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Research article

# Understanding factors affecting fundamental school teachers' use of technology in Luxembourg through a survey study

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ABSTRACT

Over the last few decades, Information and Communication Technologies (ICT) have brought about significant disruptions across nearly every industry, including education. Acknowledging the power of the digital revolution to make a positive change, educational policy makers in Luxembourg have made efforts to translate these trends into policies leveraging the potential of technologies while also tackling the challenges they present. However, these efforts and their impact on teacher ICT integration behaviors in Luxembourg are rather underexplored. The aim of the study was to examine and understand factors associated with efficient educational technology practices. The study data were collected through an online survey of 159 teachers and analyzed through a mixed-method approach, including regression and correlation analyses. Findings shed light on the connections between professional use of ICT and a set of interrelated factors such as (a) teacher attitudes followed by (b) subjective norms, (c) teacher self-efficacy beliefs, (d) facilitating conditions, (e) teacher value beliefs, and (f) fundamental pedagogical beliefs. The study also revealed possible deterrents and challenges of ICT integration in Luxembourgish fundamental schools, including gaps between teacher ICT competencies and advanced ICT uses, class management issues, and developed suggestions for professional development training to ensure efficient and advanced ICT uses in the classroom.

## 1. Introduction

In the last decades information and communication technologies (ICT) have transformed every aspect of our lives, including social, cultural, industrial, financial, and economic processes and have been widely used in diverse organizations [1]. Acknowledging the power of the digital revolution to make a positive change and enhance every aspect of teaching and learning experiences by means of new pedagogies [2,3], governments all over the world have already developed many policies and invested billions of dollars in education and technologies for classrooms [4,5]. The enormous public expenditures have not left the education sector of Luxembourg behind. According to OECD, the Luxembourgish total expenditure on educational institutions per student in 2018 was the highest in the EU and amounted to USD 24 973 compared to USD 11 680 on average across OECD countries [6].

Pertaining to the policy aspect of ICT integration into classrooms, the Ministry of Education of Luxembourg has been truly dedicated to policies on digital transformation of education. For instance, in 2015 the Ministry presented 'Digital4Education', a strategy aimed at "preparing young people for a professional landscape of rapid and permanent change" [7] through improving their media

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literacy, providing sufficient digital tools, and promoting Science, Technology, Engineering and Mathematics (STEM) [8]. In 2020 this initiative was replaced by 'Einfach Digital', a policy focused on "critical thinking, creativity, communication, collaboration and coding" and including introduction of coding and computer science courses, and a wide usage of diverse technologies and technology-based practices in the education process [9].

However, the vast education expenditure and coherent policies partly aimed at equipping schools with sufficient technical resources do not always lead to frequent and innovative ICT applications and their successful integration into the classrooms [4,10,11]. The findings of diverse studies on ICT usage in education show that the increased availability of technology in schools does not guarantee efficient and high-level uses [12]; many teachers still struggle integrating technologies in their classrooms [12] and use them just as presentation tools to support and enhance the traditional forms of [4,10,13].

It is vital for technologies to get accepted by employees in organizations [1,11], namely by school teachers as key drivers of the digital transformation of education, to ensure high quality educational processes. ICT acceptance and integration are indeed not so easily accomplished [13], as they require changing multiple educational practices and challenging teacher beliefs [14], which "act as filters and frames, provide an orienting and guiding function, and serve as a connection between knowledge and action" ([2], p. 1412).

The lack of proper understanding of incentives required to foster positive change has resulted in numerous studies on reasons for 'technology avoidance' behaviors and barriers hindering the successful ICT integration in schools. The identified barriers as major catalysts of ICT usage may be grouped in two major categories:

- the first-order barriers which are extrinsic to teachers [14]: resources (lack of availability or access to technologies) [14–16], inadequate institutional and administrative support [15];
- the second-order barriers which are intrinsic to teachers [14]: insufficient training and experience [15], attitudinal and personality factors (teacher beliefs, resistance to change, etc.) [14,15].
- Despite the abundance of research investigating the technology integration landscapes of diverse countries, there are not so many studies dedicated to Luxembourgish experience with technologies in schools. Hence, this research paper aims to develop a better understanding of educational technology usages in Luxembourgish pedagogical settings, in comparison with international experiences, and to determine ways and scenarios for further technology integration into the Luxembourgish fundamental schools.

## 2. ICT in education: theoretical framework

Technology integration is typically defined as "the use of technology for instructional purposes" ([17], p. 55) or as "use of technology to enhance what we are doing in the classroom" ([18], p. 345). It is believed that the successful technology integration implies innovative ICT applications which are understood as those which "support the learning objectives based on the need of the current knowledge society" ([19], p. 187), transform instruction and "facilitate student-centered learning" ([4], p. 502). Hence, in the present study efficient technology integration will be considered as innovative ICT uses to enhance learning and teaching activities in the classroom and to successfully meet the educational needs of a digitalized knowledge society.

To develop a proper definition of teacher beliefs is a tough task to achieve, since this construct is obscure and often replaced or confused with other related constructs, such as attitudes, opinions, perspectives, or perceptions ([20], see also [21]). In the context of ICT integration, the task of defining teacher beliefs is even more complicated due to their narrowing to technology-related beliefs which is to be found in the research on ICT in education [22]. These beliefs often include teacher value beliefs as "beliefs about the value of technology for their teaching practice" ([23], p. 71), and self-efficacy beliefs as "the teacher's personal belief in [their] ability to plan instruction and accomplish instructional objectives" ([24], p. 49), in our case, using technologies in their teaching practice [25].

We share the view that it is crucial to additionally investigate so-called fundamental pedagogical beliefs which are connected and associated with the technology-related teacher beliefs [26]. These beliefs present beliefs about the nature of knowledge and learning [2], "schooling, teaching, and students" ([20], p. 316), in other words, beliefs about diverse educational components, such as the role of teachers and schools, the curriculum, appropriate and efficient teaching and learning practices, etc. [20]. However, Mertala [21] suggests that this is "a narrow understanding of pedagogy" which excludes teacher beliefs about their task to promote physical, social, and emotional wellbeing of students (broader understanding of pedagogy). Moreover, it is essential to distinguish mentioned educational teacher beliefs from general or non-educational ones (beliefs beyond the profession) [20] which together with institutional context, personal experiences shape the educational belief system of teachers [27]. Thus, in this research paper teacher beliefs encompass technology-related and other educational beliefs (including aspects of their broader understanding) which influence and determine teachers' ICT uses in professional activities.

The great research interest in reasons for teachers to accept/avoid technology has resulted in the development of new frameworks and the implementation of existing behavioral theories to analyze different factors of technology usage (including teacher beliefs), and their interrelations. These theories and the models derived from them largely share a lot of constructs, which are as follows:

- Performance expectancy (UTAUT)/Perceived usefulness (TAM) is analogous to teacher value beliefs and is defined as degree to which individuals, in our case teachers, believe that using a system, in our case technologies, will help them "attain gains in job performance" ([1], p. 447), or "enhance their performance" ([28], p. 180)
- Effort expectancy (UTAUT)/Perceived ease of use (TAM)/Perceived behavioral control (TPB) is to be compared with teachers' self-efficacy beliefs and considered as "the self-rated ability in applying technology to instruction" ([25], p. 331), or the "perceived ease

of performing a particular behavior and control over the attainment of the goals" ([28], p. 179); and the extent to which individuals "believe that using a system will be relatively free of effort" ([28], p. 180).

- Social influence (UTAUT)/Subjunctive norm (TPB) refers to the "perceived social pressure to perform or not to perform the behavior" ([29], p. 300), "individual's perceptions regarding the approval or disapproval of important others of a target behavior" ([11], p. 2503), and the "degree to which individuals perceive that important others believe they should use the new system" ([1], p. 451).
- Facilitating conditions (UTAUT) are defined as the "degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" ([1], p. 453) and partly include some concepts of perceived behavioral control (TPB), namely the idea of "control over the attainment of goals" ([28], p.179).
- Attitudes towards using technology (TPB, TAM) are believed to be "positive or negative feelings about performing a certain behavior", in our case, using ICT in professional settings ([1, p. 456), arising from beliefs and values [30].

According to the **Technology Acceptance Model (TAM)** developed by Davis [31], two belief categories, namely perceived usefulness and perceived ease of use, present key predictors of user's attitudes, which influence the behavioral intention as a direct determinant of actual technology usage [24,28], (Fig. 1). This model is heavily criticized for "its parsimonies" ([32], p. 388) and has constantly been improved and expanded by other authors [11].

The **Theory of Planned Behavior (TPB)** [33] suggests that the behavioral intention influencing the actual usage is directly determined by three interrelated categories, namely attitudes, subjunctive norms, and perceived behavioral control [29] (Fig. 2).

The authors of the **Unified Theory of Acceptance and Use of Technology (UTAUT)** theorize that performance expectancy, effort expectancy, facilitating conditions and social influence, moderated by gender, age, experience and voluntariness, determine "the user acceptance and usage behavior" ([1], p. 446–447), (Fig. 3). This theory is a product of different models and is widely used in the corporate settings [34,35].

