Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 6, 4078-4091

The Training And Self-Efficacy Of Mathematics Teachers In The Teaching-Learning Process Through Ict

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Abstract: The application of ICT in the current mathematics teaching and learning process is a challenge. Current teaching staff do not feel trained in the use of ICT for mathematics education. ICT support is important for the continuing education of today's university students. The present study aims to assess the self-efficacy of mathematics teachers in the teaching-learning process through ICT. The study is in the quantitative approach. The sample consisted of 249 participants. The Control-Value theory was applied to verify the assessment of control, enjoyment and self-efficacy of ICT through a digital questionnaire. The results show that control, enjoyment and self-efficacy perceived by trainee teachers is important in mathematics education delivered through ICT. The results demonstrate from a theoretical point of view that emotions are important for mathematics education in general, as well as specifically for the use of ICT tools for mathematics education. Universities play an essential role in the training of digitally competent teachers. The trainee teachers' enjoyment directly affected their self-efficacy in teaching ICT in mathematics. Control, valuing control and values also positively affected enjoyment.

Keywords: Vocational education, Mathematics education, Information and communication technology, ICT self-efficacy, control value theory

Introduction

Competence in the use of information and communication technologies (ICT) is considered critically important in today's world and is assigned a fundamental role in all theoretical frameworks of 21st century skills (Camargo, 2018). Consequently, it is generally believed that ICT use should be facilitated by the formal K-12 education system (Alamin, et al., 2022). Moreover, ICT tools allow for innovative ways of teaching and have the potential to enrich learning activities (Pilliza & Parra, 2022). For example, the application of ICT in schools has been shown to have a positive effect on pupils' mathematical performance (Aydin & Gurol, 2019). Studies also suggest that the use of ICT during teacher education is beneficial for the development of trainee teachers' professional content knowledge in mathematics, demonstrating that ICT is a valuable learning tool in various educational contexts (Pozo, et al., 2021). Therefore, the appropriate use and application of ICT in the classroom is increasingly becoming an essential part of teachers' professional competence, which means that teaching staff must be competent users of ICT and know how to integrate ICT meaningfully into classroom teaching, i.e. develop digital

competences (Greer & McCann, 2018; Guzmán, et al., 2019).

At the same time, there is great heterogeneity in ICT infrastructure and ICT use in schools among Latin countries (Flores, et al., 2021). Mendoza (2018) found that the use of ICT in Ecuadorian education is one of the lowest in South America, at only 20%, with more than 30% of teachers using ICT on a regular basis. The substantial difference may (at least in part) be due to the lower level of technical infrastructure in Ecuador. It is not surprising, therefore, that teachers in Germany report the need for substantial professional development in the field of ICT, particularly about the didactic use of ICT.

Studies have shown that beliefs and feelings held by teachers are important factors when deciding for or against the use of ICT (Chaidi, et al., 2021). Teachers' affective-motivational values in determining the use of ICT in the classroom are important. For example, the willingness, ability, tool model. Sharma, (2020) describes not only common constructs such as teacher knowledge of ICT tools and specific characteristics of ICT tools. Tadeu, et al., (2019), express that there are affective-motivational factors, which together can explain up to 90% of the variance in the use of ICT at school. The technology acceptance model also takes into account teachers' attitudes towards ICT and relates them to the perceived usefulness of the tool and ease of use (Hafifah, 2020). The common ground between the models is that beliefs or attitudes are considered essential to the decision to use ICT in the classroom (Dziuban, et al., 2018). It is emphasized that a teacher's belief in their own efficacy in using ICT intentionally must be reinforced to ensure that ICT will be used by them (Eleftheriadi, et al., 2021). However, with few exceptions, emotions are not addressed in existing studies (Guillén, et al., 2020). Since according to Ismaili, (2022) the use of ICT is associated with specific emotional experiences that have significant effects on educational processes.

Camargo's (2018) studies show that the use of ICT varies across subjects and is influenced by content. Although some ICT tools are applicable to different subjects, many of them are intended to enhance learning in a specific subject (Bansa, 2020). In the case of mathematics, for example, robots allow children to experience algorithmic thinking in relation to geometric ideas. Apps simultaneously provide multiple ways of representing arithmetic concepts. Digital tools help students to structure numbers, thus reducing cognitive load.

