Delft University of Technology

Teachers' Intention to Integrate Computational Thinking Skills in Higher Education
A Survey Study in the Netherlands

Zhang, Xiaoling; Aivaloglou, Efthimia ; Specht, Marcus

DOI
10.1109/EDUCON60312.2024.10578887

Publication date
2024

Document Version
Final published version

Published in
Proceedings of the 2024 IEEE Global Engineering Education Conference (EDUCON)

Citation (APA)
Zhang, X., Aivaloglou, E., & Specht, M. (2024). Teachers' Intention to Integrate Computational Thinking Skills in Higher Education: A Survey Study in the Netherlands. In *Proceedings of the 2024 IEEE Global Engineering Education Conference (EDUCON)* IEEE.
https://doi.org/10.1109/EDUCON60312.2024.10578887

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright
Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy
Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

This work is downloaded from Delft University of Technology.
For technical reasons the number of authors shown on this cover page is limited to a maximum of 10.

Green Open Access added to TU Delft Institutional Repository

'You share, we take care!' - Taverne project

https://www.openaccess.nl/en/you-share-we-take-care

Otherwise as indicated in the copyright section: the publisher is the copyright holder of this work and the author uses the Dutch legislation to make this work public.

Teachers' Intention to Integrate Computational Thinking Skills in Higher Education: A Survey Study in the Netherlands

1st Xiaoling Zhang
Delft University of Technology
Delft, the Netherlands
X.Zhang-14@tudelft.nl

2nd Efthimia Aivaloglou
Delft University of Technology
Delft, the Netherlands
E.Aivaloglou@tudelft.nl

3rd Marcus Specht
Delft University of Technology
Delft, the Netherlands
M.M.Specht@tudelft.nl

2024 IEEE Global Engineering Education Conference (EDUCON) | 979-8-3503-9402-3/24/$31.00 ©2024 IEEE | DOI: 10.1109/EDUCON60312.2024.10578887

***Abstract*—Computational Thinking (CT) is vital in today's digital era, especially in Engineering Education. While no official policy or teaching framework on CT education has been established in the Netherlands, a Western European country, there have been various initiatives for the integration of CT into the curriculum. Recognizing the crucial role of teachers in CT integration, we surveyed the perceptions and intentions of teachers in tertiary education in the Netherlands. Our survey encompassed two aspects: (1) teachers' perceptions of CT, and (2) their intentions to integrate CT into pedagogical activities. 38 teachers, mostly in Engineering Education, from across the Netherlands completed the questionnaire based on the UTAUT framework. Regarding CT perceptions, our investigation reveals that teachers possess an inadequate understanding of the relationship between CT and Computer Science, have limited training experiences in CT, and hold differing opinions on when and which constructs of CT should be integrated into different domains. Concerning teachers' intentions to integrate CT, the results exhibited a strong positive correlation between performance expectancy, attitude towards CT, and behavioral intention to implement CT in learning activities. To foster the integration of CT in tertiary education, our findings suggest the need for further development of higher education teacher training programs focused on CT and its relation to CS. Additionally, there is a call for further exploration of how to enhance teachers' performance expectancy and effort expectancy.**

***Index Terms*—Computational Thinking, Higher Education, Teachers, Perceptions, UTAUT**

I. Introduction

Computational Thinking (CT) has gained recognition as a crucial competence for students. The international educational and research communities have witnessed numerous practical and theoretical initiatives aimed at promoting CT in K-12 education [1]. In this context, teacher training has emerged as a key factor for successfully facilitating CT integration in the curriculum [2], [3]. Scholars such as Cuny [4] and Lye and Koh [5] have highlighted the significance of proper training and support for teachers in integrating CT into their daily teaching activities. According to Yadav et al. [6] beside the fact that there is an active discussion shaped by the Academy's report from The Royal Dutch Academy of Arts and Sciences (an advisory body to the Dutch government) in 2013, as well as explorative studies for example by Thijs et al. in 2014 [7] there is not yet an official national policy on integrating CT in the curriculum. It is worth noting that most existing studies on CT in the Netherlands have focused on the K-12 context [8], while scholars have identified the need for more implementations of CT within higher education [9], [10]. To identify the facilitators of CT education in the Netherlands, it is crucial to understand teachers' perceptions and intentions to integrate CT into their daily teaching activities in higher education.

Technology acceptance models, such as the Technology Acceptance Model (TAM) [11] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [12], are utilized to address users' perception and acceptance of new technologies or technological skills [13]. Several studies have applied these models to investigate teachers' perceptions and attitudes toward specific skills. For instance, Oluwole [14] employed TAM to explore the relationship between Information Literacy Skills and technology acceptance, revealing the influence of Internet knowledge on the perceived security of E-marketing. Additionally, Ling et al. [13] investigated teachers' perceptions of CT in Malaysian primary education using TAM-based questions and found a strong correlation between perceived ease of CT integration and teachers' attitudes toward behavioral intention. Similarly, Fessakis and Prantsoudi [15] surveyed Computer Science (CS) teachers in Greek primary and secondary schools regarding their perceptions, beliefs, and attitudes toward CT, employing the Theory of Reasoned Action (TRA) and TAM. One of their findings indicated that teachers considered secondary education as the most suitable level for CT integration.

In the context of the Netherlands, Bruggink [16] utilized the Theory of Planned Behavior (TPB) to identify factors influencing teachers' intention to implement CT in primary education programs, leading to the finding of the significant influence of subjective norm and perceived control on teachers' intention to integrate CT in teaching programs. Most related to our work is that of Specht and Joosse [17], who developed a questionnaire based on the UTAUT model to investigate teachers' attitudes and acceptance factors toward integrating CT skills in primary and secondary education classrooms.