## 3. Materials and methods

### 3.1. Research model and hypotheses

Basic relationships of the existing research models on ICT acceptance and integration, including those described in the previous section (TAM, TPB, UTAUT), were adopted and incorporated into the conceptual model of this study (Fig. 4):

Based on the above-mentioned model, the following research hypotheses were formulated and tested:

**H1**. Fundamental pedagogical beliefs will influence teacher value beliefs expressed through perceived usefulness (constructivist ones – positively, traditional ones – negatively) (tested by Ref. [3]);

**H2.** Subjective norms will influence teacher value beliefs expressed through perceived usefulness (mentioned by Refs. [11,36]);

**H3.** Facilitating conditions will influence self-efficacy beliefs expressed through perceived ease of use [37];

**H4.** Self-efficacy beliefs expressed through perceived ease of use will influence teacher value beliefs expressed through perceived usefulness (also tested by Refs. [11,24,36]);

**H5.** Teacher value beliefs expressed through perceived usefulness will influence attitudes towards technology (analyzed by Refs. [11, 37]);

**H6.** Self-efficacy beliefs expressed through perceived ease of use will influence attitudes towards technology (investigated by Refs.

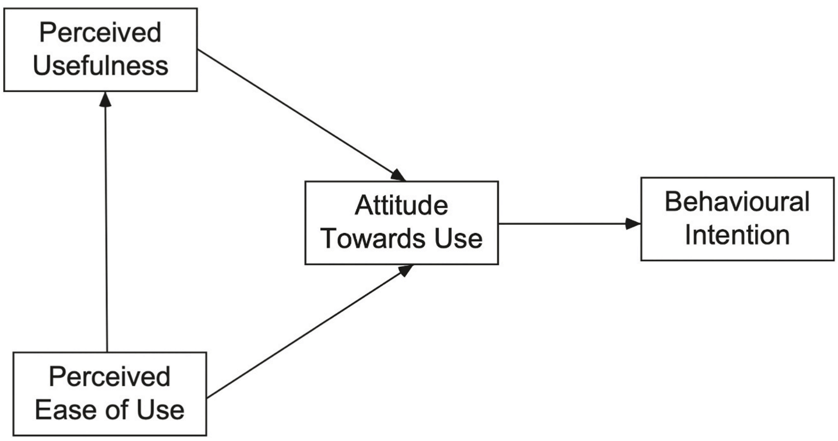


**Fig. 1.** Technology acceptance model (TAM) (adopted from Ref. [28]).

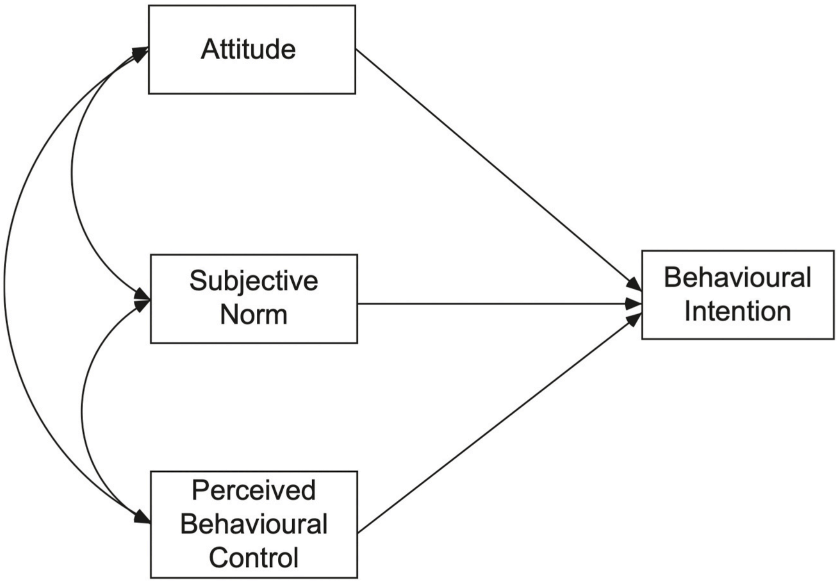


**Fig. 2.** Theory of planned behavior (TPB) (adopted from Ref. [28]).

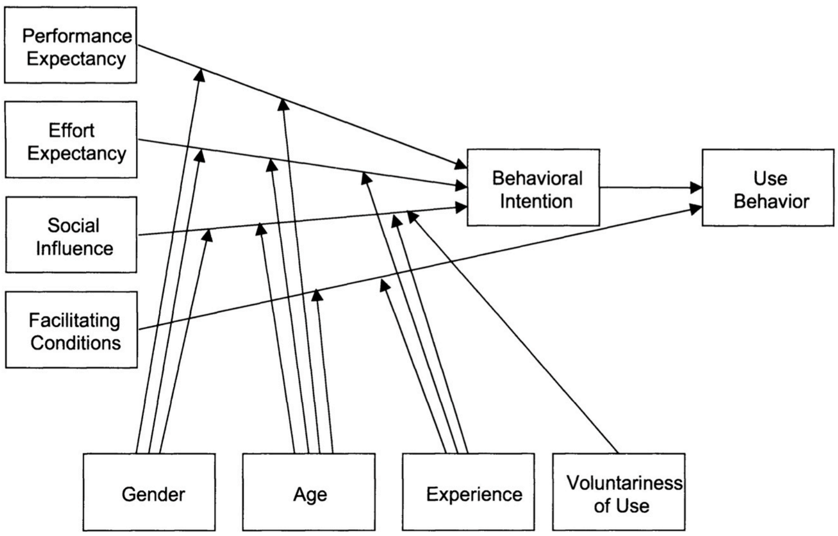


**Fig. 3.** Unified theory of acceptance and use of technology (UTAUT) (adopted from Ref. [1], p. 447).

[11,37]);

**H7**. Facilitating conditions will influence attitudes towards technology;

**H8**. Subjective norms will influence attitudes towards technology [11];

**H9**. Attitudes towards technology will influence professional use of technologies (studied by Ref. [11]);

**H10**. Teacher value beliefs, moderated by age, gender, and subject taught, and expressed through perceived usefulness, will influence professional use of technologies (partly tested by Refs. [1,4,24];

**H11**. Self-efficacy beliefs, moderated by age, gender and experience, and expressed through perceived ease of use, will influence professional use of technologies (partly tested by Refs. [1,4,24]);

**H12**. Facilitating conditions moderated by age and experience will influence professional use of technologies (mentioned by Refs. [1,38]);

**H13**. Subjective norms will influence professional use of technologies ([1,38]).

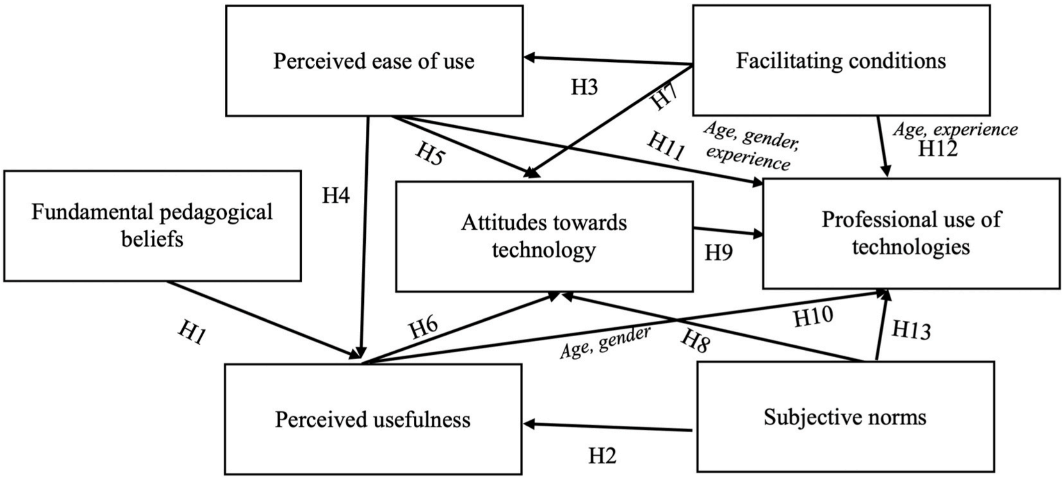


**Fig. 4.** Conceptual research model.

### *3.2. Research instrument and variables*

To enable data collection and analysis, the survey was developed. The formulation of the survey questions was informed by items validated in prior research [26,39,40]. This approach ensured the incorporation of reliable items, providing a foundation for the study. Moreover, while designing the survey, the authors took into account a general understanding of the constructs under investigation and considered the key features associated with the study variables to construct meaningful and relevant questions. In addition to that, careful attention was devoted to the unique policy context of the educational technology integration in Luxembourg, and the factors specific to this context were explored.

The research instrument contained 86 items divided into 8 categories presenting research variables: 1) demographic information (6 items); 2) fundamental pedagogical beliefs (5 items); 3) subjective norms (9 items); 4) facilitating conditions (12 items); 5) perceived ease of use (6 items); 6) perceived usefulness (11 items); 7) attitudes towards technology (4 items); 8) professional use of ICT (33 items).

*Demographic information* items were used to collect and systematize data on the participants' gender, age group, professional experience, functions, regions of employment, and cycles they taught in. It was impossible to identify participants directly, and all the information was treated confidentially and anonymously in accordance with the EU regulations.

*Fundamental pedagogical beliefs* were mainly measured by three items adopted from Teaching, Learning and Computing Survey (TLC) (as cited in Ref. [26]) which presented two different classrooms (traditional and constructivist ones) and asked participants in which kind of classroom they would feel more comfortable, and students would gain more knowledge and skills. Two additional single-choice questions on the fundamental goal of a teacher and an instruction were included to ensure more reliable findings (partly developed based on [39]).