Furthermore, Yeboah, et al., (2020) consider that a person's emotional experience is also domain specific. For example, the way mathematics is conceptualised and taught determines the emotions experienced in mathematics-related situations according to König, et al., (2020). Confrontation with demanding tasks, the hierarchical nature of mathematics and a high right-wrong orientation are likely to produce emotions such as helplessness, anxiety or embarrassment (Sharma, 2020). In contrast, mastering a challenging mathematical task can lead to emotions such as enjoyment or pride (Murithi & Yoo, 2021). However, it is not the mathematical situation itself that triggers these emotions. Rather, it is a person's appraisals of the situation that trigger these emotions (Mendoza, et al., 2021b). Control-value theory describes the antecedents and effects of emotions in educational contexts and differentiates between control appraisal and value appraisal (Pozo, et al., 2021). While control valuation considers the level of subjectively available resources that serve to satisfy a certain need, value valuation reveals the subjective relevance or importance of the situation; the interaction of both valuations then leads to a specific emotional experience (Maila, 2020).

The present study examines the importance of enjoyment for the self-efficacy of trainee teachers using ICT as a teaching tool in mathematics teaching. Factors identified in the literature review as relevant to the development of emotions are considered. In addition, the means to facilitate the development of self-efficacy of trainee teachers using ICT as a didactic tool for teaching mathematics were investigated.

Literature Review

Self-efficacy in ICT teaching

The concept of self-efficacy is derived from Hasin & Nasir's (2021) social learning theory. General self-efficacy is defined as the

confidence or belief in one's ability to master and execute specific requirements (Hashemi & Kew, 2021). Self-efficacy can be conceptualised as a disposition at a general level or in specific domains. It should be noted that each form of self-efficacy does not only describe belief in an overall ability, but in a specific capability (Tadeu, et al., 2019).

With respect to ICT, several concepts of self-efficacy can be distinguished (Henderson, 2020). ICT self-efficacy, for example, refers to the belief in one's own ability to use ICT for everyday purposes, such as writing an email, surfing the Internet or creating a digital presentation (Adarkwah, 2021). Studies reveal that teachers' ICT self-efficacy positively predicts the use of ICT tools in the classroom (Aydin & Gurol, 2019). Furthermore, Fraillon, et al., (2020) express that according to the IEA International Computer and Information Literacy Study (ICILS, 2018) it is shown that adolescents' ICT self-efficacy varies substantially across countries. Furthermore, Eleftheriadi, et al., (2021) have shown that student teaching experiences during teacher education could improve the ICT self-efficacy of trainee teachers. Given these findings, the development of teacher ICT self-efficacy becomes an integral part of teacher education programmes (Gómez, et al., 2018).

ICT self-efficacy can also refer to the belief in one's own ability to use ICT specifically as a teaching tool in the classroom (ICT teacher self-efficacy). For example, the use of dynamic geometry environments, robots designed for educational use and applications designed to aid learning in general. As already mentioned, self-efficacy in ICT teaching is a crucial factor in the will, skill and tool model. These skills can be considered as a constituent part of teacher preparation according to Purnamawati, et al., (2019). However, in Ecuador, teachers often report that they do not feel sufficiently prepared to use ICT in ways that promote learning activities (Mendoza, et al., 2020). Consequently, self-efficacy should not only be promoted in terms of general ICT use, but also in terms of creating good digitally supported learning environments that promote high quality learning (Yeboah, et al., 2020).

Teachers' ICT self-efficacy is conceived as the belief in their own ability to use ICT as a teaching tool in the classroom. In this sense, ICT teaching self-efficacy encompasses two distinct components. Firstly, making instructional decisions about the suitability of ICT tools for teaching a mathematical topic. Secondly, the design of a formal learning environment in mathematics with digital support.

Enjoyment of ICT use

Shanks, (2020) showed that emotions play an important role in deciding for or against the use of ICT in mathematics classes. In contrast to the present study, the effects of enjoyment on teachers' self-efficacy in using ICT are examined. According to Abu & Yahuza, (2019), enjoyment can be analyzed as a pleasant and activating emotion as such, it constitutes the emotional counterpart of anxiety. According to Eleftheriadi, et al., (2021), it can be described as the pleasure of being able to solve problems in the educational context. Enjoyment can be experienced both prospectively and retrospectively in relation to specific educational outcomes as well as during the educational process and is therefore closely related to a person's performance (Ashtiani & Valoojerdy, 2022). Based on the control-value theory it can be assumed that enjoyment is experienced when an individual perceives a high level of control and values the situation positively.