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

They suggested using the UTAUT model to assess teachers' intention to implement coding skills in the curriculum. To the best of our knowledge, although the UTAUT model explains 70% of the variance in behavioral intention and outperforms previous models [12], it has not been applied in the higher education context.

To contribute evidence for designing effective training programs and providing proper support to teachers for the integration of CT in education, our study aims to investigate teachers' perceptions of CT skills and their intention to integrate CT into teaching and learning practices in the higher education context. To achieve this, we adopted items from the UTAUT model [12] and other existing studies that capture teachers' perceptions and intention on CT integration [13], [15], [17]. The research questions guiding our study are as follows:

RQ1 What are higher education teachers' perceptions of CT skills?

RQ2 What factors influence higher education teachers' intention to integrate CT in teaching and learning practices, and how do these factors relate to each other?

Regarding teachers' perception of CT, we examined their previous training, understanding the relation between CT and CS, scoring on the importance of CT constructs, views on who can teach CT, and what education level would be appropriate for CT integration. Regarding teachers' intention to integrate CT into pedagogical activities, we utilized the adopted UTAUT model and tested seven hypotheses.

The following sections present the background knowledge and theoretical bases for this study, the methodology we employed, the results and findings from a questionnaire-based survey of teachers, and finally, a discussion and conclusion based on the results.

II. Background and Related Work

A. CT, CT Frameworks, and the Hybrid Three-Dimensional CT Framework

Over the past few decades, numerous studies have focused on advancing CT education in various aspects, such as curriculum design, the development of teaching materials and tools, assessment frameworks, and teacher training programs. Wing emphasized the significance of CT, positioning it alongside essential skills such as reading, writing, and counting [18]. Research has shown that CT can enhance higher-order thinking skills and improve problem-solving abilities [19]–[21].

Integrating CT concepts into classrooms and effectively delivering them requires comprehensive exploration and identifying appropriate support mechanisms to assist teachers in their teaching practices. However, one challenge in this regard is the lack of a universally agreed operational definition of CT.

Throughout the years, various operational definitions of CT have emerged, encompassing key concepts, skills, and examples of its integration in different scenarios. For instance, Wing suggested that CT involves dimensions such as *abstraction, problem decomposition, pattern recognition, algorithmic thinking,* and *logical thinking* [18]. Computer Science Teachers Association (CSTA) and International Society for Technology in Education (ISTE) included nine core concepts and capabilities in CT, including *data manipulation (collection, analysis, representation), problem decomposition, abstraction, algorithms and procedures, automation, parallelization,* and *simulation* [22]. Other dimensions have been proposed in other studies (e.g. [1], [23], [24]. However, most operational definitions primarily cover limited dimensions and are predominantly adopted in K-12 contexts.

In the context of higher education, the latest comprehensive framework is a hybrid three-dimensional framework from Lu et al. [9], which is derived from Weintrop et al.'s CT framework for mathematics and science classrooms [25], Grover and Pea's two-dimensional framework [26], and Brennan and Resnick's three-dimensional framework [27]. This hybrid framework encompasses 26 dimensions, shown in Figure 1, and it serves as the adopted framework in the present study.

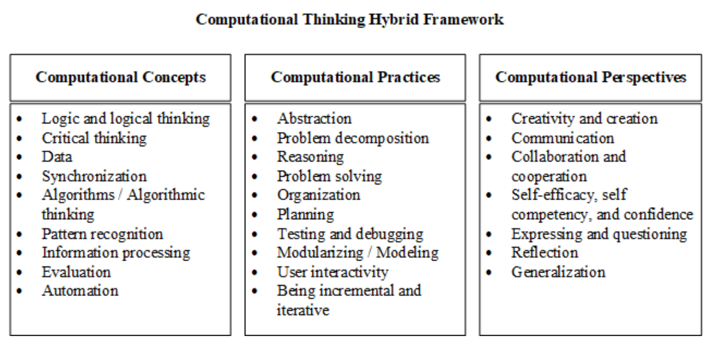

Fig. 1. Hybrid three-dimensional CT framework [9]

B. Technology Acceptance Models

Several theories and models have been developed in the past few decades to examine users' acceptance or rejection of specific technologies or technological skills for decision-making purposes. These models focus on the factors influencing users' intention to implement the technology in their practices.

One well-known model is the TAM, proposed by Davis [11], which originated from the psychological theories of reasoned action and planned behavior. TAM assumes that perceived ease of use and perceived usefulness mediate the relationship between system characteristics (external variables) and potential system usage. Other models that have been utilized in this area include the Theory of Planned Behavior [28], Diffusion of Innovation theory [29], Theory of Reasoned Action [30], Model of PC Utilization [31], Motivational Model [32], Unified Theory of Acceptance and Use of Technology (UTAUT) [12], and Social Cognitive Theory [33].

Several technology acceptance models have been applied to investigate the integration of Computational Thinking (CT) in education. For instance, Ling et al. [13] employed the Technology Acceptance Model (TAM) to explore Malaysian teachers' perceptions of CT in primary education through a questionnaire. Specht and Joosse [17] utilized the UTAUT model to examine teachers' attitudes and acceptance factors

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

regarding the integration of CT skills in primary and secondary education in the Netherlands. Bruggink [16] employed the Theory of Planned Behavior (TPB) to identify factors influencing teachers' intention to implement CT in primary education programs in the Netherlands. Fessakis and Prantsoudi [15] used the Theory of Reasoned Action (TRA) and the Technology Acceptance Model (TAM) to survey Computer Science (CS) teachers in Greece, investigating their perceptions, beliefs, and attitudes towards CT in primary and secondary school.