*Subjective norms* items were divided into 2 subcategories: items measuring internal culture of a school (management attitude, collegial interactions, and support, etc.) (5 items), and those measuring the efficiency and coherence of recent public policies and activities of the Ministry (4 items).

*Facilitating conditions* items were used to explore a) availability of hardware and software at schools (internet connection, technology resources, etc.) (5 items) (adapted from the technology access and support section of STIR [40]; b) organizational components (IT specialists, possibilities to use technologies, time to prepare, classroom management issues) (6 items) (partly adapted from the barriers to technology integration section of STIR [40], and the Technology Skills, Beliefs and Barriers scale [41]).

*Perceived ease of use* items measured teacher perceptions regarding their technology self-efficacy, readiness to tackle obstacles, accessibility, and ease of use of technologies (as a result of public policies and strategies) (partly adopted from 95-item TAM model, [42].

*Perceived usefulness* items measured teacher perceptions regarding value of technology for their performance (productivity, speed) (subcategory 1, 4 items) (partly adopted from TAM model [31], and Model of Personal Computer Utilization (MPCU), [43]), and learning and teaching (instructional strategies, distractions, etc.) (subcategory 2, 7 items) (partly adopted from 95-item TAM model [42], the Technology Skills, Beliefs and Barriers scale [41], and STIR [40]).

*Attitudes towards technology* items measured how teacher felt about technology, if they enjoyed using it and thought that technologies made an important pedagogical contribution (partly adopted from 95-item TAM model [42]).

*Professional use of technology* items measured the frequency and goals of use of different technologies (smartphone, laptop, printer, interactive board, etc.) by teachers (communications, presentations and multimedia enhancements, administrative tasks) and by their students (drill and practice activities, collaborations, and reflection, etc.) (subcategory 1, 23 items) (partly adapted from STIR [40]). Additional 9 items were used to investigate for which courses (mathematics, natural and social sciences, languages, arts, etc.) teachers prefer using technologies.

The survey respondents were mostly asked a) to express their degree of agreement/disagreement with the survey statements using a Likert-type scale ranging from totally agree (1) to totally disagree (5); b) to indicate the frequency of certain actions using a scale ranging from never (1) to at least once a day (5); c) to choose one option which suited their beliefs best.

### 3.3. Participants

Before the recruitment of the participants and data collection, the research instrument was revised and approved by the Ethics Review Panel of the University of Luxembourg (22-084 EdTechLU) and the Ministry of Education. After the approvals, the survey was added to the LimeSurvey platform hosted by the University of Luxembourg and potential respondents were invited to participate.

The target population of the survey consisted of all the K-6 teachers at Luxembourgish fundamental schools, encompassing general teachers (Instituteurs), teaching interns (Stagiaires), non-certified teachers (Chargé(e)s), substitute teachers (Remplaçant(e)s), educators (Éducateurs/Educatrices) and graduate educators (Éducateurs/Educatrices) gradué(e)s). Fundamental school employees not directly involved in teaching, such as those in management and administration roles, were intentionally excluded from the study sample.

**Table 1**
Study descriptive statistics and national statistics on fundamental school teachers in the 2021/2022 school year.

| | National statistics for 2021–2022 | | Study participants | |
|---|---|---|---|---|
| | N | % | N | % |
| **Gender** | | | | |
| Male | 1243 | 18,7 | 43 | 27,1 |
| Female | 5389 | 81,3 | 115 | 72,3 |
| Other | n/a | n/a | 1 | 0,6 |
| **Age** | | | | |
| 19–29 | 1374 | 20,7 | 30 | 18,9 |
| 30–39 | 2400 | 36,2 | 51 | 32,1 |
| 40–49 | 1908 | 28,8 | 50 | 31,4 |
| 50–59 | 912 | 13,7 | 27 | 17 |
| 60+ | 38 | 0,6 | 1 | 0,6 |
| **Professional experience (in years)** | Data is not available | | | |
| 0–5 | | | 36 | 22,6 |
| 6–15 | | | 55 | 34,6 |
| 16–35 | | | 63 | 39,7 |
| 36+ | | | 5 | 3,1 |
| **Function** | | | | |
| Stagiaire | 305 | 4,6 | 7 | 4,4 |
| Instituteur | 4760 | 71,7 | 140 | 88 |
| Remplaçant(e) | 317 | 4,8 | 3 | 1,9 |
| Chargé(e) | 639 | 9,6 | 4 | 2,6 |
| Éducateurs/-trice | 423 | 6,3 | 1 | 0,6 |
| Éducateurs/-trices gradué(e) | 105 | 1,7 | 1 | 0,6 |
| Other | 83 | 1,3 | – | – |
| n/a | – | – | 3 | 1,9 |
| **Cycle** | Data is not available | | | |
| C1 | | | 37 | 23,2 |
| C2 | | | 64 | 40,2 |
| C3 | | | 54 | 34 |
| C4 | | | 54 | 34 |
| Appui pédagogique | | | 9 | 5,6 |
| Classe d'accueil | | | 6 | 3,7 |
| Other | | | 8 | 5 |
| **Region** | Data is not available | | | |
| Luxembourg | | | 24 | 15 |
| Esch-sur-Alzette | | | 8 | 5 |
| Echternach | | | 9 | 5,6 |
| Mamer | | | 24 | 15 |
| Dudelange | | | 11 | 6,9 |
| Mersch | | | 9 | 5,6 |
| Petange | | | 4 | 2,6 |
| Bettembourg | | | 4 | 2,6 |
| Redange | | | 6 | 3,7 |
| Differdange | | | 29 | 18,2 |
| Remich | | | 8 | 5 |
| Diekirch | | | 20 | 12,5 |
| Sanem/Belval | | | 7 | 4,4 |
| Grevenmacher | | | 5 | 3,1 |
| Wiltz | | | 2 | 1,2 |

To recruit participants, non-probability convenient and snowball sampling techniques were used. Firstly, the directors of 15 primary education directorates were contacted and asked to disseminate the survey to the teaching staff of their directorates. The email communication included not only the survey link but also a detailed description of the study's objectives and a comprehensive overview of the data collection instrument (survey). Additionally, researchers proactively approached fundamental school teachers within their network and invited them to participate in the study. These teachers were further encouraged to share the survey among their colleagues and acquaintances who met the specified criteria.

The sample consisted of 159 participants-representatives of the teaching personnel of fundamental schools in Luxembourg. Given the total number of fundamental school teachers in the 2021/2022 school year (6632 teachers) [44], the participation rate amounted to 2,4%. The study's margin of error, determined at a 95% confidence level and computed using SurveyMonkey, was established at 8%. This margin fell within the acceptable range of 4–8%, affirming the relative representativness of the study sample. Based on the comparison of the study participants demographics with the available national statistics on fundamental school teachers in the 2021/2022 school year (Table 1) [44], the sample relatively reflected the characteristics of the entire population (gender ratio among teachers, age distribution).

As shown in Table 1, the majority of teachers who responded to the survey were female (115 respondents, 72,3%), 27,1 % of respondents (43 participants) were male, and 0,6% participants (1 respondent) self-declared as 'others'. 57,2% of teachers had less than 16 years of experience. The mean age range of teachers was between 19 and 39 (81 teacher, 50,1%) and 40–49 (50 respondents, 31,4%). 88% of participants (140 respondents) were employed as regular teachers (Instituteurs) and worked in C2 (64 teachers, 40,2%) and C3-C4 classes (54 respondents (34%) in each cycle), many respondents taught in several classes at once. A great number of participants worked in schools located in Differdange (29 teachers, 18,2%), Luxembourg (24 teachers, 15%), Mamer (24 teachers, 15%) and Diekirch (20 teachers, 12,5%).

The majority of demographic characteristics, including gender, age, professional experience, were tested as moderators of key relationships of the study.

### 3.4. Data analysis

#### 3.4.1. Data conversion

For the data analysis, responses of all the respondents were extracted from the individual reports and converted into a numerical format suitable for statistical analysis.

The first two items of the fundamental pedagogical beliefs scale (FPB-1, FPB-2) were structured as single-choice questions with two possible numerical values. Responses indicating a 'teacher-centered' perspective (option 2) were assigned a numerical value of '1', while 'constructivist' responses (option 1) were assigned a value of '5'. For the remaining items within this scale, numerical values ranged from '1' to '5', where '1' corresponded to "Definitely Ms. Meyer's" responses and '5' to "Definitely Mr. Weber's" responses.

For the items of the *subjective norms* (*internal culture subscale*) with a positive connotation (SN_IN-a, SN-IN-c, SN-IN-d, SN-IN-e), numerical values ranged from '1' to '5', where '1' corresponded to "Totally disagree" responses and '5' to "Totally agree" responses. For the remaining item with a negative connotation (SN-IN-b) the procedure was reversed. "Totally disagree" responses were assigned a value of '5', and "Totally agree" responses were assigned a value of '1'. This rating methodology was mirrored for items with both positive (SN-PP-a, SN-PP-c) and negative connotations ((SN-PP-b, SN-PP-d) within *the public policies subscale of the subjective norms*.

Possible values of the items measuring the *availability of hardware and software* of the *facilitating conditions* scale (items from FC-AV-a to FC-AV-e) ranged from '1' to '5', where '1' corresponded to "Poor" responses and '5' to "Excellent" responses. Moreover, the rating methodology applied to the positive (FC-OC-c, FC-OC-d, FC-OC-g) and negative statements (FC-OC-a, FC-OC-b, FC-OC-e, FC-OC-f) in the *organizational components* subscale of *facilitating conditions* mirrored that of the subjective norms.