Junaid, et al., (2022) state that teachers experience enjoyment more often than other emotions when teaching mathematics with the use of ICT. Moreover, teachers who enjoy mathematics are more likely to promote enjoyment among their students than those who do not (Pólya, 1977). Other studies have shown that teachers' enjoyment is positively related to students' enjoyment (Shanks, 2020). Marbán, et al., (2020), suggest that the enjoyment experienced by trainee teachers as mathematics learners positively affects their experience of enjoyment when teaching mathematics themselves. Therefore, teacher education programs play an essential role in the development of enjoyment on the part of trainee teachers.

It is likely that enjoyment also plays a vital role in teachers' decisions to use ICT tools for teaching. Clearly, there is no strict necessity to use ICT for teaching and teachers have no obligation, legal or otherwise, to use ICT tools for teaching (Das, 2019). Consequently, and to

promote the didactic use of ICT tools in schools, it is necessary to understand what makes teachers decide to integrate ICT tools into their teaching. Purnomo & Jailani, (2019) have shown that enjoyment motivates exploration, information seeking and promotes sustained engagement in learning activities. On the other hand, Joshi, et al., (2021), have further revealed that enjoyment facilitates a deep state of engagement with ICT, moreover, enjoyment is known to be a source of self-efficacy and a learning process that leads directly to experiencing digital competence. Specifically, enjoyment in mathematical learning processes has been shown to positively predict mathematical self-efficacy and enjoyment in ICT use, for Trujillo, et al, (2020) ICT self-efficacy can be predicted with a $\beta = 0.24$. There are no studies available on the effect of enjoyment on ICT teaching self-efficacy (neither in general nor for a specific subject).

Factors affecting self-efficacy and enjoyment

Affective-motivational constructs such as self-efficacy and enjoyment not only influence other constructs and variables but are themselves affected by a variety of factors (Purnamawati, et al., 2019). For example, Mendoza, et al., (2021b) have found that age is negatively correlated with ICT self-efficacy, perceived usefulness of ICT and frequency of use. Similarly, gender differences in ICT self-efficacy have been revealed for females in Ecuador. However, since the results on gender differences are generally quite divergent, this result should be treated with caution.

Hong & Yu's (2018) technology acceptance model describes specific cognitive appraisals (such as perceived ease of use) that influence affective-motivational willingness to use ICTs. Pekrun's (2006) control-value theory also describes appraisals that influence the development of emotions. Within the framework of control-value theory it is assumed that these appraisals are shaped by learning experiences and the social learning environment.

Drehlich, et al., (2020) found that the emotional experience of trainee teachers differed when they attended online instruction compared to regular instruction. The study revealed that the discrepancy was mainly due to differences in appraisals. Specifically, they found that differences in appraisals had a greater effect on participants' emotional experience than proximal factors in the learning environment. The study authors used the terms technological control and technological value to emphasise the technological nature of the appraisals examined. Beliefs about value and control are generally considered to be determinants of pre-service teachers' intended use of ICT (Flores, et al., 2021). Thus, teachers with high control and value appraisals are more likely to use ICT tools in teaching than trainee teachers with low control and/or low value appraisals.

García & Rivera, (2021) conceptualized self-efficacy in relation to perceived control. This relationship is also evident with respect to ICT self-efficacy. If teachers feel well supported (e.g. by a good technological infrastructure or by social support from colleagues), their ICT self-efficacy and also their ICT teaching self-efficacy will increase. Years of experience can also be considered as a teacher's resource for ICT management. Such aspects are personal characteristics and strategies that enable experiences of control. Thus, "control" means that the trainee teachers perceive themselves as having control over the ICT tool and not the other way around. To experience control in this sense, it is important that any difficulties in using the ICT tool can be overcome. According to Fraillon, et al., (2020), teachers consider it important that education and training programs enable them to constantly engage in these experiences of control. It was also found that teachers use ICT much more frequently for simple tasks than for complex ones, which could indicate a low level of appreciation of control. However, it is not enough for a person to possess certain personal characteristics and strategies. ICT tools themselves must also have specific characteristics (such as flexibility of use) so that teachers can exercise control by adapting them to the needs of their students (García & Rivera, 2021).