Among the various models mentioned, the UTAUT model [12], which was developed based on earlier models, has shown superior performance by explaining 70% of the variance in behavioral intention. The UTAUT model comprises four key constructs: effort expectancy (EE), performance expectancy (PE), social influence (SI), and facilitating conditions (FC). Additionally, it includes four moderating variables: age, gender, experience, and voluntariness of use. Specht and Joosse [17] investigated the attitude and acceptance factors by including PE, EE, SI, FC, and attitude (AT) as independent variables. Considering that this study aims to investigate teachers' perceptions of CT skills and their intention to integrate CT into teaching and learning practices, we have adapted Venkatesh et al.'s (2003) [12] UTAUT model through discussions between the authors. The adapted model includes PE, EE, SI, FC, BI (behavioral intention), AT, and voluntariness of use.

III. Method

A. Design

This survey study adheres to the research procedure outlined by Bethlehem [34], encompassing study design, data collection, data editing, non-response correction, data analysis, and publication. The primary research design employed in this study is predominantly quantitative, aiming to investigate the relationship between various factors measured using scale-rated questions. The specific areas under investigation in this research encompass participants' demographic information, their perceptions of CT, and their intention to integrate CT into teaching and learning practices. To examine participants' perceptions of CT, relevant questions have been adapted from existing works, as indicated in Section III-C. For assessing the intention to integrate CT in higher education, in this study, we utilized the UTAUT model for its high explainability [12] similar to how it has been applied in [17]. Within the UTAUT framework, the dependent variable is behavioral intention (BI) to incorporate CT into teaching and learning practices, while the independent variables consist of performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), attitude (AT), and voluntariness of use (VU).

B. Participants - Population and Sampling

The participants of this study consisted of experienced teachers in higher education in the Netherlands, with a particular focus on teachers from non-computer science (CS) domains. To ensure compliance with General Data Protection Regulation (GDPR) regulations and to facilitate the practicality of conducting survey research, a combination of convenience sampling and referral sampling methods was employed as the sampling approach.

Convenience sampling involved selecting participants who were readily available or easily recruitable for the study. Various strategies were employed, such as displaying QR codes and distributing leaflets during workshops and other institutional events where higher education teachers were likely to participate, as well as utilizing social media platforms like blog posts, LinkedIn, Twitter, and institutional newsletters to disseminate the survey.

Referral sampling, on the other hand, encompassed two techniques. Firstly, network sampling was utilized, wherein a probability sample of a larger population likely to have connections to the target population was obtained by contacting communication officers and different contact persons at institutions such as Delft University of Technology. Secondly, snowball sampling was employed, whereby research participants who volunteered to be part of the study were requested to identify and invite additional individuals who met specific characteristics and were potentially willing to participate in the research. Participants were also encouraged to share the survey study within their network.

Before their participation, the teachers were provided with an informed consent form explaining the purpose of the research. A total of 84 individuals responded to the questionnaire, and out of the total responses received, 38 responses were complete and were deemed suitable for analysis.

C. Materials - Instrumentation

A comprehensive questionnaire consisting of a total of 13 questions, including sub-questions within certain items, was employed as the data collection instrument. The construction of the survey involved a systematic process of identifying constructs appropriate for answering the research questions via reviewing relevant literature and engaging in discussions with subject matter experts. The primary author formulated an initial survey draft based on these constructs, which was subsequently refined iteratively through feedback received from both experts and the remaining authors.

The final version of the survey encompassed the following key components: (1) Informed Consent: Participants were provided with an informed consent section outlining the purpose and nature of the study; (2) Demographic Information: Participants were requested to provide demographic details, including gender (Q1), age range (Q2), educational background (Q3), as well as their teaching and training experiences (Q4-Q5); (3) Perceptions and Understanding of CT: The questionnaire included items (Q6-Q10) aimed at assessing participants' perceptions and understanding of computational thinking (CT); (4) UTAUT Model Factors: Questions (Q11) pertaining to factors derived from the UTAUT model were incorporated to explore their potential influence on participants' intention to integrate CT into teaching and learning practices; (5) Optional Questions: Two additional questions (Q12-Q13) were provided

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

on an optional basis; one question invited participants to provide supplementary comments on skills they deemed important in higher education within their respective domains; the second question sought to identify whether participants were located outside the Netherlands. An overview of the questions can be found in the supplementary file [1]. The subsequent subsections will elaborate further on the specific items included in the study.

1) RQ1 - Teachers' Perceptions and Understanding on CT (Q6-Q10): Questions Q6 to Q10 were specifically included to address RQ1, which focused on exploring participants' perceptions of computational thinking (CT). The selection and adaptation of these questions were guided by relevant scholarly works in the field.

Q6, derived from the study conducted by Ling et al. [13], was incorporated to assess respondents' understanding of computer programming, CT, and computers. This question aimed to gain insights into participants' existing knowledge and comprehension of these concepts.

Q7, adapted from Fessakis [15], served to examine participants' understanding of the relationship between CT and computer science (CS). By utilizing this question, the study sought to gauge participants' awareness of the connection between CT and the broader field of CS.

To investigate the significance of various CT dimensions in participants' understanding, Q8 included CT constructs identified in Lu et al.'s [9] comprehensive review. This question aimed to explore participants' perceptions of the importance attributed to different facets of CT.

Additionally, Q9 and Q10, adapted from Fessakis [15], were included to probe participants' views on who should teach CT and when it is deemed appropriate to integrate CT, respectively. These questions aimed to shed light on the perspectives regarding the stakeholders involved in CT education and the optimal timing for its integration into teaching and learning practices.

Last but not least, concerning respondents' perceptions regarding the importance of computational thinking (CT) skills, Q12 aimed to explore the skills within the realms of computer science (CS), data science, or machine learning that are deemed relevant to graduates in the respondents' respective domains.

The incorporation of these specific questions aimed to gather comprehensive insights into participants' perceptions of CT and its various dimensions, thereby addressing the research objective outlined in RQ1.