Positive (PEU-a, PEU-c, PEU-e) and negative statements (PEU-b, PEU-d, PEU-f) of the *perceived ease of use* scales were rated using the above-specified methodology.

The authors used the same rating methodology for items with a positive and a negative connotation of both subscales of the *perceived usefulness* scale and the *attitudes* scale. Items coded as PU-P-a, PU-P-d (*performance* subscale of the *perceived usefulness* scale), PU-L-b, PU-L-c, PU-L-f (*teaching and learning* subscale of the *perceived usefulness* scale), AT-a, AT-b, AT-c (*attitudes* scale) were considered as positive. The remaining statements were considered as negative.

Numerical values of almost all the statements within the *professional use of technologies* scale ranged from '1' to '5', where '1' corresponded to "Never" responses and '5' to "At least once a day" responses. The only item with a different ranging methodology was an item coded as SB-1. Numerical values of the items also ranged from '1' to '5', but '1' corresponded to "Totally agree" responses and '5' to "Totally disagree" responses.

#### 3.4.2. Statistical analysis

In the process of data analysis, different methods were implemented, and descriptive statistics were generated using SPSS. These statistics were utilized in several ways:

a) the distribution was computed to analyze and summarize *demographic information of the participants*, providing a comprehensive overview of the sample characteristics;

b) the mean, as a measure of central tendency, was used to measure the average values of the study scales and subscales (if applicable) for each participant. These mean scores were subsequently integrated into the statistical analysis, forming a basis for testing the study hypotheses;
c) a combination of measures of central tendency (mean, median) and measures of variability (standard deviation, extremes) was calculated for individual items within the study constructs. The inclusion of both central tendency and variability measures provided a more nuanced perspective on the distribution and characteristics of responses to individual items, contributing to a thorough exploration of the studied phenomena.

Before the correlation, regression and moderation tests, the internal consistency of each survey scale was tested (Cronbach alpha test) following the standard procedure in SPSS Statistics (Table 2). In addition to calculating the general reliability for each scale, we also computed the reliability when individual scale items were deleted. For the *fundamental pedagogical beliefs* scale, it was observed that the exclusion of two items (FPB-1, FPB-2) contributed to an improvement in the overall Cronbach alpha of the scale. Similarly, within the *subject subcategory* scale, the exclusion of one item (SB-1) positively impacted the reliability of the construct. In both cases, the specified individual items were excluded from the correlation, regression, and moderation (for the subject subscale) tests, and only their descriptive statistics were used for a more in-depth analysis. Following the described procedure, all the study constructs exhibited an a-value greater than 0.7, a benchmark of acceptable internal consistency [36].

The study hypotheses were tested in SPSS through statistical methods (regression, correlation, and moderation analyses).

Pearson correlation coefficients and the corresponding two-tailed p-values (Sig) were computed to explore the nature and strength of relationships between the study variables. This analysis aimed to explore the interdependencies among different subscales and the studied constructs, and to shed light on the nuanced connections between various study variables.

Multiple linear regression tests, conducted with a confidence interval set at 95% using the "enter" method, were carried out to examine the impact of independent variables on the dependent variables across various hypotheses:

- For H1, H2, and H4, where the dependent variable was *teacher value beliefs* (perceived usefulness), the independent variables included *fundamental pedagogical beliefs*, *subjective norms*, and *self-efficacy beliefs* (perceived ease of use).
- For H3, focusing on the dependent variable *self-efficacy beliefs* (perceived ease of use), the independent variable was *facilitating conditions.*
- For H5 to H8, with *attitudes* as the dependent variable, the independent variables consisted of *teacher value beliefs* (perceived usefulness), *fundamental pedagogical beliefs*, *subjective norms*, and *self-efficacy beliefs* (perceived ease of use).
- Lastly, for H9 to H13, where the dependent variable was *professional use of technologies*, the independent variables encompassed *attitudes*, *teacher value beliefs* (perceived usefulness), *fundamental pedagogical beliefs*, *subjective norms*, and *self-efficacy beliefs* (perceived ease of use).

These regression analyses were designed to unravel the intricate relationships and quantify the impact of the specified independent variables on the respective constructs.

To detect multicollinearity in regression, a Variance Inflation Factor (VIF) was used (Statistics – Collinearity diagnostics). Specifically, in this study, a VIF value exceeding 2.5 was considered as high, and tolerance of below 0.40 was deemed concerning [45]. When multicollinearity was detected, a strategy of dropping one of the correlated features was employed to mitigate the observed multicollinearity and enhance the robustness of the regression analysis.

Moderation tests were carried out to check if *age*, *gender*, *professional experience*, and *subject* may be considered as moderators of key relationships of the study model. To perform the moderation analyses the following steps were taken:

- the independent and moderator variables were standardized and saved as variables (Analyze → Descriptive Statistics → Descriptives);
- By computing the product between the standardized independent and moderator variables the interaction effect (intercept) was calculated (Transform → Compute Variable);

**Table 2**
Internal consistency of the survey scales.

| Scale (number of items) | Cronbach alpha | N |
|---|---|---|
| Fundamental pedagogical beliefs (3) | 0.806 | 153 |
| Subjective norms (9) | 0.728 | 133 |
| Facilitating conditions (12) | 0.799 | 109 |
| Perceived usefulness (11) | 0.849 | 144 |
| Perceived ease of use (6) | 0.723 | 134 |
| Attitudes towards technology (4) | 0.839 | 156 |
| Professional use of ICT (23) | 0.811 | 106 |
| Subject subcategory (9) | 0.890 | 71 |

- a linear regression analysis to test the interaction effect was conducted, where the interaction term and the non-standardized independent variable were added to the Independent(s) box.

## 4. Results

After the statistical analyses, 7 hypotheses were supported, while 6 hypotheses did not find empirical support (Table 3).

### 4.1. Fundamental pedagogical beliefs

The overall mean score for this section was 3.9 (Table 4), indicating that respondents predominantly shared constructivist pedagogical beliefs. Individual mean scores showed that teachers perceived this approach as contributing to student knowledge (M = 3,9, SD = 1,05) and skills (M = 3.9, SD = 1,05). However, when it came to practical implementation, considerable variations in responses emerged (M = 3,1, SD = 1,17), highlighting a significant number of teachers who held constructivist beliefs but were more comfortable using a teacher-centered approach in their classroom.

### 4.2. Subjective norms

The mean score for this scale was 3.3, indicating that teachers assessed the social ‘pressure’ to use technology as ‘moderate’ (Table 4).

Teachers expressed a relatively high level of satisfaction with the internal digital culture of their schools (M = 3.7, SD = 0.767). They could always turn to more experienced colleagues for help (M = 4,1, SD = 0.973) and perceived the overall school attitudes towards technology as positive (M = 3,9, SD = 0.956).

Teachers were mostly skeptical about the impact of recent public policies and actions on technology integration (M = 2,8, SD = 0.684), and questioned their coherency (M = 2,5, SD = 0.848) and ability to lead to regular and efficient ICT uses (M = 2,8, SD = 0.911).

Correlation tests unexpectedly revealed close intersections between *fundamental pedagogical beliefs* and the “*policy component*” of *subjective norms*, r (155) = 0.192*, p = 0.016 (Table 5), suggesting that teachers pay attention to the public (governmental) expectations for teachers and align their understanding of a good teacher accordingly.

### 4.3. Facilitating conditions

The overall mean score of this section, M = 3,4, showed that teachers perceived technological and organizational conditions for technology use as ‘adequate’ (Table 4).

Teachers were relatively satisfied with the technology availability in their schools (M = 3,5, SD = 0.987). However, the hardware (M = 3,4, SD = 1.22), and the technology resources (M = 3,4, SD = 1,17) showed the most dispersity.

Results showed that teachers encountered organizational challenges when attempting to integrate technology (M = 3.3, SD = 0.671). Issues included difficulties in scheduling time to use common computers (M = 3.2, SD = 1.05), finding time to plan technology-based lessons (M = 3.1, SD = 1.19), managing their classrooms while using technology (M = 3.1, SD = 1.13).

Correlation tests revealed unexpected connections between the “*organizational subscale*” of *facilitating conditions* and *fundamental pedagogical beliefs*, r (155) = 0.204*, p = 0.010 (Table 5). These findings suggest that teachers with constructivist pedagogical beliefs are more inclined to allocate time for lesson planning and adopt appropriate class management strategies.

“The *organizational component*” of *facilitating conditions* also correlated with *teacher value beliefs*, r (155) = 0.495**, p = <0.001, indicating that when teachers have organizational support for technology use, they are more likely to perceive it as valuable for teaching and learning. Conversely, when teachers see technology as valuable, they are more willing to turn for assistance to IT specialists and find time to plan their lessons (Table 5).

