ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

An investigation into the current status of information technology teachers' efficacy in teaching computational thinking

Baitong Zhu[1,a,*]

[1]*Educational Management, Philippine Women's University, Manila, Philippines*
[a]*2022t0704.pwu.edu.ph*
[*]*Corresponding author*

Abstract: *In the 21st century, as the importance of computational thinking is increasingly emphasized, information technology (IT) teachers have gradually assumed the important responsibility of cultivating students' computational thinking, and how to effectively improve students' computational thinking has become the focus and difficulty of the IT curriculum. In order to improve students' computational thinking, teachers as instructors need to be equipped with high computational thinking ability and strong sense of teaching efficacy. It is thus necessary to pay attention to how to improve teachers' computational thinking ability and teaching efficacy. However, relevant literature on the research status of teachers' computational thinking teaching efficacy is currently very limited. Most of the literature research mainly focuses on the cultivation of computational thinking of college students, primary and secondary school students as well as high school and vocational students, while the literature on how to improve the computational thinking teaching efficacy of information technology teachers is very scarce, and in-depth systematic research and practice in this area has not yet started. In this paper, the concepts of computational thinking and computational thinking teaching efficacy are first interpreted by combing relevant journals, and certain articles are organized that can represent the current status of computational thinking and teaching efficacy of IT teachers. Further, this paper gains insight into analyses of scholars on the level of computational thinking teaching efficacy of IT teachers in various dimensions. Finally, corresponding strategies are proposed to improve the computational thinking teaching efficacy of teachers in the light of the current situation, hoping to contribute to the enhancement of the effectiveness of IT teachers worldwide.*

Keywords: *Computational Thinking, Instructional Efficacy, Information Technology Teachers*

1. Introduction

Computational thinking is a new concept in the 21st century, which has been unanimously recognized by experts and scholars at home and abroad. Prof. Zhou Yizhen clearly pointed out that "Computational thinking ability will become the basic ability of every person in the middle of 21st century". Nowadays, computational thinking has been integrated into everyone's life. Why is computational thinking so important?

1.1. An unprecedented emphasis on computational thinking under the concept of artificial intelligence

Countries around the world attach great importance to artificial intelligence, and many countries have long been developing artificial intelligence at the national strategic level. In October 2016, the U.S. White House's Office of Science and Technology Policy distributed reports including "Getting Ready for an Artificially Intelligent Future" and "National Artificial Intelligence Research and Development Strategic Planning", which provides more targeted and specific recommendations for promoting future development of artificial intelligence (AI). The European Commission has formulated the SPARC Robotics Innovation Program. The Japanese government has deployed a super-intelligent society and planned the industrialization route of artificial intelligence. The Chinese government released the New Generation Artificial Intelligence Development Plan on July 8, 2017, which comprehensively deploys a series of important tasks for the development of a new generation of artificial intelligence in China. With the advancement of the AI era, education has evolved into one of the most important areas of AI

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

application. Since artificial intelligence is so crucial, the foundation of artificial intelligence requires computational thinking.

1.2. The importance of developing students' computational thinking

For K-12 students, computational thinking skills are as important as the basic skills of reading, writing, and arithmetic, and are one of the core competencies for students in the 21st century (Qualls & Sherrell, 2010)[1] . Indeed, this concept is well recognized by the international community. The education systems of more and more countries in the world have begun to incorporate computational thinking into K12 education (Zhang&Nouri, 2019)[2] .

The CSTAK-12 Standards, published in 2017 by the Computer Science Teachers Association of America (CSTA), make clear the need to integrate the development of computational thinking throughout every stage of K-12 education[3] .

1.3. The need to develop teachers' computational thinking

The International Society for Technology in Education (ISTE) Computational Thinking Competency Standards for Educators, released in 2018, state that educators who integrate computational thinking into their classrooms can develop students' problem-solving skills and critical thinking, to help them become successful computer science learners and computational thinkers[4] . Meanwhile, the National Science Council (NRC) report claims that students can learn computational thinking and other thinking strategies while studying a subject, that teachers and curricula can construct these strategies for students, and that appropriate teacher instruction can encourage students to use these strategies independently. If educators incorporate computational thinking concepts into their teaching, then K-12 students will obtain more opportunities to engage in computational thinking, which will have a positive impact on the development of computational thinking skills (National Research Council, 2010)[5] .