2) RQ2 - UTAUT Model Structure and Definition of Each construct (Q11): To address RQ2, we operationalized the constructs and sub-constructs of our research model based on the UTAUT framework proposed by Venkatesh et al. [12]. These constructs were integrated into Question 11 of the questionnaire. This section of the survey enabled the assessment of both the independent and dependent variables outlined in the UTAUT model, utilizing a 5-point scale.

[1]Supplementary file available at https://drive.google.com/file/d/1p8AtRJLc993_Aoyb7FIRmIE3zt-_hVMz/view?usp=sharing

The questionnaire items related to the independent variables were distributed as follows: Performance Expectancy (PE) comprised four questions, Effort Expectancy (EE) included four questions, Attitude (AT) consisted of four questions, Social Influence (SI) encompassed four questions, Facilitating Conditions (FC) involved four questions, and Voluntariness of Use (VU) comprised four questions. Each of these variables was measured using a 5-point scale to capture participants' perceptions.

The dependent variable in the questionnaire pertained to the "intention to integrate CT into teaching" and was assessed through three sub-questions presented in the supplementary file. These questions aimed to gauge participants' intentions to incorporate CT into their teaching practices and were rated on a 5-point scale.

By employing the UTAUT framework and utilizing a comprehensive set of items, this section of the questionnaire allowed for the measurement of the independent variables and the dependent variable in our research model. The inclusion of these specific items enabled the exploration of participants' perceptions and intentions regarding the integration of CT into teaching and learning practices.

Hypotheses for the Constructs: Based on the constructs incorporated in the research model, the following hypotheses were formulated:

- **H1**: There exists a positive relationship between performance expectancy and teachers' intention to integrate CT.
- **H2**: There exists a positive relationship between effort expectancy and teachers' intention to integrate CT.
- **H3**: There exists a positive relationship between social influence and teachers' intention to integrate CT.
- **H4**: There exists a positive relationship between facilitating conditions and teachers' intention to integrate CT.
- **H5**: There exists a positive relationship between attitude and teachers' intention to integrate CT.
- **H6**: There exists a positive relationship between voluntariness of use and teachers' intention to integrate CT.
- **H7**: There exists a relationship between different pairs of independent variables.

D. Procedure

1) Survey Implementation and Distribution: In line with the survey design, an online questionnaire was developed using the Qualtrics platform. The questionnaire can be accessed through a provided link: https://tudelft.fra1.qualtrics.com/jfe/form/SV_egFndjtwP6Ljfvw. To ensure data anonymization, IP address tracking was disabled in the implemented Qualtrics survey. Before the formal commencement of the survey study, a pilot testing phase was conducted. Professionals in higher education were approached through the authors' network to seek their feedback and suggestions. This pilot testing aimed to refine the questionnaire and ensure its content validity. Subsequently, the questionnaire was distributed as addressed in Section III-B. The questionnaire yielded a total of 84 responses from October 2022 to May 2023, out of which 38 responses (45.2%) were deemed valid for analysis.

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

2) Data Inspection, Editing, Non-response correction: By May 2023, a total of 84 responses were received for the survey. Some of these responses were deemed unusable due to incompleteness or other errors commonly encountered in survey data. To facilitate data processing, including data editing and non-response correction, the responses were downloaded from the Qualtrics platform in Excel files. Incomplete responses and test cases created by the authors were subsequently excluded from the completed sample. As a result, a final sample size of 38 responses remained for further analysis.

E. Data Analysis Techniques

The collected data underwent several analyses to assess the reliability of the questionnaire, explore descriptive statistics of the sample, and investigate the hypothesized relationships between the measured variables. These analyses included basic data analysis, calculation of Cronbach's alpha coefficient to evaluate questionnaire reliability, and correlation analysis to examine the associations among variables. Additionally, regarding the open-text question Q12, among the 34 respondents who provided answers to this optional open-text question, their responses were analyzed using directed content analysis, applying existing skill categories shown in Figure 1.

TABLE I
DESCRIPTIVE ANALYSIS OF THE SAMPLE (Q1-Q5)

Items	Category	Frequency	%
Gender	Female	10	26.3 %
	Male	26	68.4 %
	Prefer not to say	2	5.3 %
Age	21-30	5	13.2 %
	23-40	13	34.2 %
	41-50	10	26.3 %
	51-60	7	18.4 %
	Above 60	3	7.9 %
Education	Bachelor of Science (BSc)	1	2.6 %
	Master of Arts (MA)	1	2.6 %
	Master of Science (MSc)	9	23.7 %
	Ph.D.	25	65.8 %
	Others	2	5.3 %
Experience in teaching in higher education	1-3 year (s)	7	18.4 %
	3-5 year	3	7.9 %
	5-10 year	9	23.7 %
	More than 10 years	19	50.0 %
Teaching Domain Classification	Alfa	6	15.8 %
	Beta	20	52.6 %
	Gamma	5	13.2 %
	Alfa and Beta	1	2.6 %
	Alfa and Gamma	2	5.3 %
	Beta and Gamma	3	2.6 %
	Not applicable	1	7.9 %

IV. RESULTS AND ANALYSIS

A. Descriptive Analysis of the Sample (Q1-Q5 and Q13)

A summary of participant profiles is provided in Table I. According to answers to Q13, all respondents in the study were or had been involved in teaching activities within the Netherlands, with males constituting the majority. The age distribution indicated that most participants fell within the 31-40 age group. Furthermore, a significant proportion of the respondents held a Ph.D. degree and had more than 10 years of teaching experience in the field of Beta domain, as per the categorization outlined in the document provided by the National Research Council of the Netherlands. Additionally, Figure 2 presents a word cloud representing the frequency of terms in the responses to Q5. The larger the size of the term, the higher its frequency in the dataset. The most frequently occurring terms in the word cloud include science, design, and engineering.