**Table 3**
Hypotheses testing results.

| Hypothesis | Concept | |
|---|---|---|
| H1 | Fundamental pedagogical beliefs → teacher value beliefs | Supported |
| H2 | Subjective norms → teacher value beliefs | Supported |
| H3 | Facilitating conditions → self-efficacy beliefs | Supported |
| H4 | Self-efficacy beliefs → teacher value beliefs | Supported |
| H5 | Teacher value beliefs →attitudes | Supported |
| H6 | Self-efficacy beliefs → attitudes | Supported |
| H7 | Facilitating conditions → attitudes | Not supported |
| H8 | Subjective norms → attitudes | Not supported |
| H9 | Attitudes → professional use of ICT | Supported |
| H10 | Teacher value beliefs, moderated by age and gender → professional use of ICT | Not supported |
| H11 | Self-efficacy beliefs, moderated by age, gender and experience → professional use of ICT | Not supported |
| H12 | Facilitating conditions moderated by age and experience → professional use of ICT | Not supported |
| H13 | Subjective norms → professional use of ICT | Not supported |

**Table 4**
Descriptive statistics of the study constructs.

| Construct | Min | Max | Mean | Std. Deviation | MD | Construct | Min | Max | Mean | Std. Deviation | MD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **FPB** | **1,00** | **5,00** | **3,9** | **,768** | **4,2** | **PEU** | **1,00** | **4,75** | **3,4** | **,67** | **3,5** |
| FPB-1 | 1,00 | 5,00 | 4,7 | ,94 | 5 | PEU-A | 1,00 | 5,00 | 3,6 | 1,07 | 4 |
| FPB-2 | 1,00 | 5,00 | 4,8 | ,841 | 5 | PEU-B | 1,00 | 5,00 | 3,4 | 1,09 | 4 |
| FPB-3D | 1,00 | 5,00 | 3,1 | 1,17 | 3 | PEU-C | 1,00 | 5,00 | 4,1 | ,77 | 4 |
| FPB-3-K | 1,00 | 5,00 | 3,9 | 1,05 | 4 | PEU-D | 1,00 | 5,00 | 3,4 | 1,11 | 4 |
| FPB-3-S | 1,00 | 5,00 | 3,9 | 1,05 | 4 | PEU-E | 1,00 | 5,00 | 3,1 | ,98 | 3 |
| | | | | | | PEU-F | 1,00 | 4,75 | 3,4 | ,677 | 2 |
| **SN** | **1,00** | **4,78** | **3,3** | **,584** | **3,3** | | | | | | |
| *SNI-N* | *1,00* | *5,00* | *3,7* | *,767* | *3,8* | *SN-PP* | *1,00* | *4,50* | *2,8* | *,684* | *3* |
| SN-IN-A | 1,00 | 5,00 | 3,6 | 1,03 | 4 | SN-PP-A | 1,00 | 5,00 | 3,1 | 1,03 | 3 |
| SN-IN-B | 1,00 | 5,00 | 3,3 | 1,20 | 4 | SN-PP-B | 1,00 | 5,00 | 2,5 | ,848 | 2 |
| SN-IN-C | 1,00 | 5,00 | 3,7 | ,984 | 4 | SN-PP-C | 1,00 | 5,00 | 3,0 | ,868 | 3 |
| SN-IN-D | 1,00 | 5,00 | 4,1 | ,973 | 4 | SN-PP-D | 1,00 | 5,00 | 2,8 | ,911 | 3 |
| SN-IN-E | 1,00 | 5,00 | 3,9 | ,956 | 4 | | | | | | |
| **FC** | **1,00** | **4,67** | **3,4** | **,664** | **3,5** | | | | | | |
| *FC-AV* | *1,00* | *5,00* | *3,5* | *,987* | *3,6* | *FC-OC* | *1,00* | *4,57* | *3,3* | *,671* | *3,4* |
| FC-AV-A | 1,00 | 5,00 | 3,4 | 1,22 | 4 | FC-OC-A | 1,00 | 5,00 | 3,7 | 1,05 | 4 |
| FC-AV-B | 1,00 | 5,00 | 3,6 | 1,06 | 4 | FC-OC-B | 1,00 | 5,00 | 3,5 | 1,10 | 4 |
| FC-AV-C | 1,00 | 5,00 | 3,4 | 1,17 | 4 | FC-OC-C | 1,00 | 5,00 | 3,2 | 1,05 | 3 |
| FC-AV-D | 1,00 | 5,00 | 3,5 | 1,16 | 4 | FC-OC-D | 1,00 | 5,00 | 3,6 | 1,32 | 4 |
| FC-AV-E | 1,00 | 5,00 | 3,4 | 1021 | 4 | FC-OC-E | 1,00 | 5,00 | 3,1 | 1,13 | 3 |
| | | | | | | FC-OC-F | 1,00 | 5,00 | 3,1 | 1,19 | 3 |
| | | | | | | FC-OC-G | 1,00 | 5,00 | 2,9 | ,908 | 3 |
| **PU** | **1,00** | **4,91** | **3,6** | **,620** | **3,7** | | | | | | |
| *PU-P* | *1,75* | *5,00* | *3,7* | *,769* | *3,7* | *PU-L* | *1,00* | *5,00* | *3,6* | *,641* | *3,6* |
| PU-P-A | 1,00 | 5,00 | 3,8 | 1,00 | 4 | PU-L-A | 1,00 | 5,00 | 3,7 | ,963 | 4 |
| PU-P-B | 1,00 | 5,00 | 3,6 | 1,01 | 4 | PU-L-B | 1,00 | 5,00 | 3,8 | ,856 | 4 |
| PU-P-C | 1,00 | 5,00 | 3,9 | 1,01 | 4 | PU-L-C | 1,00 | 5,00 | 4,0 | ,767 | 4 |
| PU-P-D | 1,00 | 5,00 | 3,7 | ,943 | 4 | PU-L-D | 1,00 | 5,00 | 2,7 | ,940 | 3 |
| | | | | | | PU-L-E | 1,00 | 5,00 | 3,1 | 1,04 | 3 |
| | | | | | | PU-L-F | 1,00 | 5,00 | 4,1 | ,791 | 4 |
| | | | | | | PU-L-G | 1,00 | 5,00 | 3,7 | ,940 | 4 |
| **ATT** | **1,00** | **5,00** | **3,8** | **,786** | **4** | | | | | | |
| ATT-A | 1,00 | 5,00 | 3,7 | ,840 | 4 | ATT-C | 1,00 | 5,00 | 4,0 | ,886 | 4 |
| ATT-B | 1,00 | 5,00 | 3,8 | ,866 | 4 | ATT-D | 1,00 | 5,00 | 3,5 | 1,12 | 4 |
| **PrUse** | **2,09** | **4,76** | **3,4** | **,566** | **3,4** | | | | | | |
| *PrUse-T* | *2,33* | *4,93* | *3,7* | *,526* | *3,8* | | | | | | |
| PrUse-T-smart | 1,00 | 5,00 | 4,6 | ,783 | 5 | PrUse-T-AC-A | 1,00 | 5,00 | 4,1 | ,905 | 4 |
| PrUse-T-Phone | 1,00 | 5,00 | 3,4 | 1,41 | 4 | PrUse-T-AC-B | 2,00 | 5,00 | 4,4 | ,642 | 5 |
| PrUse-T-PC | 1,00 | 5,00 | 3,6 | 1,65 | 5 | PrUse-T-AC-C | 1,00 | 5,00 | 3,3 | 1,32 | 3 |
| PrUse-T-laptop | 1,00 | 5,00 | 3,9 | 1,51 | 5 | PrUse-T-AC-D | 1,00 | 5,00 | 3,5 | ,994 | 4 |
| PrUse-T-Tablet | 1,00 | 5,00 | 3,7 | 1,30 | 4 | PrUse-T-AC-E | 1,00 | 5,00 | 3,6 | 1,48 | 4 |
| PrUse-T-proj | 1,00 | 5,00 | 3,5 | 1,59 | 4 | PrUse-T-AC-F | 3,00 | 5,00 | 4,6 | ,513 | 5 |
| PrUse-T-scan | 1,00 | 5,00 | 3,03 | 1,23 | 3 | PrUse-T-AC-G | 1,00 | 5,00 | 3,8 | 1,09 | 4 |
| PrUse-T-printer | 3,00 | 5,00 | 4,5 | ,530 | 5 | | | | | | |
| PrUse-T-board | 1,00 | 5,00 | 1,8 | 1,58 | 1 | | | | | | |
| *PrUse-S* | *1,00* | *4,71* | *2,5* | *,880* | *2,5* | | | | | | |
| PrUse-S-A | 1,00 | 5,00 | 3,2 | 1,05 | 4 | PrUse-S-E | 1,00 | 5,00 | 2,0 | 1,17 | 1 |
| PrUse-S-B | 1,00 | 5,00 | 2,6 | 1,16 | 3 | PrUse-S-F | 1,00 | 5,00 | 2,2 | 1,12 | 2 |
| PrUse-S-C | 1,00 | 5,00 | 2,7 | 1,10 | 3 | PrUse-S-G | 1,00 | 5,00 | 1,8 | 1,18 | 1 |
| PrUse-S-D | 1,00 | 5,00 | 2,7 | 1,18 | 3 | | | | | | |
| *SB-1* | *1,00* | *5,00* | *3,5* | *1,09* | *3* | | | | | | |
| SB-M | 1,00 | 5,00 | 3,07 | 1,08 | 4 | SB-G | 1,00 | 5,00 | 3,5 | 1,22 | 4 |
| SB-NS | 1,00 | 5,00 | 2,5 | 1,15 | 3 | SB-S | 1,00 | 5,00 | 1,7 | 1,20 | 1 |
| SB-A | 1,00 | 5,00 | 3,4 | 1,21 | 3 | SB-V | 1,00 | 5,00 | 2,5 | 1,22 | 3 |
| SB-F | 1,00 | 5,00 | 3,5 | 1091 | 4 | SB-ME | 1,00 | 5,00 | 3,0 | 1,05 | 3 |
| | | | | | | SB-CT | 1,00 | 5,00 | 2,9 | ,877 | 3 |

### 4.4. *Teacher value beliefs*

The mean score of this construct was 3,6, revealing that teachers recognized the overall value of technology for education (Table 4).