2. Conceptualization

2.1. Computational thinking

Computational thinking was first mentioned in 1980 in Professor Seymour Papert's Mindstorms: Children, Computers, and Powerful Ideas[6] . In March 2006, Prof. Jeannette M. Wing systematically described computational thinking, pointing out that computational thinking is mainly embodied in a series of behavioral activities such as designing systems, solving problems, and understanding human behaviors by using computer science concepts[7] . Subsequently, she revised the definition of computational thinking in 2011 by absorbing suggestions of other scholars: “Computational thinking is a thinking process of presenting problems and solutions through formalization, so that solutions can be effectively executed by information processing, and it is a kind of entry angle for problem solving”[8] .

In the author's view, computational thinking is an emerging way of thinking relative to traditional thinking, based on the integration of mathematical thinking, computer science thinking and engineering thinking, through the application of abstraction, automation and computation, to break down complex problems and tasks into a number of simple and easily handled sub-problems and sub-tasks, and then consciously and purposely use the computer to solve these problems and tasks. The fundamental purpose of developing computational thinking skills is to transfer both paradigms and methods of problem solving in computer science to other disciplines, i.e., to analyze complex problems through abstraction, automation, modeling, and computation, and to further generate automated and computational solutions. With computational thinking skills, learners are not just consumers and users of tools, but are those who master computational thinking and can actively build tools.

2.2. Teachers' computational thinking self-efficacy

Self-efficacy is based on social cognitive theory. Bandura (2010) believed that it is the strength of a person's belief in his ability to complete a task, which includes judgments about his ability to perform the task and confidence in having the ability to complete the task[9] . Self-efficacy refers to the degree to which an individual assesses his or her ability to perform a behavior, rather than the true level of an individual's ability (Yuting Cui, 2019)[10] .

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

Based on the full integration with Bandura's self-efficacy theory, teacher self-efficacy is categorized into personal teaching efficacy and general teaching efficacy. Personal teaching efficacy refers to a teacher's evaluation of his/her own ability to bring about a positive change in the ability of students. General teaching efficacy refers to a teacher's belief that he/she is in control of his/her surroundings. Soodak et al. (1996)[11] believed that teacher self-efficacy consists of individual self-efficacy and outcome self-efficacy. Individual self-efficacy refers to a teacher's belief that he or she possesses a particular instructional skill. Outcome self-efficacy refers to a teacher's belief that the implementation of these instructional skills will produce the desired learning outcomes for students.

In summary, the author believes that teachers' computational thinking self-efficacy refers to teachers' self-confidence in the process of teaching computational thinking. Specifically, computational thinking personal self-efficacy refers to teachers' belief that they have computational thinking as an ability; computational thinking teaching self-efficacy refers to teachers' belief that they will incorporate computational thinking in their future teaching (Weeseetal., 2017)[12] .

3. Analysis of the Current Situation

Using the new version of the curriculum standards and the validated scales of "Computational Thinking Teaching Efficacy" developed by Kaya et al. and "Teacher Teaching Efficacy" developed by Yu Guoliang et al., a questionnaire on Computational Thinking Teaching Efficacy for IT Pre-service Teachers was compiled to explore the current status of computational thinking teaching efficacy for IT pre-service teachers[13].

First, the overall sense of efficacy in teaching computational thinking among pre-service IT teachers was at a medium to high level, and there was some room for upward mobility in personal sense of teaching computational thinking, i.e., in terms of professional foundation and the planning and preparation for teaching. Through the accumulation of a professional knowledge base, pre-service IT teachers could drive an increase in the number of teachers using teaching strategies and methodologies that they established for teaching and designing, so as to perform well in teaching planning and preparation.