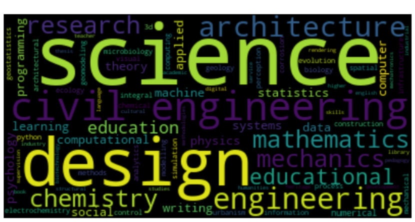

Fig. 2. Word cloud for the domains/subjects. (Q5)

B. RQ1: Teachers' and Perceptions of CT in Higher Education (Q6-Q8, and Q12)

Teachers' training and workshops on CT/CS/Programming were captured with Q6, the results presented in Table II present the findings. It reveals that 26.3% of the participants reported never attending any workshops or training related to computer science or programming. At the same time, a larger proportion, specifically 63.2%, indicated no attendance in workshops or training specifically focused on computational thinking (CT).

When examining participants' understanding of the relationship between CT and computer science (CS), only 26.3% of the respondents provided the anticipated response, acknowledging that CT and CS intersect and are not entirely distinct. A majority of the participants (57.9%) expressed that CS is a subset of CT (Table III). These results show that the respondents seem to have an inadequate understanding of the relationship between CT and CS.

TABLE II
TRAINING WITH COMPUTER SCIENCE (CS) AND/OR PROGRAMMING AND COMPUTATIONAL THINKING (CT) (Q6)

Item	Category	Frequency	%
I have attended workshops / training related to computer science and / or programming.	Never	10	26.3 %
	Once	3	7.9 %
	Sometimes	15	39.5 %
	Repeatedly	6	15.8 %
	Regularly	4	10.5 %
I have attended workshops / training related to Computational Thinking.	Never	24	63.2 %
	Once	2	5.3 %
	Sometimes	7	18.4 %
	Repeatedly	3	7.9 %
	Regularly	2	5.3 %

In terms of respondents' perceptions regarding the importance of CT dimensions and constructs, we examined the mean and standard deviation values on the transformed Likert scale (ranging from 1 for "Not important" to 5 for "Very important"). The findings, as presented in Table IV, indicate that all CT dimensions (CT concepts, CT practices,

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

TABLE III
TEACHERS' UNDERSTANDING OF THE RELATION BETWEEN CT AND CS (Q7)

Category	Frequency	%
CT is a concept wider than CS, because it further includes the ability to solve problems in various disciplines, even without the use of computers.	22	57.9 %
CT and CS have common attributes, but each one also has special, discrete attributes.	10	26.3 %
CS is a concept wider than CT, because it further includes, e.g. the study of computation, programming languages, and computer hardware.	6	15.8 %

and CT perspectives) are deemed important. Notably, CT perspectives exhibit the highest standard deviation, suggesting greater variability in respondents' perceptions. Furthermore, the correlation analysis conducted on the importance of CT dimensions reveals moderate correlations among all dimensions. This implies that the various CT dimensions are interconnected to some extent. The distribution of the importance values for each CT construct is visually represented in Figure 3. It can be observed that most constructs have a median value of 4, indicating a relatively high level of importance attributed to them. However, none of the constructs reached the maximum value of 5, indicating that no respondents considered any of the constructs as "Very important."

Concerning respondents' perceptions regarding the importance of computational thinking (CT) skills, Question 12 aimed to explore the skills deemed relevant to graduates in the respondents' respective domains, specifically within the realms of computer science (CS), data science, or machine learning.

By analyzing the answers to the open-text question, we identified eight constructs from CT practices (*abstraction, being incremental and iterative, debugging, modularization/modeling, organizing, planning, problem decomposition, problem-solving*), six constructs from CT concepts (*algorithm / algorithmic thinking, critical thinking, data, evaluation, logic and logical thinking, pattern recognition*), and three constructs from CT perspectives (*collaboration, communication, generalization*).

Among the various responses, the most frequently mentioned CT constructs were *abstraction, algorithm / algorithmic thinking, critical thinking, data, logical thinking*, and *modeling*. Additionally, respondents from different domains often referenced *programming, software engineering, artificial intelligence*, and *machine learning* in their answers, indicating their significance within the context of CT skills.

TABLE IV
MEANS AND STANDARD DEVIATIONS FOR EACH CT DIMENSION (Q8)

	Mean	Standard deviation
avg_CT concepts	3.47	0.292
avg_CT practices	3.48	0.350
avg_CT perspectives	3.50	0.514

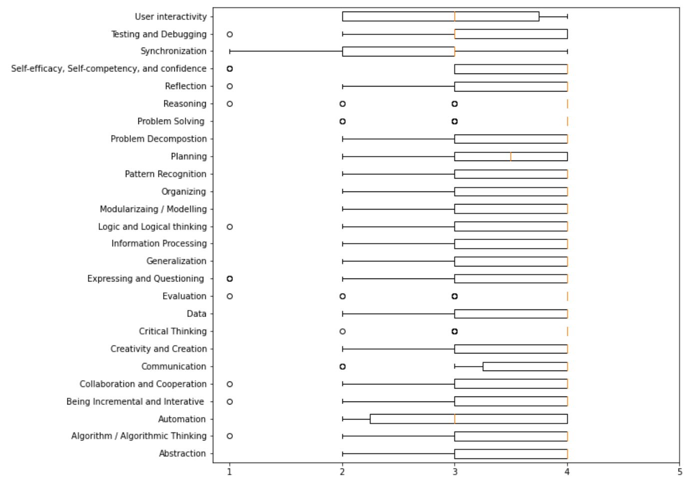

Fig. 3. Summary of values on the importance for each CT dimension (Q8)

Question Q9 aimed to investigate respondents' perceptions regarding the individuals who should teach computational thinking (CT). The findings, summarized in Table V, reveal that a majority of the respondents (52.6%) believe that all teachers could effectively teach CT after receiving appropriate training. Conversely, a smaller portion of the participants expressed the view that only teachers with a background in computer science (CS) education should be responsible for teaching CT. Notably, a significant number of respondents hold the belief that anyone can teach CT, irrespective of prior experience in CS.