Regarding value ratings, Bandura, (1995) and Fraillon, et al., (2020), revealed that teachers in all countries rate the benefits of ICT use as high. According to the aforementioned authors, teachers report that they are convinced that ICT tools can help students acquire skills and facilitate the university career environment. The perceived value of ICT is generally conceptualised as a constituent part of teacher preparation, as they also recommend

experiencing the value of digital tools in the context of teacher education. Bansa, (2020) showed that high technological value is also associated with experiencing enjoyment in ICT-based learning environments. With respect to ICT teacher trainees, he highlights the importance of investigating whether and how appraisals of control value affect self-efficacy.

Research question and hypotheses

The present research relates self-efficacy for teaching ICT in mathematics and enjoyment of using ICT for teaching mathematics within the framework of control-value theory. For this purpose, the effects of control-value appraisals, self-efficacy for teaching ICT and enjoyment are examined. The following research question emerges:

How does self-efficacy for ICT teaching relate to enjoyment of using ICT tools for teaching mathematics when considering the context of control-value theory?

Based on the existing theories of social learning theory and Bandura's (1995) conception of general self-efficacy, control-value theory and applying a quantitative research approach, the following hypotheses are put forward:

- Alternative hypothesis: Enjoyment is considered to have a direct positive effect on self-efficacy in ICT teaching (H_{10}).

- Null hypothesis: Enjoyment is not considered to have a direct positive effect on ICT teaching self-efficacy (H_{01}).

- Alternative hypothesis: Both control and value appreciation have effects on trainee teachers' experience of enjoyment in the context of ICT in mathematics (H_{20}).

- Null hypothesis: Both control and value appreciation have no effect on trainee teachers' experience of enjoyment in the context of ICT in mathematics (H_{02}).

- Alternative hypothesis: Control appraisal and value appraisal have direct effects on self-efficacy in ICT teaching (H_{30}).

- Null hypothesis: Valuing control and valuing value have no direct effect on self-efficacy in ICT teaching (H_{03}).

The stated hypotheses can be derived from the empirical results and the assumptions of the willingness, ability, tool and technology acceptance model (Mendoza, 2018). Based on the empirical results, gender, semester of training and teacher age are expected to affect all the constructs examined. Consequently, effects controlling for gender, semester and age will be examined. All possible indirect effects are analyzed. The hypothetical model of the present study is shown in Figure 1.

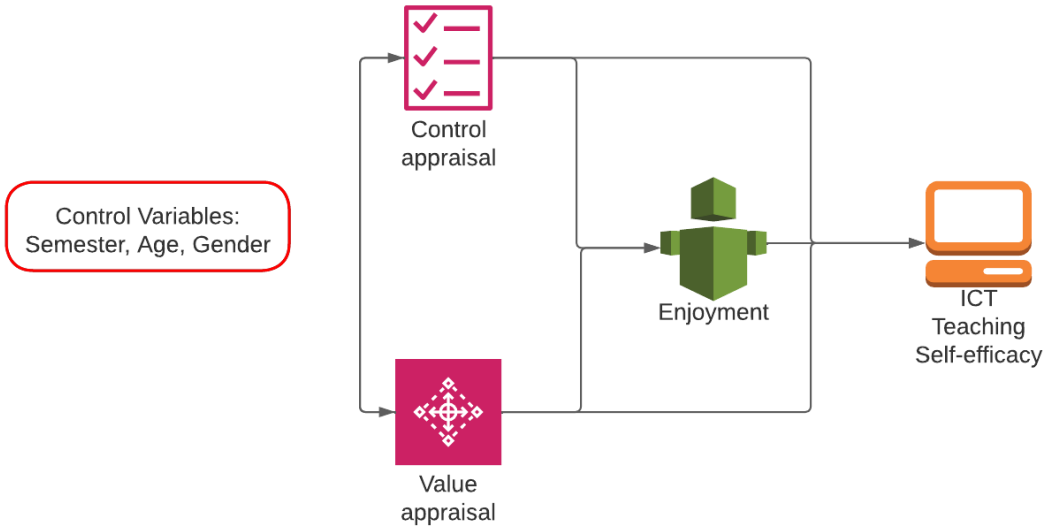

Figure 1. Theoretical model of control for semester, gender and age variables

Methodology

Research Design

The research was developed under the quantitative approach. As a quantitative study it uses statistics to test descriptive hypotheses of populations or tests. In this way the researcher formulates hypotheses based on the formulation

of the problem and the theoretical study. The study has a hypothetical descriptive design. The descriptive hypothetical design establishes temporal conjectures about the value of a variable, which do not express relationships or comparisons (Hernández & Mendoza, 2018).