A variety of factors contributed to pre-service IT teachers' sense of efficacy in teaching computational thinking, with general computational thinking teaching efficacy being slightly higher than personal computational thinking teaching efficacy. The major to which pre-service IT teachers belonged to had no significant difference in their sense of efficacy in teaching computational thinking. Moreover, different internship experiences and different computational thinking teaching experiences did not make a significant difference in their sense of efficacy in teaching computational thinking in general, whereas gender, grade level, type of school attended, internship experience, subject taught during internship, computational thinking teaching experience, willingness to teach in the subject of information technology, and description of understanding of computational thinking produced remarkable differences in computational thinking teaching efficacy. Finally, the relationship between IT teachers' computational thinking ability and computational thinking teaching efficacy was explored. The results of correlation analysis showed that there was a significant positive correlation between computational thinking ability and computational thinking teaching efficacy. The results of regression analysis indicated that computational thinking ability caused a predictive effect on computational thinking teaching efficacy, and that the higher the computational thinking ability score, the higher the level of computational thinking teaching efficacy.

4. Specific Measures to Improve Information Technology Teachers' Efficacy in Teaching Computational Thinking Skills

A number of researchers in existing studies believe that computational thinking is one of the basic skills necessary for everyone and should be developed in early childhood (Marinaetal., 2014)[14] . Durak and Saritepeci (2018)[15] analyzed the factors affecting computational thinking skills through structural equation modeling, and found that the academic period had no significant effect, indicating the feasibility of research in the area of computational thinking training for in-service teachers. Most of the early researchers focused on developing students' computational thinking skills in school education, but for the sustainability of computational thinking education, the problem of lack of teachers is inevitable. In addition, it has been demonstrated that people with higher self-efficacy are able to challenge themselves when facing difficulties and attribute their failures to lack of effort, whereas those

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

with low self-efficacy tend to give up easily and attribute their failures to lack of ability (Feng, X. et al., 2009)[16] .

A study investigated the influence of teachers' self-efficacy on teaching thinking by analyzing the data of 653 teachers from six different countries into ANOVA, and the results suggested that teachers' self-efficacy exerted a significant positive influence on teaching thinking. Dong Jingjing (2019)[17] , on the basis of reviewing and analyzing relevant foreign studies on teachers' self-efficacy, highlighted that teachers with low teacher self-efficacy are more likely to be anxious and conformist about changes in teaching methods and concepts in the actual teaching process.

In the process of teaching information technology education, teachers' own computational thinking ability is essential, and it is even more imperative to reinforce teachers' computational thinking self-efficacy, since teachers' self-efficacy affects the level of their own teaching play and the development of students' computational thinking ability. Teachers' self-efficacy, on the other hand, is one of the important factors impacting teachers' teaching behaviors and effects (Wang Zhengdong, 2006)[18] . Therefore, the first priority currently is to train teachers in computational thinking and to boost teachers' self-efficacy in computational thinking.

The author proposes countermeasures to enhance the effectiveness of IT teachers' teaching computational thinking from three aspects after reviewing a large amount of literature: IT teachers themselves, higher education institutions and teachers' work units.

4.1. How IT teachers can improve their own sense of efficacy in teaching computational thinking

4.1.1. Proactively improving self-efficacy in teaching computational thinking

Teachers of information technology must realize that computational thinking is the ability that future innovative talents must possess. They should assume the due responsibility of information technology teachers in the process of teaching and take the initiative to improve their own computational thinking ability and sense of teaching efficacy in order to be able to bear the heavy responsibility of cultivating students' computational thinking ability. At the same time, information technology teachers should rationally integrate the content of computational thinking literacy into their teaching work in the process of teaching design, and they should also intensify their computational thinking ability from time to time, such as reading relevant books after class, or learning from teachers with strong computational thinking ability in their own schools or even in other schools by listening to lectures, so as to further enhance their own computational thinking ability and sense of efficacy in teaching.

4.1.2. Proactively improve skills in teaching computational thinking

Teachers of information technology need to clarify the goal of teaching, that is, the goal of the development of computational thinking. It is necessary to create tasks with life situations based on scenario simulation, so that students can experience the elements of computational thinking in activities and tasks. In the meantime, students are guided to actively participate in the problem-solving process, and only through personal experience can students grasp the theory of computational thinking and improve their own computational thinking ability. Notably, in the face of different learners, teachers must tailor classroom teaching to the needs of students, choosing teaching strategies and methods that meet the characteristics of learners according to their later knowledge structure and learning experience, and guiding them to summarize and reflect.

