

Programming Self-Efficacy in Higher Education Research: A Systematic Literature Review

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The goal of the systematic literature review (SLR) was to provide an overview of the concepts and factors associated with programming self-efficacy (PSE) from 2017 to 2021 in Scopus (215) and the Web of Science (310) academic indexes. From the initial 525 articles identified, 405 were left after duplication identification. Using further criteria such as article years must be between 2017 and 2021 in English, and through a peer-review process, 60 remained. These 60 papers were then analyzed using a set of questionnaires, from which 36 articles were excluded. Finally, 24 articles were selected for further analysis and to answer the study's research questions. Results revealed that student success in information communication technology (ICT) and computer programming courses was from making the learners aware of their programming abilities. Therefore, higher education (HE) institutions should be encouraged to review learners' abilities in programming and their related perceptions. Finally, institutions should create a relevant learning strategy using tools appropriate for improving education quality.

Keywords: computer programming, programming self-efficacy, relevant learning strategy, systematic literature review, Thailand

INTRODUCTION

In an era where the world is changing rapidly, the challenges of cutting-edge technology, sluggish economies, and the global pandemic have resulted in every organization needing more skilled workers to meet the changing and challenging 21st-century-related work environments.

Beyond the need for things such as digital literacy, computational thinking (CT), and critical thinking skills (CTS), programming skills have also been identified as a necessity for economies moving more and more into robotics and the Internet of Things (IoT) (Durak et al., 2019). As a result, people must adjust accordingly, transitioning from third-generation-related skills to fourth generation-digital knowledge worker skills (Ruenphonphun et al., 2021). In Thailand, this has been identified as Thailand 4.0 (Ditsuwan & Sukkamart, 2022).

Therefore, educational institutions are one group that can help create quality individuals that meet the needs of the changing working world. However, these students moving from their academic lives into the real-world workforce must believe they are capable, have patience and perseverance, and are not easily discouraged.

These ideas are supported by many years of scholarship. One recognized leader in the importance of a person's perception and belief in their abilities is Bandura (1997), whose *Social Cognitive Theory* (SCT) implies that the perception of one's abilities directly affects the actions of an individual. Even when people have different abilities, the abilities can be expressed in different qualities.

Using SCT as the tool for evaluation, Compeau and Higgins (1995) observed that students, who interacted with IT systems, influenced their performance ability behavior (self-efficacy) and the perception of their expected outcomes. Therefore, PSE is a student's belief that they can do a computer-related job. Their self-efficacy in using computers affects their expectations about their future success.

This is consistent with more contemporary global studies, including research from Taiwan, in which students' PSE was examined. Results revealed positive correlations between PSE and computer programming and self-efficacy and learning efficiency (Tsai, 2019).

Moos and Azevedo (2009) also studied the relationships between computer-based learning environments (CBLEs) and student difficulties with them and how computer-self efficacy contributed to or detracted from CBLE learning. The SLR study showed that behavioral and psychological skills were positively related to PSE.

Gurer and Tokumaci (2020) investigated teaching style and self-efficacy and reported that self-efficacy affects the students' concepts and attitudes toward programming. Similarly, Abdunabi et al. (2019) determined a positive relationship between ICT student PSE and each learner's perception of the value of learning computer programming.

In Thailand, educational researchers developed a seven-step Digital Learning Ecosystem (DLE) Model whose evaluation results determined that when programming students recognized their abilities, they had better programming skills, potentially increasing their critical and analytical thinking and computational thinking. This allowed them to apply new knowledge and skills to new situations (Chinchua et al., 2022).

Therefore, seeing the importance of ICT and programming skills in nations seeking to establish economies around digitally literate knowledge workers (Intaratat, 2021), the authors undertook an extensive SLR of concepts and factors related to PSE from English language studies in the Scopus and WOS databases from 2017 to 2021. Moreover, PSE's objectives, methods, outcomes, and limitations were also investigated.

RESEARCH METHODOLOGY

Three research methods were also used to select another group of 24 studies for evaluation. These were quantitative methodologies (13), qualitative methodologies (1), and mixed methods (10). Moreover, the quantitative analysis included data collected through a self-efficacy evaluation before and after the course. For qualitative analysis, various methods were employed, including interviews and observations. Only one study used a qualitative research method.

LITERATURE REVIEW

Research Outcomes

Out of 24 selected articles, the researchers present the findings classified by research objectives, with 12 determined to have factors affecting PSE. For example, Ozturk (2021) examined the beliefs of 17 students concerning their computational thinking (CT) and PSE in an introductory programming course and determined that the post-tests indicated that authentic programming activities influenced creativity improvement, algorithmic thinking, and critical thinking skills. Furthermore, Erol (2020) and Kasalak and Altun (2020) found that Arduino robot design activities improved students' programming attitudes and PSE.