Regarding the integration of CT into different levels of education (Q10), respondents primarily identified secondary and tertiary education as the most suitable contexts for incorporating CT. In contrast, the responses regarding primary and secondary education were relatively limited, accounting for only 2.6% of the total, as presented in Table V.

TABLE V
WHO CAN TEACH CT (Q9)

Items	Counts	%
All teachers, regardless of Computer Science (CS) education experience	16	42.1 %
Teachers with Computer Science (CS) education	2	5.3 %
Teachers with proper training in Computer Science (CS) knowledge	20	52.6 %

C. Intention to Integrate CT - UTAUT Model

To explore respondents' intention to integrate computational thinking (CT) into their teaching and learning practices, we analyzed the responses to the UTAUT items. Firstly, we examined the descriptive statistics of the UTAUT items, assessing their reliability and validity. Subsequently, we calculated coefficients for the variables within the adapted UTAUT model. The mean and standard deviation values for each dimension are presented in Table VII, indicating that most dimensions

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

TABLE VI
INTEGRATION AND TEACHING OF CT IN EDUCATION (Q10)

Items	Counts	%
Primary school (primary education)	5	13.2 %
High School (secondary education)	6	15.8 %
Tertiary education (higher education)	4	10.5 %
Primary school (primary education) & High School (secondary education)	1	2.6 %
High School (secondary education) & Tertiary education (higher education)	10	26.3 %
Primary school (primary education) & High School (secondary education) & Tertiary education (higher education)	12	31.6 %

had a mean score above three and a standard deviation higher than 0.6.

To assess the internal consistency of the items, Cronbach's alpha was calculated for each dimension, as shown in Table VIII. All dimensions demonstrated an acceptable level of internal consistency.

TABLE VII
MEANS AND STANDARD DEVIATIONS FOR EACH UTAUT DIMENSION USED IN THIS PAPER (Q11)

	Mean	Standard deviation
avg_PE	3.51	0.604
avg_EE	3.02	0.796
avg_AT	3.66	0.791
avg_SI	2.43	0.644
avg_FC	2.74	0.744
avg_VU	3.50	0.828
avg_BI	3.20	0.951

TABLE VIII
CONSTRUCT RELIABILITY FOR EACH DIMENSION

Construct	Cronbach's Alpha
Performance Expectancy (PE)	0.702
Effort Expectancy (EE)	0.825
Social Influence (SI)	0.924
Facilitating Conditions (FC)	0.715
Attitude (AT)	0.678
Voluntariness of Use (VU)	0.875
Behavior Intention (BI)	0.945

To test each of the hypotheses, Pearson correlation analysis was employed. The correlation model is illustrated in Figure 4. Out of the six hypotheses (H1 to H6), five were accepted, as they exhibited strong correlations. Performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), and attitude (AT) significantly influenced respondents' behavioral intention (BI) at varying levels of significance, thereby supporting H1 to H5. Among these factors, social influence (SI) demonstrated a relatively weaker correlation with behavioral intention. Notably, there was a slightly negative correlation between respondents' behavioral intention (BI) and voluntariness of use (VU), thus rejecting H6.

Regarding H7, the correlations varied between different pairs of independent variables. Among all the determinants of behavioral intention (BI), attitude (AT) emerged as the most influential factor, primarily influenced by performance expectancy (PE) and effort expectancy (EE).

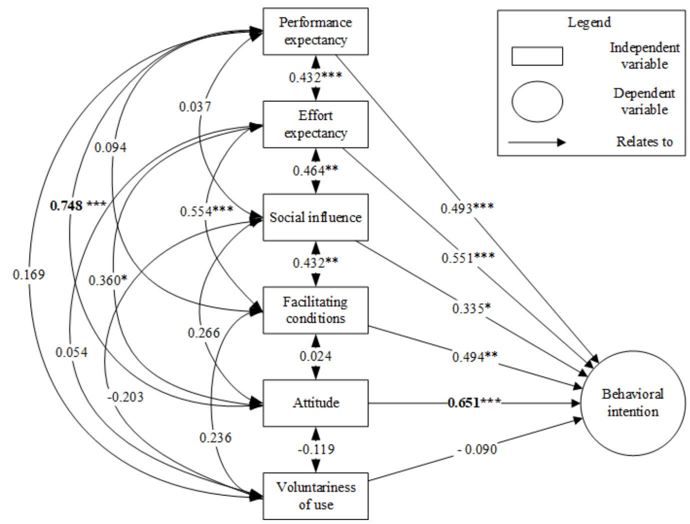

Fig. 4. Adapted UTAUT model with correlation values (Q11), *Note. The p values are indicated by the number of *(s): * p <.05, ** p <.01, *** p <.001*

V. DISCUSSION

To examine teachers' perception of CT and their intention to integrate CT into their pedagogical activities, we adopted and adapted questions from existing studies, including items adopted from the UTAUT model. Regarding teachers' perception of CT, we examined their training with CS and/or programming and CT, understanding of the relation between CT and CS, scoring on the importance of CT constructs, views on who can teach CT, and what education level would be appropriate for CT integration. Regarding teachers' intention to integrate CT into pedagogical activities, we utilized the adopted UTAUT model and tested seven hypotheses, six of which were supported. The findings of this study are further discussed below.