4.2. How teacher education institutions can improve teachers' sense of efficacy in teaching computational thinking

4.2.1. Consolidation of the theoretical knowledge base of future IT teachers

Pre-service teachers of information technology should not only master the theoretical knowledge of their own specialty, but also dabble more in the theory and practice of other specialties, so that they can accurately accomplish the teaching practice in the future. By reviewing the relevant literature, it is feasible to use programming for teaching, so that students in school information technology-related majors in the process of learning programming can analyze and decompose problems, and perform abstract modeling and generalization assessment of problems. Therefore, in addition to basic courses, institutions of higher education can develop courses conducive to the cultivation of computational thinking, such as big data, cloud computing, robotics, etc. In the process of training future information technology teachers, it is crucial to concentrate on subtle penetration of the components of

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

computational thinking, the construction of basic concepts of computational thinking and the accumulation of professional basic knowledge.

4.2.2. Improving the thinking skills of future IT teachers

Without the baptism of practical teaching, school teachers will not be able to accumulate practical teaching experience, which makes them unclear about where to start to develop students' computational thinking, and what stages need to go through in the development of computational thinking. Hence, inexperienced teachers need the help of professional teachers with teaching experience before they work. This is why professional support from university teachers, frontline teachers, researchers in the field of computational thinking, etc. is particularly important. By means of thematic conferences or micro-lesson simulations, teachers who have not yet graduated can be encouraged to get familiar with the classroom teaching atmosphere in advance, understand experience of experienced students in teaching computational thinking, and learn about relative methods and principles of teaching computational thinking skills in advance, thus promoting them to have a high sense of efficacy in teaching computational thinking.

4.3. How government departments can improve teachers' sense of efficacy in teaching computational thinking

4.3.1. Valuing the sense of efficacy in teaching computational thinking among recruited IT teachers

It is due to the fact that most junior high schools, elementary school and vocational high schools emphasize the development of students' computational thinking skills that both computational thinking skills and teaching effectiveness of IT teachers are not high. Therefore, regardless of the type of school, such as junior high school or elementary school, the recruitment of information technology teachers should take the information technology of computational thinking ability and sense of efficacy as one of the objectives of assessment. Teachers with strong computational thinking ability and a high sense of efficacy of teaching will be given priority to recruit. Additionally, for IT teachers who have already been employed, if they are found to have a low level of computational thinking efficacy in the teaching process during the inspection, relevant training should be provided to them so as to strengthen their own computational thinking ability.

4.3.2. Provision of modern hardware and software platforms

In order to effectively improve students' computational thinking ability, it is essential to offer regular training for in-service information technology teachers, enabling them to reasonably and effectively utilize computer technology and computational thinking in the teaching process, so that they can fully utilize computational thinking for knowledge enrichment and expansion, and integrate computational thinking into information technology education and teaching. Therefore, it is necessary for schools at all levels and local education departments to optimize the environment for the development of computational thinking, and to fully equip information technology teachers and students with relevant software and hardware facilities for good development of thinking, for example, appropriately introducing computer equipment, creativity equipment, electronic blocks, intelligent robots, 3D printers, drones, etc. With the application of these facilities, information technology teachers can further develop their teaching practice skills and continuously improve their thinking mode. Information technology teachers can also have the conditions for on-the-job learning during their working period to continuously improve their computational thinking ability, and at the same time, they should be equipped with a large number of relevant books for information technology teachers to read for reference.

4.3.3. Emphasizing the overall workforce of IT teachers

Information technology teachers lack strong computer thinking ability in the teaching process, and they are unable to carry out teaching practice reasonably and effectively. In order to improve the computer thinking ability of information technology teachers, school leaders at all levels and in all kinds of schools can take some effective measures to strengthen the computer thinking ability of information technology teachers, which can be realized by carrying out relevant training on a regular basis, hiring experts or scholars to provide professional guidance and training, or arranging information technology teachers to go to other schools for mutual study and exchange in order to achieve the purpose of training. The advantage of training to strengthen the computer thinking ability of IT teachers is that it can allow IT teachers to understand theoretical knowledge and combine it with practice simultaneously.

