AI4T
AI FOR TEACHERS

Work Package 3:
Evaluation

Deliverable D3.3
National Evaluation Report
Luxembourg

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of the European Union

Project Title:	Artificial Intelligence for and by Teachers
Project Acronym:	AI4T
Project Number	626154
Grant Agreement Number	626154-EPP-1-2020-2-FR-EPPKA3-PI-POLICY
Deliverable number	D3.3
Work Package	3 Evaluation
Work Package Leader	Centre national d'étude des systèmes scolaires – Conservatoire national des arts et métiers (Cnesco-Cnam)
Work Package Partners	Dublin City University (DCU), Istituto Nazionale di Documentazione, per l'Innovazione e la Ricerca educativa (INDIRE), Pedagoski Institut, Université du Luxembourg
Dissemination level	Public
Delivery date	2023-12
Status	Final
Version	2
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ABSTRACT	This report presents the quantitative and qualitative evaluation of the impact of the AI4T professional learning pathway in Luxembourg. The first parts are dedicated to introducing the intervention – which is the AI4T professional learning pathway, and the experimental design detailing: the recruitment and randomisation procedures, the theoretical framework of the evaluation and the instruments used for data collection. The sample is then described, and elements are provided on data processing, along with verifications regarding the experiment's internal and external validity. The results are then outlined in three parts, first the teachers' results, then the school leaders' and finally the students. A bigger focus is given to teachers as they are the main target of the AI4T project. After detailing their reactions to the professional learning pathway, the report delves into the three main outcomes of the experiment: teachers' knowledge, perceptions and use of AI. Both the initial state and the impact of the intervention are presented for each outcome. Additional analyses on the heterogeneity of the impact of the intervention depending on teachers' engagement in the MOOC, teachers' self-efficacy for integrating technologies into the classroom, and teachers' subject are then outlined. The final part highlights the takeaways from teachers and school leaders which could inform educational policies on AI. It focuses on their needs regarding professional learning, tool development and ethical safeguards.
KEYWORDS	Artificial intelligence, experimentation, evaluation, impact study, professional learning, teachers

Dissemination level		
PU	Public	**X**
PP	Restricted to project partner (including the Commission)	
RE	Restricted to a group defined by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

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Introduction

In recent years, the rapid development of new technologies based on Artificial Intelligence (AI) has prompted a crucial discussion on its implications for education. At the European level, the Digital Education Action Plan 2021-2027 emphasized the necessity of developing students' AI skills and providing ethical guidelines on the topic.

Funded by the European Commission, the Artificial Intelligence For and by Teachers (AI4T) project was a three-year experiment to explore and support the use of AI in education. It consisted in producing, implementing and evaluating professional learning activities with the goal of acculturating teachers to AI. The project was conducted in 5 countries: France, Slovenia, Italy, Ireland and Luxemburg. 17 partners, including education ministries, evaluators and research labs took part in the project, under the coordination of France Education Internationale (FEI).

The AI4T intervention was built around two common online resources developed for the project: the AI4T Mooc created under the coordination of the Institut national de recherche en sciences et technologies du numérique (Inria) and the textbook AI for teachers: an open textbook written under the coordination of the Université de Nantes. Both resources received contributions from the consortium partners. In each country, professional learning pathways, with common learning objectives but varied formats (online platforms, webinars, face-to-face sessions), were then developed.

Following a pilot phase conducted in 2021-2022 in a small sample of schools, the intervention took place during the 2022-2023 school year. The program was aimed at math, science and language teachers with students aged 15 to 17. In most countries, participating schools where randomly assigned to one of two groups: one half were randomly chosen within each country so that the teachers would engage in the professional learning pathway during the experimentation year; the teachers in the remaining schools served as a control group and were given access to the resources only after the end of the experimentation. In some countries, like Luxembourg, the number of participating schools was too small and consequently all participating schools were engaged in the learning pathway.

The findings presented were gathered by administering surveys to teachers, school leaders, and students, as well as conducting interviews with teachers and school leaders. These findings are complemented with elements from the analysis conducted by a partner of the project, the Laboratoire lorrain de recherche en informatique et ses applications (Loria) on teachers' learning traces on the Mooc. Based on the data collected, this report will address the four evaluation questions formulated at the beginning of the project.