Despite that, teachers tended to focus on potential drawbacks, such as decreased personal treatment (M = 3.7, SD = 0.963) and student distraction (M = 3.7, SD = 0.940), rather than its advantages (M = 4.1, SD = 0.791). Moreover, teachers considered technology use by students as a low priority (M = 3.1, SD = 1.04), emphasizing the importance of content knowledge over it (M = 2.7, SD = 0.940).

The statistical tests identified that *teacher-value beliefs* were closely correlated with *fundamental pedagogical beliefs*, r (157) = 0.4843**, p = <.01, *self-efficacy beliefs*, r (157) = 0.458**, p = <.01, and *subjective norms*, r (157) = 0.267**, p = <.01 (Table 5). The

**Table 5**
Study correlation matrix.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FPB | r | 1 | 0.118 | 0.05 | 0.192* | 0.087 | 0.047 | 0.204* | 0.194* | **0.484**** | 0.217** | 0.553** | 0.463** | 0.093 | 0.094 | 0.059 |
| | P | | 0.139 | 0.532 | 0.016 | 0.278 | 0.560 | 0.010 | 0.014 | **<0.001** | 0.006 | <0.001 | <0.001 | 0.243 | 0.238 | 0.474 |
| | N | | 159 | 159 | 157 | 159 | 158 | 157 | 159 | 159 | 158 | 159 | 159 | 159 | 159 | 152 |
| SN | r | | 1 | 0.867** | ,642** | 0.601** | 0.101 | 0.531** | 0.438** | **0.362**** | 0.250** | 0.326** | **0.425**** | **0.364**** | 0.336** | 0.321** |
| | P | | | 0.000 | <0.001 | <0.001 | 0.205 | <0.001 | <0.001 | **<0.001** | 0.002 | <0.001 | **<0.001** | **<0.001** | <0.001 | <0.001 |
| | N | | | 159 | 157 | 159 | 158 | 157 | 159 | 159 | 158 | 159 | 159 | 159 | 159 | 152 |
| SN-IN | r | | | 1 | 0.207** | 0.500** | 0.099 | 0.429** | 0.360** | 0.267** | 0.189* | 0.227** | 0.336** | 0.394** | 0.372** | 0.333** |
| | p | | | | 0.009 | <0.001 | 0.215 | <0.001 | <0.001 | <0.001 | 0.018 | 0.04 | <0.001 | <0.001 | <0.001 | <0.001 |
| | N | | | | 157 | 159 | 158 | 157 | 159 | 159 | 158 | 159 | 159 | 159 | 159 | 152 |
| SN-PP | r | | | | 1 | 0.426** | 0.047 | 0.399** | 286** | 0.329** | 0.183 | 0.333** | 0.346** | 0.113 | 0.83 | 0.136 |
| | P | | | | | 0.000 | 0.563 | <0.001 | <0.001 | <0.001 | 0,22 | <0.001 | <0.001 | 0.157 | 0.302 | 0.096 |
| | N | | | | | 157 | 156 | 155 | 157 | 157 | 156 | 159 | 157 | 157 | 157 | 150 |
| FC | r | | | | | 1 | 0.375** | 0.783** | **0.489**** | 0.335** | 0.271** | 0.279** | **0.387**** | **0.331**** | 0.355** | 0.250** |
| | P | | | | | | <0.001 | <0.001 | **<0.001** | <0.001 | <0.001 | <0.001 | **<0.001** | **<0.001** | <0.001 | 0.002 |
| | N | | | | | | 158 | 157 | 159 | 159 | 158 | 159 | 159 | 159 | 159 | 152 |
| FC-AV | r | | | | | | 1 | 0.216** | 0.077 | 0.069 | 0.011 | 0.081 | 0.083 | 0.000 | 0.007 | 0.26 |
| | p | | | | | | | 0.007 | 0.338 | 0.391 | 0.889 | 0.311 | 0.298 | 0.998 | 0.926 | 0.750 |
| | N | | | | | | | 156 | 158 | 158 | 157 | 158 | 158 | 158 | 158 | 151 |
| FC-OC | r | | | | | | | 1 | 0.533** | 0.495** | 0.400** | 0.436** | 0.525** | 0.256** | 0.242** | 0.240** |
| | p | | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 | 0.002 | 0.003 |
| | N | | | | | | | | 159 | 157 | 156 | 157 | 157 | 157 | 157 | 151 |
| PEU | r | | | | | | | | 1 | **0.458**** | 0.522** | 0.318* | **0.504**** | **0.337**** | 0.292** | 0.296** |
| | P | | | | | | | | | **<0.001** | <0.001 | <0.001 | **<0.001** | **<0.001** | <0.001 | <0.001 |
| | N | | | | | | | | | 159 | 158 | 159 | 159 | 159 | 159 | 152 |
| PU | r | | | | | | | | | 1 | 0.825** | 0.923** | **0.805**** | **0.320**** | 0.286** | 0.288** |
| | P | | | | | | | | | | <0.001 | <0.001 | **<0.001** | **<0.001** | <0.001 | <0.001 |
| | N | | | | | | | | | | 158 | 159 | 159 | 159 | 159 | 152 |
| PU-P | r | | | | | | | | | | 1 | 0.525** | 0.639** | 0.315** | 0.266** | 0.302** |
| | P | | | | | | | | | | | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| | N | | | | | | | | | | | 158 | 158 | 158 | 158 | 151 |
| PU-L | r | | | | | | | | | | | 1 | 0.747** | 0.270** | 0.246** | 0.241** |
| | P | | | | | | | | | | | | <0.001 | <0.001 | 0.002 | 0.003 |
| | N | | | | | | | | | | | | 159 | 159 | 159 | 152 |
| ATT | r | | | | | | | | | | | | 1 | **0.367**** | 0.313** | 0.382** |
| | P | | | | | | | | | | | | | **<0.001** | <0.001 | <0.001 |
| | N | | | | | | | | | | | | | 159 | 159 | 152 |
| PrUse | r | | | | | | | | | | | | | 1 | 0.910** | 0.838** |
| | p | | | | | | | | | | | | | | <0.001 | <0.001 |
| | N | | | | | | | | | | | | | | 159 | 152 |
| PrUse-T | r | | | | | | | | | | | | | | 1 | 0.558** |
| | p | | | | | | | | | | | | | | | <0.001 |
| | N | | | | | | | | | | | | | | | 152 |
| PrUse-S | r | | | | | | | | | | | | | | | 1 |
| | p | | | | | | | | | | | | | | | |
| | N | | | | | | | | | | | | | | | |

low p-values ($p < 0.001$) suggested that these variables could be also considered strong predictors of *teacher value beliefs* (Table 6).

The statistics show teachers' ideas about key pillars of a good teacher and effective instruction had a primary influence on their perceptions of the value of technology for education, r (157) = 0.553**, p = <.01, and a secondary influence on those about the value of technology for their own professional activities, r (156) = 0.217**, p = .06.

When teachers measured their ability to use technology, they mostly considered how this ability/disability influenced their performance as teachers, r (156) = 0.522**, p = <.01, and not the learning process as a whole, r (157) = 0.318**, p = <.01 (Table 5).

The governmental vision on technology integration, r (155) = 0.329**, p = <.01, played a more substantial role in shaping teacher perceptions of the value of technology for teaching and learning compared to the influence of the internal digital culture in school, r (157) = 0.267**, p = <.01.

### 4.5. *Teacher self-efficacy beliefs*

The mean score of this scale was 3.4, suggesting that teachers were rather confident about their technology skills, and ability to tackle possible obstacles (M = 4.1, SD = 0.77) (Table 4).

Teachers mostly questioned the ability of recent public policies and actions to make technologies accessible and easy to use (M = 3.1, SD = 0.098).

It became apparent that merely having access to sufficient high-quality hardware and software was not enough for teachers to perceive technology as easy to use, r = 0.077, p = 0.338. An adequate technological support system was also essential for fostering a sense of self-efficacy among teachers, r = 0.533**, $p < .01$).

Unexpected connections were also observed between *subjective norms* and *teacher self-efficacy beliefs*, r (157) = 0.438**, p = <0.001, suggesting that idea-sharing, collaborative practices and governmental guidelines help teachers feel more confident with technology (Table 5).

### 4.6. *Attitudes*

The mean score of this scale was 3,8, suggesting that teachers had positive attitudes towards technology (Table 4). Teachers enjoyed using computers in their professional life (M = 4,0, SD = 0.886), and were excited to learn more about them (M = 3,8, SD = 0.866).

When individual connections were studied, *attitudes* did not only correlate with *teacher value beliefs*, r (157) = . 805**, p = <0.001, *teacher self-efficacy beliefs*, r (157) = . 504**, p = <0.001, *facilitating conditions*, r (157) = . 387**, p = <0.001, and *subjective norms*, r (157) = . 336**, p = <0.001, but were also heavily dependent on them (Table 5).