This is similar to Okal et al. (2020), who found that a model developed for the study of programming positively affects PSE and learner attitudes. Furthermore, Ling et al. (2021) reported that motivation, PSE, and wrong perception affect student learning efficiency in Python programming classes.

Then, eight articles looked at the relationship between variables. Kanaparan et al. (2019) investigated PSE, emotional involvement, emotional attachment, and the programming performance relationships of learners. The results showed that learner belief in PSE was positively affected. However, satisfaction and attention had a negative effect on programming efficiency.

Abdunabi et al. (2019) found that recognizing the importance of PSE can help ICT teachers provide efficient and effective courses in programming, ultimately resulting in learners' development of advanced programming skills while also having fun with programming. Gurer and Tokumaci (2020) found that attitudes toward PSE by engineering students were determined by learner and programming attitudes, with PSE significantly predicting perceived learning. Finally, in Thailand, Hiranrat et al. (2021) stated that findings from other research have shown that student self-efficacy beliefs had a strong influence in predicting career interests and goals in ICT disciplines.

Research Limitations

The authors asked, "What are the research limitations of self-efficacy in programming in higher education?" We discovered that of the final 24 articles selected, *data collection methods* were the most common limitation ($n = 8$). The following limitation was the *sample size* ($n = 5$), and the last limitation was that the *information in the research lacked credibility* ($n = 4$). Another group of articles *did not specify research limitations* ($n = 7$). From this analysis, we detail these types of restrictions on research in Table 1.

TABLE 1
TYPES OF RESEARCH LIMITATIONS

No	Investigation	Type of limitations
1	Tsai (2019)	Data Collection Method
2	Psycharis and Kallia (2017)	Data Collection Method
3	Yildiz and Gündüz (2020)	Not mentioned
4	Gorson and O'Rourke (2020)	Data Collection Method
5	Hilal et al. (2018)	Not mentioned
6	Ozturk (2021)	Self-reported data
7	Crompton and Burke (2018)	Sample size
8	Arslan and İşbulan (2021)	Data Collection Method
9	Erol (2020)	Self-reported data
10	Okal et al. (2020)	Data Collection Method
11	Türker and Pala (2020)	Sample size
12	Günbatar (2020)	Sample size
13	Abdunabi et al. (2019)	Sample size
14	Durak et al. (2019)	Data Collection Method
15	Wei et al. (2021)	Not mentioned
16	Emmons and Zager (2018)	Not mentioned
17	Threekunprapa and Yasri (2020)	Data Collection Method
18	Kanaparan et al. (2019)	Not mentioned
19	Çoklar and Akçay (2018)	Data Collection Method
20	Sun and Hsu (2019)	Not mentioned
21	Kasalak and Altun (2020)	Self-reported data
22	Gurer and Tokumaci (2020)	Self-reported data
23	Ling et al. (2021)	Sample size
24	Avcu and Ayverdi (2020)	Not mentioned

Search Strategies

The authors conducted their international SLR using the Scopus and Web of Science academic indexes. Search terms included the title, keyword, and article, as well as the following search criteria techniques:

WOS: TS = ((“programming self-efficacy *” OR “computer programming in self-efficacy *” OR “self-efficacy in programming *”) AND (“higher education” OR “university*” OR “college*”))

Scopus: TITLE-ABS-KEY ((“programming self-efficacy *” OR “computer programming in self-efficacy *” OR “self-efficacy in programming *”) AND (“higher education” OR “university*” OR “college*”))

Study Selection

The article selection process was incremental and iterative, from which 525 articles were initially identified.

Criteria for Exclusion and Inclusion

Table 2 shows the criteria for paper inclusion and exclusion for the study, with the criteria reviewed by three university experts, including one psychology specialist and two educational technology experts. Further analysis determined that from the initial 525 articles identified, 120 were duplicate articles (Figure 1).

Quality Assessment Criteria

All papers that met the criteria for inclusion and exclusion (Table 2) were reviewed to check whether the paper met the Quality Assessment Criteria (QAC) list for the study’s PSE SLR (Table 3). Once again, the QAC was reviewed by three university-level experts, with each item being assessed for accuracy and clarity.

Finally, Figure 1 details the data manipulation process through a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart (Moher et al., 2009).