1) *Was the professional learning experience conducive to teachers' learning of AI?*
2) *Was the professional learning experience conducive to changing teachers' perceptions of AI?*
3) *Was the professional learning experience conducive to modifying teachers' use or behavioural intentions of using AI?*
4) *What are some key factors that can account for the impact of the intervention?*

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1. Intervention

The AI4T intervention revolved around two common online resources translated for all five countries. The first resource was the AI4T Mooc created under the coordination of the Inria. A textbook entitled *AI for Teachers: An Open Textbook,* was also developed under the coordination of the Université de Nantes as a resource for more experienced users and trainers. Finally, a set of common learning outcomes was established for the professional learning pathways in all countries:

1. Being able to express ones understanding and attitude towards AI and discuss it.
2. Being able to understand the basic principles of AI systems.
3. Being aware of AI educational applications and key considerations when identifying, assessing and selecting an AI tool for teaching, learning and assessment.
4. Being aware of legal considerations when using AI in an educational setting.
5. Being aware of ethical considerations when using AI in an educational setting.
6. Being aware of generic AI tools and being able to reflect on their impact on education and critically consider the possibilities for AI tools in education.

In Luxembourg, the professional learning pathway took place from January to March 2023 and followed a hybrid format.

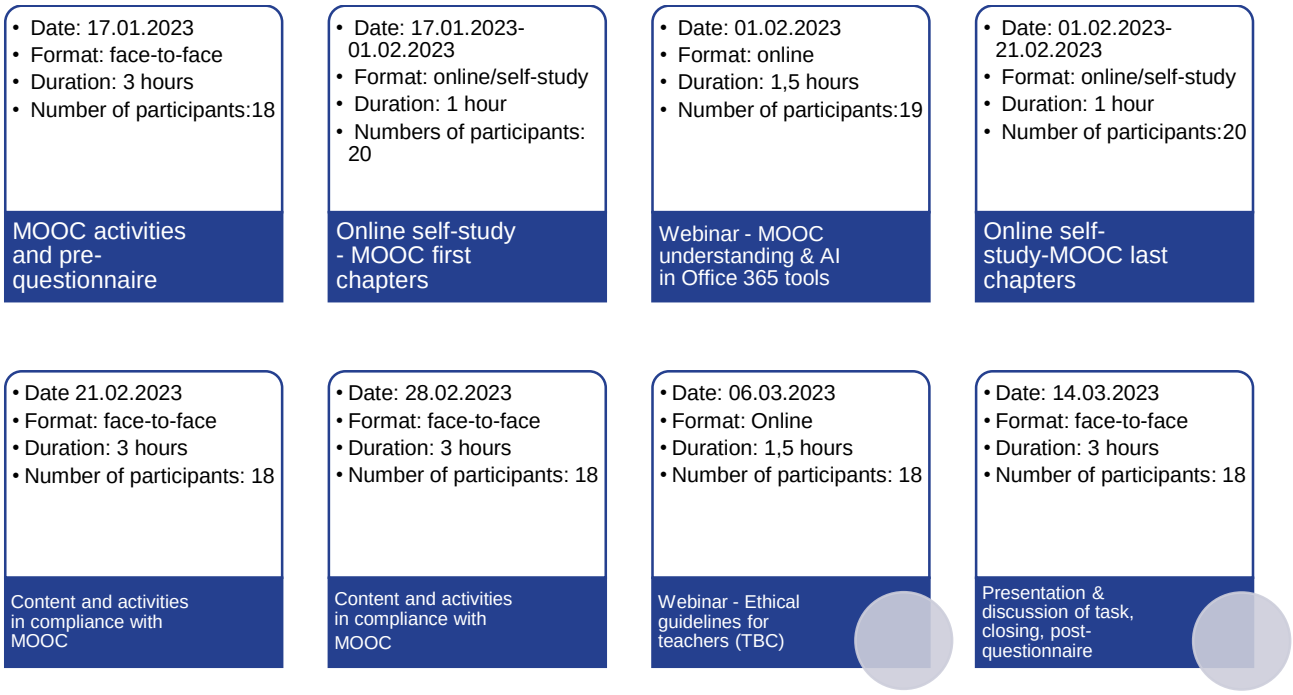

Figure 1: AI4T professional learning pathway in Luxembourg

Participating teachers in Luxembourg were given access to the AI4T MOOC, hosted on the Moodle platform of the National Institute for Teacher Education (IFEN), during the first live session on the 17th of January 2023. In this first session, they were introduced to the organisation and structure of the training pathway and were granted access to the MOOC. In the second part, a discussion on personal