Population and sample

According to the Secretary of Higher Education, Science, Technology and Innovation (SENESCYT, 2022) there is a university student population of 850 students in the area of mathematics. For the selection of the sample, a non-probabilistic participatory sampling was applied (Otzen & Manterola, 2017). In this way, an email was sent to undergraduate and postgraduate universities in Ecuador, which provide university academic training in the area of mathematics, requesting the participation of teachers in training to develop the digital questionnaire.

Of the total, a participatory sample of n=249 trainee teachers of mathematics education were estimated. Many participants were male (82.9% male, 17.1% female). The mean age was = 28.16 years (SD = 8.00). Participants were recruited from the entire mathematics study programmed. On average, participants were in their fourth semester of study (= 3.80, SD = 2.42, Min = 1, Max = 15). About two thirds were in the bachelor's programmed (65%) and about one third were in the master's or experimental science programmed (35%).

Data collection instrument

A standardized questionnaire was used to assess the constructs. The questionnaire was developed specifically for the present study. The wording of the items was initially based on the theoretical assumptions underlying the different constructs (such as Bandura's self-efficacy theory for the scale covering self-efficacy in ICT teaching) and adapted to the proposed research question. The items of the scales are listed in Table 1. The list of items is preceded by a clarification of the term ICT tools, indicating that the term is used in the questionnaire to refer either to a physical device (hardware) or to the digital content of that device (software) or to combinations of both. All five scales asked to what extent participants agreed with the statements.

The items were rated on a 5-point scale. The lowest value was 1, meaning "not at all". This was followed by the value 2 "hardly ever applied". The value 3 as a statistical mid-point determines "sometimes applied". Value 4 determined "almost always applied". Finally, value 5, which determined "always applies". Content validity was ensured through systematic review and iterative revision by the research team. The reliability of the instrument was determined by means of a diagnostic test through the Cronbach's Alpha coefficient with a result of 0.783 which determined it to be a reliable instrument.

Data analysis

The data were analyzed using structural equation modelling. The respective items were used as indicators of the latent trait variables. All factor loadings were estimated freely. Accordingly, McDonald's ω was estimated to test the reliability of each scale. Due to the small sample size, a maximum likelihood estimator of with robust standard errors (MLR from Ravinder & Saraswathi, 2020) was applied. The maximum likelihood procedure with full information was used to adequately handle missing data on the variables. Common fit indices were used to assess the fit of the complex model. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS version 25) from International Business Machines (IBM) recommended by Muthén & Muthén, (2017).

Findings / Results

Table 1 shows the descriptive results of the questionnaire items.

Table 1. Means, standardized factor loadings and standard errors for all latent variable indicators.

Construct	Ítems	Media	Factor load	SE
Control	It's important for me to understand how ICT tools work.	4,10	0,70	0,04

	It is important for me to be able to modify the ICT tools.	3,48	0,73	0,05
	I find it easy to adapt ICT tools to my needs.	3,89	0,68	0,06
Value	The use of ICT tools increases the student's motivation for mathematics.	4,73	0,02	0,06
	The use of ICT tools facilitates the monitoring of learning processes in mathematics.	3,97	0,81	0,05
	The use of ICT tools improves students' understanding of mathematics.	4,0	0,88	0,03
	The use of ICT tools improves students' performance in mathematics.	3,72	0,67	0,05
Entertainment	I enjoy the use of ICT tools.	4,53	0,72	0,04
	I enjoy designing learning environments with digital support for mathematics.	4,20	0,82	0,03
	I like to think about the possible uses of ICT tools for teaching mathematics.	3,49	0,73	0,04
ICT self-efficacy	I believe I can use ICT tools for teaching mathematics in a way that benefits students.	4,33	0,76	0,03
	I think I can properly consider the advantages and disadvantages of an ICT tool when planning a math class.	4,27	0,79	0,03
	I am convinced that I can design a learning environment with digital support for most mathematical subjects.	3,80	0,89	0,02
	I think I can use ICT tools in ways that facilitate mathematical learning processes.	4,15	0,89	0,02

Note: ICT = information and communication technologies, SE = standard error.