FIGURE 1
PRISMA FLOW DATA EXTRACTION PROCESS

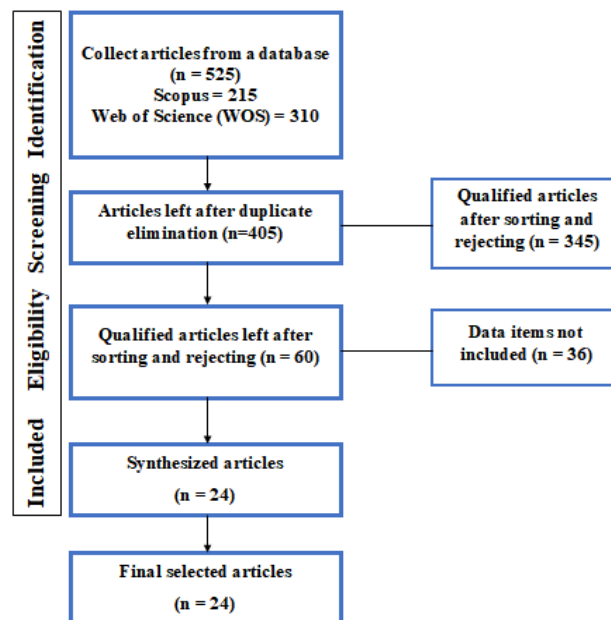


Table 2 details the inclusion and exclusion criteria used with the SLR on PSE. Each question in Table 2 had three options: correct or yes answers getting 1 point, no score = 0, and partially correct answer = 0.5 points. Articles are scored based on the content of the research question. The final sum must be greater than or equal to 7.5, the intersection for the document selection.

The remaining 60 articles were assessed for quality using a series of questionnaires, with 36 articles finally excluded. However, 24 articles were selected for further analysis and to answer research questions.

Table 3 shows the quality assessment criteria used for the SLR on PSE.

**TABLE 2
EXCLUSION AND INCLUSION CRITERIA**

Exclusion Criteria
<ul style="list-style-type: none"> - Programming self-efficacy articles that need to be updated. - Papers that were published outside the years 2017 to 2021. - Published research papers in a language other than English. - Published research papers that used no peer-review process.
Inclusion Criteria
<ul style="list-style-type: none"> - Up-to-date articles on programming self-efficacy - Published research papers from 2017 to 2021. - Published research papers in English - The published research went through a peer-review process.

**TABLE 3
QUALITY ASSESSMENT CRITERIA**

Quality Assessment Criteria
<ol style="list-style-type: none"> 1. Is the PSE concept clear? 2. Is the research objective clearly stated? 3. Were the research objectives achieved with the design? 4. How were the research tools designed? 5. Was the population clearly defined, and what methods were used to select the appropriate sample size for the analysis? 6. Are the answers to the research questions clear and complete? 7. Is the conclusion based on the results clearly explained? 8. Are the problems and limitations of the research discussed clearly? 9. Did the study offer further suggestions for studies related to PSE? 10. Is there a future research guideline?

RESULTS AND DISCUSSION

The following sections detail how the researchers answered the research questions from the Systematic Literature Review (SLR) analysis and results.

Definition of Higher Education Learner Programming Self-Efficacy (PSE)

The 24 articles selected were reference-related research, with most of the studies having concepts and factors affecting self-efficacy in general. However, eight articles described concepts and factors that affect PSE in terms of learners at a tertiary level.

Also, Gorson and O'Rourke (2020) added their interpretation of PSE, stating that PSE is a learner's confidence in their abilities to finish assignments. Therefore, this can significantly affect a student's decision to remain in computer science (CS) studies.

Unfortunately, lacking PSE can contribute to a high dropout rate in CS programs (Hines & Lynch, 2019). This is consistent with Gurer and Tokumaci (2020) and Kanaparan et al. (2019). They determined that students' attitudes or beliefs about programming and their PSE positively affect learning and can predict significant learning outcomes.

In multiple studies from Turkey, Erol (2020) discovered a significant and positive connection between robotic design activities and the 25 university students' attitudes toward programming and PSE. Ozturk (2021) also examined how student CT and PSE development were related and reported that their students' PSE beliefs improved significantly.

What Are the Main Research Objectives, Methods, and Outcomes of the PSE Study in the HE Context From 2017 to 2021?

The research summarizes the concept of PSE from various aspects and presents the tools used under different theoretical frameworks. In order to assess and clarify research on PSE in HE from 2017 to 2021, the investigators examined each paper's research objectives, methods, and findings to catalog the related information. From the analysis of the objectives of the selected articles, the researchers sorted them into multiple categories, as discussed in the following:

Factors

The factors related to learner success were examined. Articles in this category identified several factors that affect students' success in computer science, programming, or ICT, including students needing more knowledge about their perception of programming.