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representations of AI was launched, using either science-fiction or realistic film material. At the end of the first session, all participants completed the baseline questionnaire.

Before the first webinar on February 1st, 2023, participants were encouraged to complete the first three chapters of the MOOC and to ask eventual questions in the Moodle forum. At the beginning of the webinar, the participant's questions about the MOOC were answered. Afterwards, a Microsoft Office 365 expert (Luxembourg's national education platform) introduced participants to the AI features of O365 and discussed possible use cases.

Until the second live session on 21 February 2023, the participating teachers were asked to work through the remaining chapters of the MOOC and to exchange on the Moodle forum. In this session, the focus was on linking the MOOC content to concrete use cases of learning with, about and for AI in the classroom. During this session, teachers participated in discussions and activities around selected AI tools. They tried out the mathematics tool kywck, generative AI (ChatGPT and DallE) and Duolingo, and reflected on a template for assessing the ethics of an AI tool before using it in the classroom.

The third live session took place on 28 February 2023 and drew the line from AI literacy to the national media literacy framework and the related ethical and legal considerations when using AI in the classroom. Participants were asked to prepare a teaching lesson idea for the final live session using one of the AI tools presented. The link to the textbook was provided as an additional resource and source of inspiration.

The second webinar, held on 6 March 2023, complemented this discussion with an intervention by a representative of the European Commission, who presented the ethical guidelines for teachers. The presentation was followed by a lively discussion and exchange.

In the final live session, participants presented their teaching ideas, some of which they had already implemented in their classrooms. Experiences, fears and hopes were shared in a lively discussion.

Throughout the experimental phase, the two teacher trainers were available to the teachers every day via the Moodle forum.

By this time (March 2023), as the launch of ChatGPT had raised awareness of AI among teachers, the national teacher training institute contacted the AI4T teacher trainers and asked them to offer a second wave of the training pathway. This request was accepted by the consortium.

Hence, the second intervention wave took place from the 20 of March to the 16 of May 2023. It followed the same structure as the previous pathway. In accordance with the demand from the field, in this second wave, both secondary and primary school teachers were accepted to participate in the training. We agreed within the consortium (WP3) to give the primary school participants specific codes to distinguish them from the secondary school teachers who might be relevant for the AI4T evaluation.

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2. Experimental design

2.1. Recruitment and randomization

The details of the recruitment procedure for schools to participate in the AI4T study are described in WP1_D1.2 Report on Experimentation phase. In short, the Ministry of Education presented the AI4T project to the “Collège des directeurs” (the assembly of all secondary school principals in Luxembourg) on 4.10.2022. Subsequently, the Ministry of Education sent letters to all secondary schools (on 7.10.2022, with a reminder on 28.10.2022) and published an article on the AI4T study in the national newsletter on media literacy education (edumedia) in October 2022. Overall, it was very challenging to recruit schools to participate in this study and the final sample sizes were much smaller than originally planned, which prevented us from randomly assigning participating schools into an experimental and a control group. Thus, in the AI4T study in Luxembourg there was no control group; all voluntary schools were granted access to the AI4T professional learning pathway.

This being said, all types of secondary schools participated in the project (16% Lyceum-Classique; 11% secondary schools offering technical and classical diplomas; 32% secondary schools offering technical and professional/VET diplomas; 42% secondary schools offering all diplomas) from all regions of the country (Northern regions: 21%; Central regions: 68%; Southern regions: 11%).