When analyzed as a system, only *teacher value beliefs* and *teacher self-efficacy beliefs* were identified as predictors of *attitudes*,

**Table 6**
Regression coefficients.

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. | 95,0% Confidence Interval for B | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound | Tolerance | VIF |
| 1 | (Constant) | 1734 | ,245 | | 7083 | <,001 | 1251 | 2218 | | |
| | FC | ,495 | ,070 | ,489 | 7032 | **<,001** | ,356 | ,634 | 1000 | 1000 |
| Dependent Variable: PEUrowhead | | | | | | | | | | |
| | (Constant) | ,768 | ,299 | | 2568 | ,011 | ,177 | 1358 | | |
| | FPB | ,327 | ,051 | ,405 | 6369 | **<,001** | ,225 | ,428 | ,961 | 1041 |
| | SN | ,195 | ,074 | ,184 | 2650 | **,009** | ,050 | ,341 | ,807 | 1239 |
| | PEU | ,276 | ,065 | ,298 | 4253 | **<,001** | ,148 | ,404 | ,787 | 1270 |
| Dependent Variable: PUrowhead | | | | | | | | | | |
| 1 | (Constant) | -,524 | ,265 | | −1977 | ,050 | −1047 | ,000 | | |
| | SN | ,131 | ,079 | ,097 | 1650 | ,101 | -,026 | ,287 | ,597 | 1674 |
| | FC | ,038 | ,071 | ,032 | ,534 | ,594 | -,102 | ,178 | ,574 | 1742 |
| | PEU | ,147 | ,066 | ,125 | 2220 | **,028** | ,016 | ,277 | ,650 | 1539 |
| | PU | ,888 | ,066 | ,701 | 13 409 | **<,001** | ,757 | 1019 | ,756 | 1322 |
| Dependent Variable: Attitudesrowhead | | | | | | | | | | |
| 1 | (Constant) | 1675 | ,306 | | 5477 | <,001 | ,877 | 2473 | | |
| | PEU | ,095 | ,077 | ,113 | 1244 | **,215** | -,104 | ,295 | ,630 | 1588 |
| | PU | ,035 | ,111 | ,038 | ,311 | **,756** | -,255 | ,325 | ,349 | **2866** |
| | SN | ,167 | ,091 | ,172 | 1831 | **,069** | -,071 | ,405 | ,587 | 1704 |
| | FC | ,080 | ,081 | ,093 | ,982 | **,328** | -,132 | ,291 | ,573 | 1745 |
| | Attitudes | ,122 | ,092 | ,170 | 1330 | **,186** | -,118 | ,362 | ,319 | **3138** |
| Dependent Variable: Professional use of ICT (initial)rowhead | | | | | | | | | | |
| | (Constant) | 1714 | ,278 | | 6158 | <,001 | 1164 | 2264 | | |
| | Attitudes | ,143 | ,062 | ,199 | 2300 | **,023** | ,020 | ,266 | ,691 | 1448 |
| | PEU | ,097 | ,076 | ,115 | 1281 | ,202 | -,053 | ,247 | ,635 | 1575 |
| | SN | ,167 | ,091 | ,172 | 1838 | ,068 | -,012 | ,347 | ,587 | 1704 |
| | FC | ,080 | ,081 | ,094 | ,986 | ,326 | -,080 | ,239 | ,573 | 1745 |
| Dependent Variable: Professional use of ICT (corrected)rowhead | | | | | | | | | | |

whereby *teacher value beliefs* have the greatest impact, p = <. 001 (Table 6). *Subjective norms* and *facilitating conditions* impacted *attitudes* towards technology indirectly, through *teacher value beliefs* and *teacher self-efficacy beliefs*, respectively.

Statistics revealed that when forming *attitudes* towards technology, teachers placed slightly higher importance in the value of technology for *learning*, r (157) = 0.747**, p = <.01, than for their own about *performance*, r (156) = 0.639**, p = <.01.

### 4.7. Professional use of technologies

The mean score of this section was 3,4, revealing that technology was quite frequently used in Luxembourgish fundamental schools (Table 4).

Teachers were active technology users (M = 3.7, SD = 0.566). Smartphones (M = 4.6, SD = 0.786), printers (M = 4.5, SD = 0.530), and laptops (M = 3.9, SD = 1,51) were used the most, interactive boards (M = 1.8, SD = 1.58) were used the least. However, teachers were prone to first-level and inefficient uses, such as communication with students/parents (M = 4.1, SD = 0.905), preparation of lessons (M = 4.6, SD = 0.513), and Internet search for planning and ideas (M = 4.4, SD = 0.642). More advanced uses, including presentations (M = 3.3, SD = 0.1,32) and multimedia enhancements (M = 3.5, SD = 0.994) received less attention (Table 4).

Technology use by students was limited (M = 2.5, SD = 0.880). The most frequently used technology by students was drill and practice (M = 3.2, SD = 1.05) followed by group activities (M = 2.7, SD = 1.18).

In terms of subject areas, mathematics (M = 3.07, SD = 1.08), languages (M = 3.5, SD = 1.09), and arts (M = 3.4, SD = 1.21) were frequently taught with technology, while sports (M = 1.7, SD = 1.2) received relatively less attention (Table 4).

The initial regression model was not accurate due to multicollinearity. As described in the data analysis section, the collinearity statistics of *teacher value beliefs*, t = 0.347, VIF = 2,866, and *attitudes*, t = 0.319, VIF = 3,138, were considered as concerning (Table 6). After dropping one of the correlated features, namely *teacher value beliefs*, the statistics of the secondary regression test showed that only *attitudes* could be considered as strong direct predictor of *professional use of technology*, p = .23. *Subjective norms* and *facilitating conditions* influenced *professional technology use* through *teacher value beliefs* and *teacher self-efficacy beliefs*, respectively, which, in turn, impacted it through *attitudes* (Tables 5 and 6).

### 4.8. Moderation effects

The findings showed that, alongside the *subject* taught, none of the demographic characteristics of the participants (*age*, *gender*, *professional experience*) moderated any relationships in the model (Table 7). It is plausible that "the boom of technologies, digital devices, and applications, the appearance of a new, digital-age generation and the elimination of basic gender stereotypes" have resulted in their insignificance for ICT uses in education (more detailed in Ref. [46]).

## 5. Discussion

Nowadays, two types of fundamental pedagogical beliefs are distinguished: constructivist beliefs (student-centered) and objectivist ones (teacher-centered) [3]. In ICT integration research, the intersections between those types of fundamental pedagogical beliefs and teacher value beliefs (i.e., how valuable they think ICT is for teaching and learning) have been widely studied. It is suggested that teachers who are proponents of constructivist teaching practices have more positive beliefs about the value of technology [3], and, thus, are more likely to use ICT in their classrooms [38]. It is believed that such teachers are prone to believe that technology-supported education is "more effective than the use of traditional handmade materials" [21] and that it allows students to "explore and develop concepts" ([2], p. 1412). On the contrary, teachers who prefer the teacher-centered approach tend to focus on potential risks of technologies, such as distraction from classroom activities, hindrance of social interaction between students [21], and, thus, to be more

**Table 7**
Statistics of the moderation tests.

| Hypothesis | Concept | Moderator | Statistics | |
|---|---|---|---|---|
| H10 | Teacher value beliefs → professional use of ICT | Age | p = 0.233 | Not supported |
| | | Gender | p = 0.222 | Not supported |
| | | Math (subject) | p = 0.784 | Not supported |
| | | Natural and Social sciences (subject) | p = 0.376 | Not supported |
| | | Arts (subject) | p = 0.074 | Not supported |
| | | French (subject) | p = 0.151 | Not supported |
| | | German (subject) | p = 0.310 | Not supported |
| | | Sports (subject) | p = 0.894 | Not supported |
| | | Value education (subject) | p = 0.629 | Not supported |
| | | Media education (subject) | p = 0.500 | Not supported |
| | | Computational thinking (subject) | p = 0.237 | Not supported |
| H11 | Self-efficacy beliefs, → professional use of ICT | Age | p = 0.403 | Not supported |
| | | Gender | p = 0.778 | Not supported |
| | | Experience | p = 0.596 | Not supported |
| H12 | Facilitating conditions → professional use of ICT | Age | p = 0.123 | Not supported |
| | | Experience | p = 0.275 | Not supported |

skeptical about their value.

This study not only establishes a direct positive relationship between teacher value beliefs and fundamental pedagogical beliefs but also shows that teachers are potentially concerned about the impact of technology on student material absorption, well-being, and social skills. The study findings underscore the importance of finding and establishing a balance between ubiquitous ICT uses and the efficient socialization of children, especially in fundamental education, where teachers are likely to believe that their task is to "safeguard children from digitalization" ([21], p. 343).

There is no consensus on the impact of subjective norms on attitudes, and, especially, on teacher value beliefs and professional ICT use; some studies find a significant influence of subjective norms on attitudes [11], and on teacher value beliefs [11,37], some of them fail to establish those connections (see also [37]). Such differences are often explained by culture and time variations [11], community values and their compatibility with ICT uses [21], the environment where the studies were conducted [37]. In the present study, we managed to discover direct positive relationships between teacher value beliefs and subjective norms, and an indirect impact of subjective norms on attitudes.

The study brings to light unique and underrepresented connections between subjective norms and other variables, highlighting the superiority of policy-related items over those related to school attitudes, teacher interactions and collaborations which are considered as traditional pillars of subjective norms [47]. It suggests that public leadership [29,38], aligned vision on community goals and roles of ICT "are more empowering than practices of other teachers" ([46], p. 347). When teachers understand public vision on the frequency and nature of ICT uses in the classroom and feel that it helps them to stay aligned with the expectations and contribute to the common good, they are more likely to comprehend the value of technology in education, to develop more positive attitudes towards it, and to become more active users of ICT in the classroom. Furthermore, easily comprehensive guidelines on technology use for instruction help teachers feel more confident with technology, and effectively implement constructivist teaching strategies in the classroom. However, it is only achievable through transparent and coherent policy initiatives, and through challenging the professional community's beliefs [21] by "close collaborations and consultations between public officials and teachers" ([46], p. 348), teacher interactions and discussions.