For example, in order to strengthen the computational thinking ability of a high school in Inner

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

Mongolia Autonomous Region, relevant experts and scholars can be hired to give professional guidance and training to IT teachers, through which the computational thinking ability of IT teachers can be improved by explaining professional knowledge. IT teachers should actively communicate with experts or scholars, so that their professional confusion can be properly solved. It is also possible to let those information technology teachers with stronger computational thinking ability and stronger working ability to educate and guide those with weaker computational thinking ability accordingly, to strengthen their computational thinking ability through this kind of face-to-face on-site teaching. Moreover, IT teachers with strong computational thinking ability can form a team to lead IT teachers to carry out research in related fields, develop courses or examples to put them into teaching practice, and further share related methods and experiences to realize common progress as well as effective teaching and learning.

5. Conclusion

In the era of artificial intelligence, Students need to be able to take advantage of emerging technologies, including artificial intelligence, to solve problems. Information technology teachers play a crucial role in the development of students' computational thinking ability. This responsibility requires that information technology teachers have advanced computational thinking ability. Psychologically and practically, a teacher's computational thinking ability affects their efficacy, and, consequently, the quality of their teaching. Therefore, as primary and secondary school teachers learn to integrate computational thinking into the classroom, they must not only improve their own computational thinking ability but also develop a strong sense of efficacy in teaching this skill. The aim is to nurture students' computational thinking skills.

References

[1] Qualls J A , Sherrell L, B . Why computational thinking should be integrated into the curriculum[J]. Journal of Computing Sciences in Colleges, 2010, 25(5):66-71.
[2] Zhang L C, Nouri J. A systematic review of learning by computational thinking through Scratch inK-9[J]. Computers & Education, 2019: 103607.
[3] CSTA.CSTA'sK-12Standards[EB/OL]. https://www.csteachers.org/page/about-csta -s-k-12-nbsp-standards
[4] ISTE.Computational Thinking Competencies for Educators [EB/OL].https: //www.csteachers.org/page/about-csta-s-k-12-nbsp-standards
[5] National Research Council. Report of a workshop on the scope and nature of computational thinking [M]. National Academies Press, 2010.
[6] Seymour Papert.Mindstorms:Children, Computers, and Powerful IdeasM.NewYork:Basic Books, 1980:285-286.
[7] Jeannette. MComputational Thinking[J]. .Communications of the AC, 2006(3):33-35.
[8] Wing J M. Research Notebook: Computational Thinking What and Why? In the Magazine of the Carnegie Mellon University School of Computer Science,2011 .
[9] Bandura A. Self-efficacy [J]. The Corsini encyclopedia of psychology, 2010: 1-3.
[10] Yuting Cui. The effects of achievement motivation and self-efficacy on teachers' knowledge domain acquisition in primary and secondary schools [D]. Wuhan:Huazhong Normal University,2019.
[11] Soodak L, C, Podell D M. Teacher efficacy: towards the understanding of a multi-facetedconstruct [J]. Teaching and Teacher Education, 1996, 12(4): 401-411.
[12] Weese J L, Feldhausen R. STEM outreach: assessing computational thinking and problem solving[C]. ASEE Annual Conference and Exposition. Conference Proceedings. 2017.
[13] Peng Jianrui. A study on the current status of computational thinking teaching efficacy among pre-service teachers of information technology[D]. Shenyang Normal University, 2023. DOI: 10.27328/d.cnki.gshsc.2023.000093.
[14] Bers U, Flannery L, Kazakoff E R, et al. Computational thinking and tinkering: explorationof an early childhood robotics curriculum[J]. Computers & amp; Education, 2014, 72: 145-157.
[15] Durak H Y, Saritepeci M, Analysis of the relation between computational thinking skillsand various variables with the structural equation model[J]. Computers & Education, 2018, 116: 191-202.
[16] Feng X, Lu Ruoyu, Peng Lei. A study on the relationship between personal innovation behavior and work motivation and self-efficacy of employees in service enterprises[J]. Research and Development Management,2009,21(03):42-49.
[17] Dong Jingjing. Review and Prospect of Foreign Research on Teachers' Self-Efficacy in the New

ISSN 2522-6398 Vol. 7, Issue 7: 45-51, DOI: 10.25236/FER.2024.070707

Century [J]. Contemporary Teacher Education,2019,12(3):86.93.
[18] Wang Zhendong, On the teaching efficacy of distance education teachers and its cultivation [J]. China Electronic Education,2006(11):41-44.