It is important to note that the AI4T professional learning pathway was offered twice in Luxembourg (to different cohorts of participating teachers). In this report, we only focus on the first intervention wave, which ensures that our results are qualitatively comparable to the results of the other AI4T countries. Ten teachers completed the first wave of the AI4T study. Although, these 10 teachers were invited to participate in an interview at the end of the study, only 3 teachers accepted the invitation.

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2.2. Theoretical framework

AI4T started as a pioneer project on AI in education, tackling a relatively unexplored topic. To refine the evaluation questions identified at the beginning of the project, we adopted a theoretical framework drawing upon various literature on AI but also on digital technologies and professional development evaluation. More specifically, we drew upon Guskey's work as a foundational framework (2000, 2013). According to Guskey, an effective evaluation of professional development requires the collection and analysis of five critical levels of information: 1) Participants' reactions, 2) Participants' learning, 3) Organization support and change, 4) Participants' use of new knowledge and skills, 5) Student learning outcomes.

For assessing each level of information, the evaluation team created robust indicators adapted from existing scales and tested them during the pilot phase of the project. These scales, which are based on the Likert format, generally had 7 answer options for teachers and 5 for students. To ensure equal intervals between each anchor, the response anchors were chosen following the recommendations of Casper *et al.* (2019).

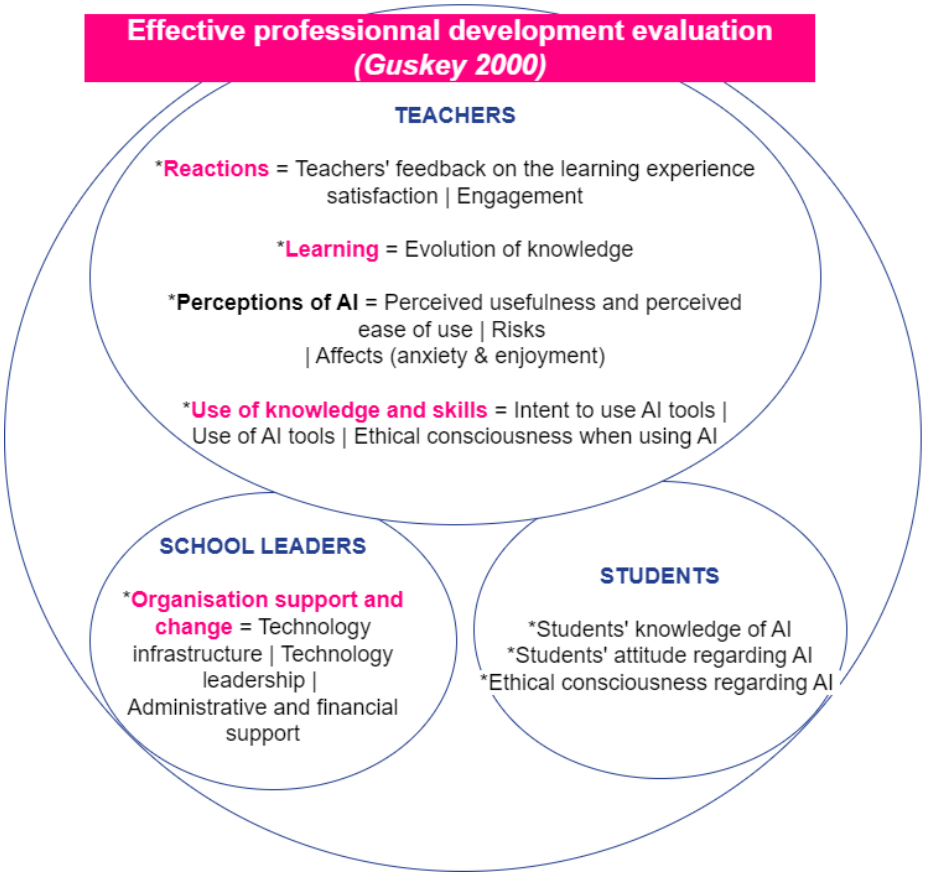

Figure 2: Theoretical framework for the evaluation of the AI4T professional learning pathway

Teacher reactions were assessed through their engagement in and satisfaction with the professional learning pathway. The engagement scale was adapted from Deng *et al.* (2020). The participant's level of engagement in the professional learning pathway was measured via their developed behavioural, cognitive, social and emotional connections with the course content, with the instructors and with other learners. While behavioural engagement corresponds to the learners' observable actions, such as taking