Facilitating conditions turned out to be a direct predictor of teacher self-efficacy beliefs and an indirect determinant of attitudes which corresponds with the findings of other authors [37,38]. When teachers are provided with adequate, mostly technical, support, and sufficient high-quality hardware and software, they tend to perceive ease of technology, and, as a result, to have more positive attitudes towards it and use it at work [37]. Shifting away from the previous research that considered lack of infrastructure as a key barrier to technology integration in education [14–16], the study revealed that, in the case of Luxembourg, adequate organizational conditions were a prerequisite for teacher confidence with technology and integration of ICT into the classroom (see also [38]). Given our findings, it seems that many teachers still struggle to translate their constructivist beliefs into practice, find time to learn how to deal with technology [48] and to prepare technology-based lessons [16], and face different classroom management issues [14]. These challenges present potential obstacles to efficient ICT integration and are to be addressed by all available means.

Many scientists agree on the positive influence of teacher self-efficacy beliefs on teacher value beliefs [24], on attitudes [37,49], and on professional use of ICT (both direct and indirect) [50], and the present study is no exception. It is reasonable to believe that when teachers feel competent to integrate technology, they perceive it as interesting and useful [49], and, thus, hold more positive attitudes towards it [37] and use it more frequently in professional settings. However, in reality, the study findings point out a 'gap' between self-efficacy beliefs and ICT uses in Luxembourg. It seems that teacher perceptions on ease of ICT use do not obligatorily lead to frequent, advanced, and efficient technology uses. Teachers may have the required ICT skills but still believe that technology is difficult to use, due to numerous reasons, including unfavorable organizational conditions and their perceptions of technology as "it is not easily applicable in the teaching/learning situation" ([51], p.10). It results in teachers being prone to first-level and inefficient uses [38] aimed at supporting administrative activities [4] and communication (rather than to more advanced ones, such as presentations and multimedia enhancement.

From our findings, it is clear that teacher-value beliefs and teacher self-efficacy belies predict attitudes, whereby attitudes influence the professional use of ICT [4,52], suggesting that when teachers perceive technology as valuable for teaching and learning, they generally hold more positive attitudes [37] and spend more time in the classroom using technology [49]. The study has shown that the use of ICT as a tool to support student learning remains a challenge [4]. Fundamental school teachers in Luxembourg prefer to bolster their teaching with technologies, rather than to enable students to enhance their learning experiences.

### *5.1. Technology integration in Luxembourgish secondary schools: similarities and differences*

The results of the large-scale International Computer and Information Literacy Study (ICILS), conducted in 2018 [53,54] facilitate the comparison of technology integration in fundamental education with a similar process at the level of secondary education.

As revealed in the study, time and opportunity for teachers to work on their ICT skills, as integral components of the "organizational construct" of facilitating conditions, proved to be "more important for teachers' use of ICT in practice than the availability of computers and a good Internet connection" [54]. This trend may be explained by the widespread presence of technology in Luxembourgish schools of all levels, as supported by the country's low ratio of students to ICT devices [53].

The statistical analysis of ICILS-2018 results for Luxembourg have supported the ideas of the importance of a shared vision on community goals and the roles of ICT, as well as collaborative activities among teachers. The study suggests that when ICT is a leadership priority for teaching in schools, it motivates teachers to use ICT for instruction. Additionally, higher reported participation in collaborative professional development learning related to ICT was found to be significantly associated with greater self-reported pedagogical use of ICT by teachers [54].

While assessing the value of technology for education, secondary teachers also tended to focus on potential drawbacks, rather than advantages. However, in contrast to fundamental school teachers, concerns among secondary school teachers were focused on student integrity, suggesting that technology facilitated material copying from internet sources [53].

Analogously to our study, the study on secondary education failed to show the existence of a relationship between demographic characteristics and professional teachers 'use of ICT [54].

Similar patterns of ICT usage were identified in both fundamental and secondary schools. Although teachers in secondary schools were active technology users [53], they tended to use technology for knowledge transmission rather than knowledge construction [54]. Moreover, technology usage by students was relatively limited, with scores falling below the average ICILS 2018 score [53].

In summary, technology integration beliefs and behaviors of fundamental and secondary education schools in Luxembourg have significant similarities, suggesting that the majority of established insights into the beliefs and behavioral patterns of Luxembourgish fundamental teachers can be easily applicable to the local secondary education context.

### 5.2. *Theoretical and practical implications*

The paper builds on existing literature exploring the educational technology integration landscapes of highly developed and developing countries across the globe. It contributes to the existing knowledge by examining the Luxembourgish case of technology integration in fundamental schools with the mixed use of items validated by prior research and policy items developed with consideration for the local context.

The study introduces new perspectives on the factors of successful technology integration. It emphasizes the role of educational policies and aligned community vision in shaping teacher educational and technology-related beliefs and behaviors and it provides a more relevant understanding of the conditions facilitating technology uses in the classroom, suggesting that adequate organizational conditions are more important than access to technology.

The foundation of the study on previous research facilitates the transferability of key insights to diverse cultural and economic settings. However, some of the study findings, for instance, those on the superior role of organizational conditions over the infrastructure for technology integration, affiliated with the widespread presence of technology in Luxembourgish schools, should be generalized to landscapes with material resources issues (Mexico, Italy) with caution [55].

The study sets conditions for informed decision and policy-making providing insights on challenges of technology integration in education in Luxembourg (teacher concerns related to the value of technology, inefficient and ICT uses). It is recommended to regularly review and adjust the existing policies and strategies to address the identified and plausible challenges. It is also advised to develop professional development programs which will (a) provide sufficient time for teachers to come to terms with technology and to experiment with it (see for instance [56]), (b) ensure an adequate support during and shortly after the training [4], (c) teach how to ensure social and physical development of children, their well-being while using ICT (fundamental schools), and how to detect and mitigate academic dishonesty practices (secondary schools), (d) build a collaborative environment and set conditions for teachers to exchange and reflect on their beliefs and experiences [21], (e) share efficient classroom management techniques and successful lesson planning strategies. Workshops, demonstrations of successful cases followed by hands-on activities and group discussions would help address the 'gap' between teacher self-efficacy beliefs and advanced ICT uses by explaining and showing how to use ICT effectively and promote students' uses of technology in the classrooms.

The results and recommendations of this study will be presented to public officials and the working groups of the Ministry of Education involved into technology integration in fundamental schools in Luxembourg (policies, curriculum, etc.) in a form of presentations and webinars.

### 5.3. *Limitations of the study and future research*

This study has some limitations. First, the research data of this study was collected through a self-reported survey, which may present response bias with teachers potentially providing answers that align with perceived social expectations and inaccurately reporting on their practices. Future studies should consider collecting data through teacher interviews and class observations, which would provide more objective information on technology integration in Luxembourgish fundamental schools.

Second, the study sample was small. While our results suggest certain trends and relationships influencing technology integration, it is crucial to interpret and generalize these findings to the larger population with caution. To address this limitation, future research should prioritize larger and more diverse samples. A larger sample would enhance the external validity of our findings.

Third, the policy items of survey instrument were developed with consideration for local nuances, so they may not be universally valid across different educational policy contexts. Future studies should adapt the specified survey items to their contexts to ensure the consistency of question interpretations across different countries.

## 6. Conclusions

Nowadays technology integration in education directly or indirectly depends on a set of interrelated factors such as (a) teacher attitudes followed by (b) subjective norms, (c) teacher self-efficacy beliefs, (d) facilitating conditions, (e) teacher value beliefs, and (f) fundamental pedagogical beliefs (indirectly through teacher value beliefs). Thus, all the factors socially (environment and cultural values), politically (national trends and governmental initiatives), technically (hardware, skills) or psychologically (beliefs and attitudes) impact teacher intentions to use technology in the classroom.

The present study revealed possible deterrents and challenges of ICT integration in Luxembourgish fundamental schools, including (a) potential teacher concerns about material absorption, socialization, and personal treatment of children, (b) gaps between teacher ICT competencies and advanced ICT uses, (c) lack of time to learn technology and plan technology-mediated lessons, (d) class management issues, and (e) student under-use of ICT in the classroom.

The boom of technologies, devices, and applications, the appearance of a digital-age generation, and the elimination of basic stereotypes on gender roles resulted in the insignificance of gender, age, and experience for ICT integration in education.

One of the most efficient ways to address ICT integration challenges and ensure innovative uses is advanced training which (a) provides sufficient time to learn technology and experiment with it, (b) ensures adequate initial and follow-up support, (c) offers workshops, groups discussions, and on-hands activities on possible uses of available software and hardware by teachers and students, (d) incorporates efficient class management techniques and strategies to bolster social and physical development of children in the digital age, (e) fosters a collaborative environment for teachers to exchange and reflect on their experiences and beliefs.

## Ethics declarations

This study was reviewed and approved by the Ethics Review Panel of the University of Luxembourg and the Ministry of Education, with the approval number: 22-084 EdTechLU.

All participants provided informed consent to participate in the study.

## Data availability statement

No data availability. The data that has been used is confidential, and the authors do not have permission to share it.


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## CRediT authorship contribution statement

**Kateryna Ivanishchenko:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Gilbert Busana:** Writing – review & editing, Writing – original draft, Project administration, Conceptualization. **Robert A.P. Reuter:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e28704.

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