A. Teachers' perception on CT

As shown in the last section, current CT education remains largely dominated by STEM subjects. A significant proportion of respondents reported never having attended workshops or training related to CT, and a majority demonstrated a low level of understanding regarding the relationship between CS and CT. We speculate that the low understanding level regarding the relationship between CS and CT could be attributed to the lack of CT-specific workshops or training, despite having attended workshops or training in CS. Prior works [35], [36] have emphasized the importance of adequate preparation for teachers to effectively incorporate CT into their teaching and learning practices. This suggests that one potential approach to enhancing CT education is to equip teachers with CT knowledge via structural training. Meanwhile, it is notable that more than a third of the respondents believed that individuals could teach CT regardless of their experience in CS education. The authors advocate here that it is vital to understand the

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

connotation of CT for the teachers, investigate the common ground among teachers, and identify what can be taught by teachers regardless of their experience in CS education. Additionally, the results show that respondents consider all levels of education, from primary to tertiary, as appropriate for implementing CT. This raises questions regarding what should be taught at each level and how to facilitate a smooth transition in teaching practices between different educational levels, if necessary.

The investigation also reveals that six constructs from the hybrid CT framework used in this study (i.e., abstraction, algorithm/algorithmic thinking, critical thinking, data, logical thinking, and modeling) are identified as important for graduates across various domains. These constructs align with those commonly found in K-12 education frameworks, suggesting consistency in curriculum design from K-12 to higher education. However, further exploration is needed to determine how these constructs should be operationalized within the context of higher education. Additionally, respondents identified other skills, such as programming, software engineering, artificial intelligence, and machine learning, as important for their graduates.

B. Teachers' intention to CT integration

The second part of this research aimed to examine teachers' intention to integrate CT skills into their pedagogical activities. All hypotheses, except for H6, received support. The study found that attitude, effort expectancy, facilitating conditions, performance expectancy, and social influence significantly influenced teachers' behavioral intention to integrate CT into their pedagogical activities. Notably, attitude (AT) exerted the most influence on teachers' behavioral intention, with performance expectancy (PE) and effort expectancy (EE) playing major roles in shaping attitudes. Although the original UTAUT model does not emphasize attitude, this finding aligns with studies by Specht and Joosse [17], Ling et al. [13], and Fessakis et al. [15], highlighting the significance of attitude in the integration of CT into education across different levels. Regarding PE and EE, when teachers have higher PE and EE, believing that integrating CT can help them teach well, such as improving their teaching efficiency and quality, and believing that integrating CT is easy, the intention of integrating CT is likely to be higher. This shows that helping the teachers understand the usefulness of CT integration and making it accessible for teachers to implement CT integration is vital for promoting CT integration in education.

VI. Limitations & Threats to Validity

A threat to the external validity of this study concerns the sample of respondents. Since the participation in the survey was voluntary, the sample can be considered occasional and there was no prior mechanism to ensure its representativeness, which is susceptible to self-selection bias. Even though the respondents reported specializing in a wide range of scientific domains, some disciplines were not represented adequately or at all, which did not allow for exploring interdisciplinary differences. Moreover, it is vital to note that the responses were obtained in the context of higher education in the Netherlands, which might not guarantee the generalizability of results in other contexts.

Concerning construct and internal validity, most of the questions used in this study were adopted from existing studies, the survey was reviewed by all authors and experts, and tested by a pilot study to examine ambiguities. Nonetheless, some items in the survey can still be misinterpreted by participants as the authors and the group of participants involved in the pilot study may not be sufficiently representative of the covered respondents.

Additionally, it should be noted that, limited by the method, this research could not explain causality.

VII. Conclusion

This study investigated higher education teachers' perceptions of CT and their intention to integrate CT via a survey that collected data from teachers in various disciplines. Through this study, we found a necessity to improve teachers' understanding of CT, potentially by offering training and workshops. Moreover, we identified the need to raise teachers' intention to integrate CT into their pedagogical activities within the context of the Netherlands, mainly regarding changing their attitudes that can be dominantly determined by performance expectancy and effort expectancy. Last but not least, discussions on what and when to integrate CT is needed as various views were identified in this study. It should be noted that, while disciplinary differences can significantly influence teachers' perceptions of CT and their intention to integrate CT into pedagogical activities, this study did not allow for exploration in this direction. Therefore, future work can further explore the disciplinary differences with more focused groups of participants.

References

[1] S. Grover and R. Pea, "Computational Thinking in K-12: A Review of the State of the Field," *Educational Researcher*, vol. 42, no. 1, pp. 38–43, 2013.

[2] A. Yadav, N. Zhou, C. Mayfield, S. Hambrusch, and J. T. Korb, "Introducing computational thinking in education courses," in *SIGCSE'11 - Proceedings of the 42nd ACM Technical Symposium on Computer Science Education*, 2011, pp. 465–470. [Online]. Available: http://cs4edu.cs.purdue.edu/comp_think

[3] A. Yadav, C. Mayfield, N. Zhou, S. Hambrusch, and J. T. Korb, "Computational Thinking in Elementary and Secondary Teacher Education," *ACM Transactions on Computing Education (TOCE)*, vol. 14, no. 1, mar 2014. [Online]. Available: https://dl.acm.org/doi/10.1145/2576872

[4] J. Cuny, "Transforming computer science education in high schools," *Computer*, vol. 44, no. 6, pp. 107–109, 2011. [Online]. Available: http://csta.acm.org/Research/

[5] S. Yee Lye and J. Hwee Ling Koh, "Review on teaching and learning of computational thinking through programming: What is next for K-12?" 2014. [Online]. Available: http://dx.doi.org/10.1016/j.chb.2014.09.012

[6] A. Yadav, S. Gretter, J. Good, T. Mclean, A. Yadav, S. Gretter, . J. Good, and . T. Mclean, "Computational Thinking in Teacher Education," *Emerging Research, Practice, and Policy on Computational Thinking*, pp. 205–220, 2017. [Online]. Available: https://link.springer.com/chapter/10.1007/978-3-319-52691-1_13

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.