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notes, cognitive engagement corresponds to their mental investment in the learning process. Social engagement refers to both learner-instructor and learner-learner interactions, whereas emotional engagement centres on the participant's emotional connections with the professional learning pathway (enjoyment, interest, etc.). The satisfaction scale was adapted from Yenneck (2014). Yenneck identified several key dimensions of satisfaction, such as the satisfaction with the utility of the course, which have an impact on the learning benefits and potential changes of practice. For both scales, participants were presented with statements and had to answer on a Likert scale ranging from strongly disagree to strongly agree. The answers were then converted into scores from 1 to 7.

The measure of **teacher's learning** was based on the content of the AI4T Mooc and additional reports on AI (European Commission, 2019; Samoili *et al.*, 2020; Fengchun *et al*., 2021). We also consulted experts on AI in education from the consortium and and outside to review the questions and their interpretation. To measure participant's learning, we asked them to self-assess their knowledge of AI, indicate their level of familiarity with AI technologies, answer questions about how AI works, and identify tools that contain AI.

Data on **organization support and change** were collected through the school leader questionnaire. Guskey recommends assessing whether the organization's policies and characteristics are compatible with the implementation of the envisioned change. To address the integration of AI, the evaluation team assessed the school's technology infrastructure and technology leadership. Access to technological equipment is sometimes described as the first-order barrier for technology integration, in comparison to the second-order barrier referring to teachers' beliefs (Ertmer *et al.*, 2012). Obviously, access to technological equipment is a prerequisite for integrating technology into the teaching practices. The second dimension, technology leadership, was suggested by Anderson and Dexter (2005). In their model on technology leadership, they point at several indicators including the school leaders' own use of technology, which encourages its adoption by the teachers. Their suggested indicators also include the number of days that the school leaders have invested in planning, maintaining and administering technology and the presence of an ethics policy on technology usage within their school. We used these indicators to assess whether the teacher's school context was favourable to AI integration. Because Shattuck (2009) emphasised the importance of an alignment between the school leader's and the teacher's vision of technology integration, we also included this element in our measures. Finally, we assessed the teacher's administrative and financial support for participating in the professional learning pathway.

Given the specific context of this project, which centres on teachers' **perceptions of AI** and the integration of AI tools within the classroom, the assessment of the **use of knowledge and skills** was extended by incorporating the Technology Acceptance Model (Davis, 1989) into the framework, as described by Scherer *et al*. (2019):

> *In the literature, the question is repeatedly put forward as to what variables determine technology integration in education. Measuring user acceptance of technology is a way of determining the teacher's intentions toward using new technologies in their educational practice. Over the last decades, a series of models have been proposed to describe the mechanism behind and factors affecting technology adoption. […] Despite the variety of models, the TAM has dominated the research landscape as the most commonly used model to describe use intentions and actual technology use. (abstract)*

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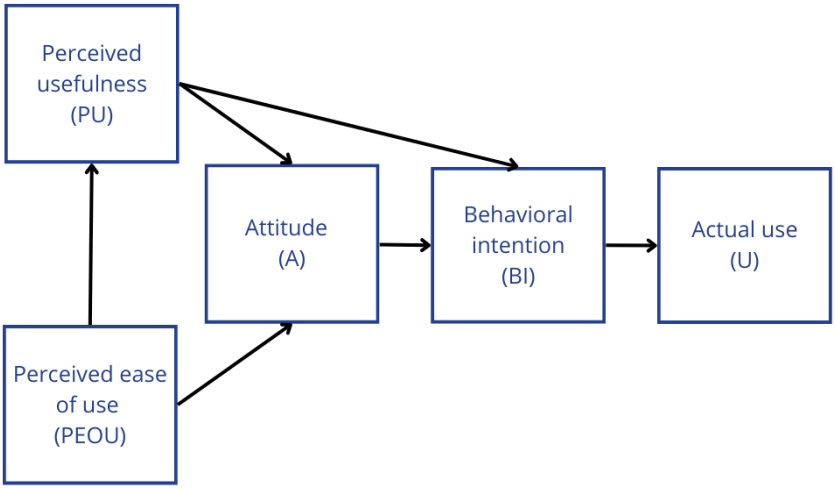