Relationships

The relationship of various related variables was also investigated, with articles in this category examining the relationship between various variables, including the effect of computer programming courses on students' ability to solve problems, their logic and reasoning skills, and the perception of each student's self-efficacy.

PSE Factors

The factors affecting student PSE were also examined. Articles in this category explored factors or learning activities related to student PSE.

Research PSE Factors

From the examination of related PSE factors, 50% ($n = 12$) of the articles fit into this category, with students' self-efficacy assessed from various perspectives.

For example, Ozturk (2021) examined the impact of programming courses designed with learning activities. The research questions asked whether the activities significantly improved students' computational thinking and did the activities significantly improve the learners' PSE.

In other studies from Turkey, Arslan, and İşbulan (2021) examined how teamwork and individual activities affected perceptions of PSE and attitudes toward robotic programming and determined there was a substantial difference in the pre-test and post-test PSE students' outcomes in both teamwork and individual workgroups.

In neighboring Greece, Psycharis and Kallia (2017) researched computer programming's effect on 66 secondary school students' Math self-efficacy, reasoning skills, and problem-solving skills. The authors concluded that there had been a significant difference in student reasoning skills in each group. Also, student self-efficacy between groups was significantly different. Finally, five papers examined the factors affecting student success accounting for 17% ($n = 4$).

PSE's Global Importance

The global importance of ICT education of PSE comes from numerous studies. In one such study, Gorson and O'Rourke (2020) interpreted PSE as a learner's belief in their ability to complete programming

tasks, significantly affecting their decision to remain in computer science (CS) studies. Erol (2020) in Turkey also discovered a significant and positive connection between robotic design activities and the researcher's university students' attitudes toward programming and PSE.

Moreover, Durak et al. (2019) examined 55 secondary student problem-solving skills (PSS) and their Influence on CT, PSE, and robotics programming. The findings revealed that a student's grade year influenced their CT and PSE. Also, Günbatar (2020) examined student computational thinking skills (CTS), computer programming skills, and PSE and found that computer PSE was a significant predictor of CTS.

Finally, Yildiz and Gündüz (2020) examined how peer instruction affected secondary school computer programming teaching and student PSE. Results showed that peer instruction increases students' PSE perceptions greater than traditional teaching methods.

CONCLUSION

This study used a systematic literature review (SLR) to investigate which factors played a role in higher education programming self-efficacy (PSE) using a systematic literature review (SLR). From two academic databases (Scopus and WOS) from 2017 to 2021, 525 papers concerning PSE were identified. After using inclusion and exclusion criteria and ten-part quality assessment criteria, 24 pages were retained for in-depth analysis.

Perspectives detailed how factors related to student PSE revealed the importance of PSE to student retention, satisfaction, academic achievement, and eventually becoming digitally enabled 21st-century knowledge workers. However, online formats need help in their development, execution, and evaluation. Therefore, it is believed that students have more significant input into what they feel makes their sessions more productive, and instructors should move more towards a 'student-centered' learning approach.

Furthermore, from the research questions, it was determined that interest in PSE-related issues is growing in higher education from the research objectives of the review and analysis of the 24 selected articles. Determination was also made that PSE research in higher education focuses on concepts and factors related to learners' PSE because 50% of the articles identified the research objectives as studying factors affecting learners' PSE.

Moreover, another 33% of articles examined the relationship between multiple variables, and 17% of the articles studied factors that may affect student success. The SLR studies concerning student success were focused on the relationships between PSE and learner achievement. Other articles focused more on PSE when applied to appropriate teaching methods.

Other theoretical frameworks and research methods also examined studies and tool validation related to PSE. Results revealed that quantitative research methodologies used questionnaires as a research tool for 90% of the selected articles.

This review is helpful for scholars to understand the definitions and applications of PSE in higher education and the other contexts of self-efficacy in programming.

LIMITATIONS AND SUGGESTIONS

This study conducted an SLR from only two academic databases (Scopus and WOS) from 2017 to 2021. As there are other resources, these should be explored. Also, as this study ages, more recent years and their studies should be examined. This study also examined research in English, but the researchers noted many papers in other languages on self-efficacy in programming, predominantly Turkish and Greek. Therefore, follow-on studies may explore these other languages.

Some of the studies in the final 24 papers selected for deep analysis touched on the role that gender played in PSE and its relationship to computational thinking, programming, and computer science studies. This should also be explored in more depth in future studies.

Similarly, the SLR also touched on age's role in PSE, with younger students lacking PSE. However, when paired up with older students, their PSE increased. The authors considered this aspect interesting, and

avenues should be explored to enhance early computer science and programming students' collaboration with older students.

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