Considering the possible range, it shows that participants rated control, value, enjoyment and self-efficacy in ICT teaching as high overall. As Table 2 shows, all factor loadings were significant ($p < .001$) and substantial $\lambda>0.3$ the reliability of the scale capturing the assessment of control was good (McDonald's $\omega = 0.79$).

Table 2. Descriptive results

	Control	Value	Enjoyment	ICT self-efficacy
Media (□)	11.46 (3.03)	16.44 (3.04)	12.20 (2.97)	16.53 (3.78)
Minimal, Maximum	3 18	4 24	3 18	5 24

Table 3. Correlations between latent variables (lower triangular matrix) and variances of latent variables (diagonal).

	Control	Value	Enjoyment	ICT self-efficacy
Control	0,81			
Value	0,40	0,43		
Enjoyment	0,83	0,56	0,64	
ICT self-efficacy	0,72	0,50	0,78	0,71

McDonald's estimate $\omega = .90$ for the assessment indicates very good reliability. Reliability for enjoyment was good according to $\omega = .83$ and reliability for ICT teaching self-efficacy was very good according to McDonald's with a value of $\omega = .93$. The variances of the latent trait

variables were significant ($p < .001$). The standardized correlations between the latent trait variables were substantial and positive, as theoretically assumed. The estimates are presented in Table 3.

The empirical fit of the theoretical model to the data was good ($\chi 2$ (103) = 162.11, p = .0002, RMSEA = .04 [.03; .05], CFI = .96, SRMR = .04). The results are presented in figure 2. Only coefficients significant at $p < .001$ are presented. Gender had no effect on any other variable in the model. in the model. Semester had a direct negative effect on control rating. Age had a direct negative effect on enjoyment. Both effects were small. Semester and age were not significantly related to each other (p = 0.81). Control and value assessments were positively related to each other. As theoretically assumed, trainee teachers' enjoyment directly affected self-efficacy in teaching ICT in mathematics (confirming alternative hypothesis H_{10}). The effect was positive and of moderate size. Control, control rating and values also positively affected enjoyment. Both effects were met in the hypothesis (confirming hypothesis H_{20}).

