge.

7. Implication for Ct Assessment and Pedagogy

The major findings show that CT demands more than just knowledge of computer programming and that it is crucial for vocational college students to develop this expertise. It is highly recommended that educational technology curricula continue to emphasize knowledge generalization in the future and that students in technical colleges gain a deeper understanding of CT. Therefore, we offer the following suggestions: First, CT education needs to be prioritized in Chinese vocational colleges. To establish the groundwork for CT, the Chinese Ministry of Education is currently emphasizing IT training in primary education. There is still a need for systematic training at vocational colleges since the development of CT abilities cannot be fragmented because the technology curriculum should have continuity. The 1+x certificate (an occupational skill certificate) proposed by the Education Ministry of PRC is an attempt to test the CT skills of vocational colleges students. 1+x certificate promotes multi-discipline and all-around development from the perspective of curriculum and certificate integration. Finally, vocational college students need to raise their self-awareness of CT. Technical knowledge not only enables students to be more effective in studies but also strengthens their career opportunities and solve practical life problems. Female students at vocational colleges, in particular, should take the responsibility to overcome societal stereotypes and fully understand that courses like computers are also advantageous for their minds and career advancement, so they will eventually achieve the consolidated development of CT.

8. Limitations and Future Research

The sample size chosen was unfavourable given the nature of this study. The cross-sectional research design and use of self-report measures were limitations of this study. The findings from this study can be utilized to guide future research on the relationship between CT and the career preferences of vocational college students in China. This will help researchers better understand if CT broadens career options.

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