[7] A. M. Thijs, P. H. G. Fisser, and M. van der Hoeven, *21e eeuwse vaardigheden in het curriculum van het funderend onderwijs [21st century skills in the curriculum of Dutch primary and lower secondary education]*. SLO, nationaal expertisecentrum leerplanontwikkeling, 2014.

[8] A. Yadav, J. Good, J. Voogt, and P. Fisser, "Computational thinking as an emerging competence domain," *Competence-based vocational and professional education: Bridging the worlds of work and education*, pp. 1051–1067, 2017.

[9] C. Lu, R. Macdonald, B. Odell, V. Kokhan, C. Demmans Epp, and M. Cutumisu, "A scoping review of computational thinking assessments in higher education," *Journal of Computing in Higher Education*, vol. 34, no. 2, pp. 416–461, 2022.

[10] J. A. Lyon and A. J. Magana, "Computational thinking in higher education: A review of the literature," *Computer Applications in Engineering Education*, vol. 28, no. 5, pp. 1174–1189, 2020.

[11] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS quarterly*, pp. 319–340, 1989.

[12] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS quarterly*, pp. 425–478, 2003.

[13] U. L. Ling, T. C. Saibin, J. Labadin, and N. A. Aziz, "Preliminary investigation: Teachers perception on computational thinking concepts," *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, vol. 9, no. 2-9, pp. 23–29, 2017.

[14] O. Durodolu, "Technology acceptance model as a predictor of using information system'to acquire information literacy skills." *Library Philosophy & Practice*, 2016.

[15] G. Fessakis and S. Prantsoudi, "Computer science teachers' perceptions, beliefs and attitudes on computational thinking in greece." *Informatics in Education*, vol. 18, no. 2, pp. 227–258, 2019.

[16] B. Bruggink, "Behavioural intention of teachers for teaching computational thinking in primary education," Master's thesis, 2019.

[17] M. Specht and R. J. Joosse, "Technology acceptance and teacher attitude for computational thinking in the netherlands," *CoolThink@ JC*, p. 113, 2019.

[18] J. M. Wing, "Computational thinking," *Communications of the ACM*, vol. 49, no. 3, pp. 33–35, 2006.

[19] Y. B. Kafai and Q. Burke, "Computer programming goes back to school," *Phi Delta Kappan*, vol. 95, no. 1, pp. 61–65, 2013.

[20] G. Fessakis, E. Gouli, and E. Mavroudi, "Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study," *Computers & Education*, vol. 63, pp. 87–97, 2013.

[21] S. Einhorn, "Microworlds, computational thinking, and 21st century learning," *LCSI White Paper*, vol. 2, pp. 2–10, 2012.

[22] ISTE and CSTA, "leadership toolkit first edition," Tech. Rep., 2011. [Online]. Available: https://cdn.iste.org/www-root/2020-10/ISTE_CT_Leadership_Toolkit_booklet.pdf?_ga=2.241613378.1334721248.1633275757-262716800.1628547941

[23] V. Barr and C. Stephenson, "Bringing computational thinking to k-12: What is involved and what is the role of the computer science education community?" *Acm Inroads*, vol. 2, no. 1, pp. 48–54, 2011.

[24] C. Selby, "Computational Thinking : The Developing Definition," *ITiCSE Conference 2013*, pp. 5–8, 2013.

[25] D. Weintrop, E. Beheshti, M. Horn, K. Orton, K. Jona, L. Trouille, and U. Wilensky, "Defining computational thinking for mathematics and science classrooms," *Journal of science education and technology*, vol. 25, pp. 127–147, 2016.

[26] S. Grover and R. Pea, "Computational thinking: A competency whose time has come," *Computer science education: Perspectives on teaching and learning in school*, vol. 19, no. 1, pp. 19–38, 2018.

[27] K. Brennan and M. Resnick, "New frameworks for studying and assessing the development of computational thinking," in *Proceedings of the 2012 annual meeting of the American educational research association, Vancouver, Canada*, vol. 1, 2012, p. 25.

[28] I. Ajzen, "The theory of planned behavior," *Organizational behavior and human decision processes*, vol. 50, no. 2, pp. 179–211, 1991.

[29] E. M. Rogers, *Diffusion of innovations*. Simon and Schuster, 2010.

[30] J. L. Hale, B. J. Householder, and K. L. Greene, "The theory of reasoned action," *The persuasion handbook: Developments in theory and practice*, vol. 14, no. 2002, pp. 259–286, 2002.

[31] R. L. Thompson, C. A. Higgins, and J. M. Howell, "Influence of experience on personal computer utilization: Testing a conceptual model," *Journal of management information systems*, vol. 11, no. 1, pp. 167–187, 1994.

[32] M. Igbaria, S. Parasuraman, and J. J. Baroudi, "A motivational model of microcomputer usage," *Journal of management information systems*, vol. 13, no. 1, pp. 127–143, 1996.

[33] D. H. Schunk, "Social cognitive theory." *APA educational psychology handbook*, vol. Theories, constructs, and critical issues, no. 1, pp. 101–123, 2012.

[34] J. Bethlehem, *Applied survey methods: A statistical perspective*. John Wiley & Sons, 2009.

[35] R. Glaser, "Education and thinking: The role of knowledge." *American psychologist*, vol. 39, no. 2, p. 93, 1984.

[36] M. Bower and K. Falkner, "Computational thinking, the notional machine, pre-service teachers, and research opportunities." *ACE*, vol. 160, pp. 37–46, 2015.

Authorized licensed use limited to: TU Delft Library. Downloaded on September 10,2024 at 11:15:32 UTC from IEEE Xplore. Restrictions apply.