Figure 3: Technology Acceptance Model developed by Davis et al. (1989)

The TAM model (see Figure 3) identifies two main variables "perceived ease of use" and "perceived utility," which determine the behavioural intention to use a specific technology and its actual use. To measure "perceived ease of use of AI," we adapted the original scale from Davis *et al*. (1989) and to assess "perceived utility of AI," we created items adapted to the teaching profession. This enabled us to gain information on the specific pedagogical functions (identified by André Tricot, Cnesco, 2020) for which teachers perceived AI to be most useful. In order to counter-balance the positive concept of "perceived utility," we also questioned participants on the "risks" they associate with AI, based on elements identified by Schiff (2021) and Remian (2019).

Some versions of the TAM also include the concept of "attitude," whose definition and scope often vary (Njiku, 2019). Regarding the assessment of the teacher's attitude, we were particularly interested in the "affective" dimension. Affects regarding AI are prominent in the AI literature (Wang & Wang, 2019; Cave *et al*., 2019), they are of interest to the AI4T partners and can also impact technology usage (Février *et al*., 2011). Therefore, we assessed AI anxiety by adapting items from the Wang and Wang AI anxiety scale (2019) and AI enjoyment by generating items based on existing scales on computer enjoyment (Christensen & Knezek, 2009; Noiwan *et al*., 2005).

In accordance with the TAM model, both the **behavioural intentions to use AI** and the **actual use of AI** were assessed. We also specified the types of AI use by asking teachers which tools they were using, how often they were using them and for which tasks. Finally, we assessed the teacher's ethical consciousness when using AI with items from the ethics sub-scale from the AI literacy scale (Wang *et al*., 2022).

Due to the characteristics of the AI4T professional learning pathway—its objectives, length and content—and its focus on the teacher population, we did not assess the **student** learning outcomes. Instead, we gathered context information on the student's knowledge of AI, their attitude towards AI and their ethical concerns. Based on Njiku's (2019) conceptualisation of attitude and on existing scales on attitude towards AI (Suh & Ahn, 2022; Shepman & Rodway, 2020), we created a scale to assess the attitude towards AI in education. Finally, we developed an ethical consciousness scale based on a literature review on the main concerns expressed regarding AI in education (Jang *et al*., 2022; Remian, 2019; Schiff, 2021; Akgun & Greenhow, 2021; European Commission, 2022; Holmes *et al*., 2021).

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2.3. Evaluation instruments

The evaluation of the AI4T intervention is both quantitative and qualitative. The main sources of data collection were questionnaires and interviews.

Online questionnaires were administered to the teachers, students and school leaders. While teachers were asked the same questionnaire twice, both at the beginning and at the end of the intervention phase, school leaders and students were only surveyed at the end. The education ministry sent generic links to the teachers' and school leaders' email address to administer the questionnaires. They were also given individual evaluation numbers, which were necessary to access the questionnaire. The student questionnaire was administered in class under the supervision of a school staff member. All the students of a given class were asked to enter the same number, which was their teacher's evaluation number. This procedure ensures the anonymity of the participating students.

The teacher questionnaires covered the main outcomes regarding teachers' knowledge, perceptions and use of AI. In the baseline questionnaire, the teachers were additionally asked to provide information on their personal background (sex, teaching experience, etc.). In the endline questionnaire, those teachers who had participated in the intervention were asked questions about their engagement in and their satisfaction with the learning pathway. Via the school leader questionnaire, data was collected on the general characteristics and the technical infrastructure of the participating schools, on the administrative and financial support dedicated to the teachers' professional development and on the integration of AI tools within the school system. The students were asked questions about their understanding of AI, their attitude towards AI and their potential ethical concerns.

Interviews were only conducted with a subset of participating teachers (all of whom had participated in the AI4T professional learning pathway). The interviews took place after the administration of the endline questionnaire to prevent the interviews from affecting teachers' responses in the questionnaire.