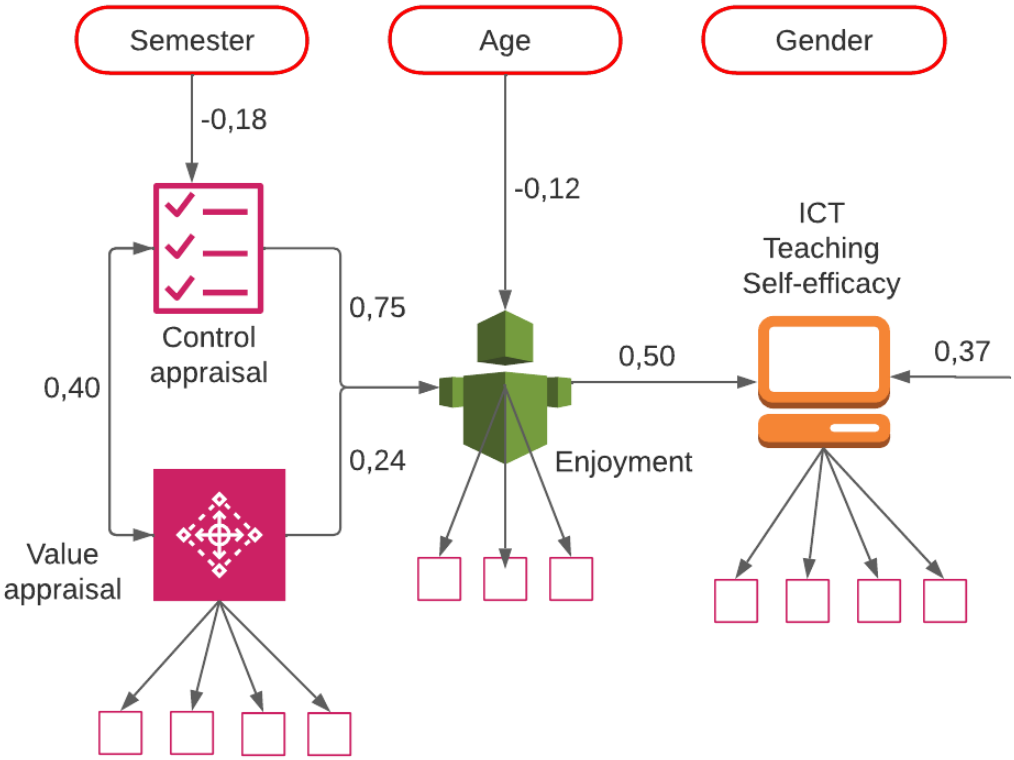

Figure 2. Empirical model

The standardized coefficient of the control evaluation on enjoyment was three times larger than the standardized effect of the value evaluation on enjoyment. While the effect of control evaluations on enjoyment was large, the effect of value evaluations on enjoyment was comparatively small. No direct effects of either control assessment or value assessment on self-efficacy in ICT teaching were found (Hypothesis H_{30} not confirmed). However, an indirect effect of control evaluation on self-efficacy in ICT teaching, mediated by enjoyment, was found (Figure 2. Empirical model.

However, an indirect effect of control evaluation on self-efficacy in ICT teaching, mediated by enjoyment, was found (βi_1 =0.38 $p<0.05$). As there was no direct effect of control assessment on ICT teaching self-efficacy, but there is a positive latent correlation between the two variables when no other variables are included, it should be noted that enjoyment can be considered as a complete mediator between control and ICT teaching self-efficacy. The indirect effect of appraisal on ICT teaching self-efficacy was βi_2 =0.12 but was not significant (p = 0.051). There was also an indirect effect of semester on enjoyment, mediated by control, with βi_3 =-1.3. This indirect effect was significant (p = 0.04) but small.

Discussion and conclusion

From a theoretical point of view, the results validate the control-value theory (Pekrun, 2006) in the ICT domain. The study shows that enjoyment is a significant emotion in the interaction between control and self-efficacy in ICT teaching. The results also reveal that the appraisal of control is much more relevant to the enjoyment of ICT use than the appraisal of value. Both appraisals affect enjoyment, but the effect of control appraisal is substantially larger than the effect of value appraisal. Moreover, while control evaluation has an indirect influence on ICT teaching self-efficacy, value evaluation does not significantly affect ICT teaching self-efficacy. The results emphasize the importance of enjoyment from an emotional psychological perspective: Making the value of ICT for teaching mathematics visible to trainee teachers and allowing them to experience control in the use of ICT is important for increasing ICT teaching self-efficacy. However, the impact on ICT teaching self-efficacy will be more prominent when (trainee) teachers enjoy using ICT tools for teaching. Therefore, enjoyment as an academic emotion should be given attention in education and training programmers and should be reflected upon from a didactic and pedagogical perspective.

While age and semester had only minor effects on the study model, the coefficients of the structural equation model appeared to be independent of the gender of the participants. However, this may be due to selection effects: In the present study only undergraduate students and teachers in the graduate process who will subsequently teach mathematics were surveyed. Therefore, the population is rather specific compared to the general population or even the student body. The fact that no gender effects were found may also be since beliefs are more stable between the chosen professions than between genders. In other words, trainee mathematics teachers might be more like female teachers who did not choose mathematics teaching as a profession. Maliheh, et al.'s, (2021) study with trainee teachers also found no gender effects in relation to emotions, even though the study did not have a domain-specific focus. The number of semesters also appeared to have minor effects on the study model. Although the number of semesters affected the assessment of control, the effect was small and, surprisingly, negative, meaning that the level of perceived control decreased as the number of semesters increased. Moreover, the enjoyment of using ICT as a teaching tool also decreased as the number of semesters increased. These effects could be since courses on the use of ICT as a teaching tool in mathematics teaching are more likely to be offered at the end of the study programmer.

Moreover, the use of ICT as a didactic tool in mathematics teaching differs substantially from the use of ICT for everyday purposes. The realization that designing a good digitally supported learning environment poses a difficult and complex problem can be overwhelming for trainee teachers at first. Moreover, it may also be the case that the decrease in perceived control is due to the mathematical content rather than the ICT tools used to teach that content. Studies have shown that trainee mathematics teachers experience mathematics as a considerable challenge, especially in Ecuador (Mendoza, et al., 2021). According to the questionnaire applied, it is not possible to distinguish between a decrease in the assessment of control that is due to the challenges in the handling of ICT tools and a decrease in the assessment of control that is due to the challenges derived from the didactic transformation of mathematical concepts. Moreover, it could be the case that ICT is perceived less as a playful tool to be responded to with curiosity and more as a challenge or even a threat to be faced formally as the number of semesters increases and the final exams approach. However, the observed effects are small and may have little practical significance. The results also show that the enjoyment of handling ICT tools in mathematics decreases with increasing age. This effect cannot be explained by an increase in the number of semesters, and since the present study was a cross-sectional investigation, no causal relationship can be assumed from the data. Possible explanations are that enthusiasm for ICT tools may be more pronounced among younger people. Younger people may approach ICT tools more on an emotional level, while older people may favors a cognitive and rational approach; younger people may also have more experience in using ICT tools, which is reflected in a higher perceived usefulness of ICT (Ashtiani & Valoojerdy, 2022). This could lead to other variables causing the observed

relationship between age and enjoyment when dealing with ICT tools in mathematics, since, according to Gómez, et al., (2021) self-concept and knowledge are directly related to emotion and possibly caused by the available experience in a domain.

The results of the present study should be seen in the context of its limitations. The effects found may be specific to the Ecuadorian context. (Trainee) teachers in Ecuador probably experience control in the use of ICT tools less frequently than in other countries (Mendoza, et al, 2021b). This could explain the large effect size of control ratings on enjoyment in the present study. However, the sample was drawn from several universities that offer courses specifically on the use of ICT tools in the teaching of mathematics or exact experimental sciences. Therefore, the participating trainee teachers may have had learning opportunities that students from other universities may not have had. The observed effect may be even greater at these universities. In addition, the study focused on the use of ICT tools for teaching mathematics. Mathematics itself is considered by many to be a difficult subject and trainee mathematics teachers are no exception. It is possible that ICT tools are subjectively perceived as an added challenge. Therefore, the results cannot be generalized to fields other than mathematics. However, this specificity of the results need not be interpreted as a disadvantage, as many investigated educational processes and constructs have been shown in the past to be domain specific. For example, ICT-assisted instruction is also assumed to be domain-specific within the current debate on the technological competences of teacher educators in other countries such as the United States (Foulger, et al., 2017).

The results confirm that universities play an essential role in training digitally competent teachers (Mendoza, et al., 2021b). Education and training programmers need to prepare teachers to use ICT as a didactic tool, trained teacher educators are needed to support teachers in acquiring the necessary skills (König, et al., 2020). In addition to highlighting the importance of the competences of teacher educators, our results also extend the ideas of TETC in the following way: trained teacher educators should not only be able to support trainee teachers in the use of ICT as didactic tools but should also consider academic emotions as relevant factors of high-quality instruction and be able to give adequate emotional support.

The enjoyment in exploring the didactic and pedagogical possibilities of ICT tools for teaching mathematics must be made visible and tangible. This can be done indirectly, by drawing (trainee) teachers' attention to the importance of emotional experiences, or directly, by inquiring about (trainee) teachers' personal experiences of enjoyment. Studies in have shown that beliefs about the value of ICT in introductory courses can be influenced by directly addressing the value of ICT (Hong & Yu, 2018). However, given that control appraisals play a substantial role in strengthening self-efficacy in ICT teaching, courses should also allow trainee teachers to experience control in the use of ICT as a teaching tool. In particular, control ratings increase when difficulties are encountered that can be overcome. Such situations can be deliberately constructed in laboratory-like learning environments or provoked during practical phases, thus generating authentic experiences.

The results demonstrate from a theoretical point of view that emotions are important for mathematics education in general, as well as specifically for the use of ICT tools for mathematics education. The study does not answer the question of how a didactic use of ICT tools in mathematics should be designed. However, the study points out that models for self-efficacy in ICT teaching (and probably also models for teachers' use of ICT tools) should consider and further examine the role of pleasant emotions, such as enjoyment. The inclusion of emotions allows for a better understanding of the psychological dynamics in teachers' use of ICT tools and highlights starting points for promoting a functional attitude towards ICT tools in teachers which, in turn, can be expected to strengthen the didactic use of ICT tools in schools in the long run.

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