The interviews focussed on the teachers' experiences with the AI4T professional learning pathway and on AI tools. The interview grid covered the dimensions addressed in the questionnaire in order to provide a better understanding of the participant's answers. During the interviews, the teachers were also asked questions about their initial expectations and the recommendations they might have regarding AI policies.

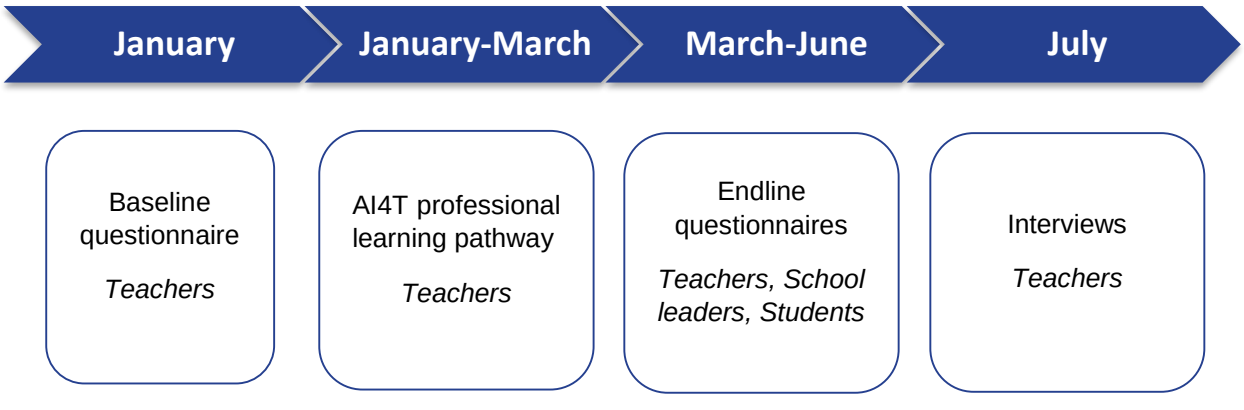

Figure 4: calendar of the evaluation of the AI4T intervention

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The questionnaires (i.e., Teacher Baseline and Endline, School Leader and Student – AI4T Deliverable D2.3) can be accessed on the AI4T website (https://www.ai4t.eu/). They were reviewed and approved by various Ethics Committee Panels (one per participating country).

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3. Data

3.1. Sample characteristics

In Luxembourg, the recruitment process was very challenging. Despite considerable efforts, it was not possible to recruit as many schools as originally planned (for details see WP1-D1.2 Report on the experimentation phase). Furthermore, it is likely that the participating teachers are not representative of the Luxembourgish teacher population but rather represent a group of teachers who are particularly interested in AI related topics. Given the very small (and likely biased) sample size (i.e., only 10 teachers participated in the original study), it was clear that Luxembourg would not be able to follow the originally planned RCT design. Due to these special circumstances and in the aim of maximising the amount of data we could gain on the AI4T learning pathway in Luxembourg, we decided to include all participating teachers in the intervention group. Thus, contrary to other AI4T countries, the AI4T study in Luxembourg did not include a control group.

The reduced number of teachers participating in the AI4T study in Luxembourg also meant that an even smaller number of teachers would be willing to participate in the interviews, and that the number of participating students and school leaders would be limited as well. The use of a quasi-experimental test design and the reduced sample size in Luxembourg considerably limit the type and the strength of conclusions that can be drawn. We, nevertheless, believe that the AI4T study in Luxembourg provides valuable insights.

The sample sizes reported in this document are as follows:

- Number of teachers who filled in a questionnaire before and after completing the AI4T professional learning pathway: 10
- Number of interviewed teachers (among those who completed the pre- and post-test): 3
- Number of students who completed the student questionnaire: 46
- Number of school leaders who completed the school leader questionnaire: 5

Table 1: characteristics of the teacher and student samples

Teacher characteristics			
Sex	Female	(3/10)	30%
	Male	(7/10)	70%
	Prefers not to say	(0/10)	0%
Teaching experience	Average number of years of teaching experience		13.3
Subject	Mathematics	(3/10)	30%
	Foreign language	(5/10)	50%
	Other	(2/10)	20%
School characteristics	Teacher sample (N=10)		
School size[1]	Estimate of the average number of students		1426.8

[1] School leaders participating in this study were asked to estimate the number of students in their school. This number represents the average reported number of students per school across participating school leaders.

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Student population[2]	Estimate of the average percentage of socio-economically disadvantaged student		33.4%
Type of schools	Academic	(5/10)	50%
	Vocational	(5/10)	50%
	Mixed	(0/10)	0%
	Lower-secondary	(0/10)	0%
Class characteristics	Student sample (N= 46)		
Student year	Year 10	(25/46)	54.3%
	Year 11	(1/46)	2.2%
	Year 12	(20/46)	43.5%
Class size	Average number of students in the class		22.5
Proportion of students with academic difficulties in the class	Median proportion of students with academic difficulties in the class		33.3%

It is important to keep in mind that our teacher sample includes only volunteers. Assuming that the teachers who were willing to participate in the AI4T project have a greater interest in digital technologies, their opinion might not be representative of the teacher population as a whole.

3.2. Data processing

Data cleaning

The administration method allowed for a single participant to respond multiple times (e.g., stopping the questionnaire and restarting it from scratch). The first step of the data cleaning process consisted in removing such multiple entries, which were identifiable by the participant's ID: an arbitrary code provided at the beginning of the questionnaire. If a participant had answered several times, we kept the most complete answer, and if several answers had the same level of completion, we kept the first one. Incomplete answers were kept as long as the participant had completed at least the first module of questions. The detailed description of the data cleaning process can be found in Appendix A.

The correspondence between the participants' ID and their reported country of residence was double-checked. A few students indicated a country that was not coherent with their evaluation number. In this case, the indicated country was modified by the evaluator to fit their ID. There were no such inconsistencies in the teacher and school leader questionnaires, though.

[2] School leaders reported the approximate number of students in their school who come from socio-economically disadvantaged homes on a four-level scale. These responses were then converted to estimated percentages which were then averaged across responding school leaders. This number therefore represents a rough estimate of participating school leaders' estimates and does not reflect the actual number of socio-economically disadvantaged students as assessed via more quantitative and objective means.

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Psychometric properties of the scales

Before calculating the participant's scores on the various scales, their psychometrics properties were tested. As the same evaluation instruments were used across all participating countries, the scales' psychometric properties were assessed on the full dataset and not only on the dataset from Luxembourg, given its small sample size. The scales' internal consistency was assessed with the Cronbach alpha. Additionally, we calculated the item-total correlation and the *alpha if item deleted*. Items were eliminated from the scale if their correlation with the total score was significantly lower than for the other items and if their removal improved the alpha score. Afterwards, we conducted a factor analysis on each scale, using Cattell's scree test to identify the number of factors. If items were found to cross-load on several factors, they were eliminated. A summary of the scale's psychometric properties can be found in Appendix B for the teachers and Appendix C for the students.

To calculate the participant's scores on each scale, the Likert scales were converted into numbers. The scores on each item were summed up and divided by the number of items.

Processing of qualitative data

The teacher interviews were conducted via Microsoft Teams or face-to-face. With the teacher's informed consent, the interviews were video- or audio-recorded and manually transcribed. These transcriptions (i.e., text files) were used for the subsequent qualitative analyses, which were based on an analysis grid specifically designed for this study and implemented across the five participating countries (cf. Appendix D). This common analysis grid, which was informed by our theoretical framework, the various research objectives and the interview grid, enabled for cross-country comparisons of the interview data. Based on the analysis grid, a label was assigned to each statement in the transcript. The summary of the interview data was recorded in a spreadsheet. The collected qualitative information was used to illustrate, confirm, qualify and shed a new light on the quantitative data gained from the questionnaires.

The open questions, which were included in the questionnaires, were also treated as qualitative data. Common analysis grids were defined in coordination with the evaluation teams across all participating countries.

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4. Teacher results

4.1. Teacher's reaction to the training

Expectations

After completing the AI4T professional learning pathway, 10 teachers accepted to respond to a questionnaire, which included an open question on their initial expectations in this regard. All the teachers had provided an answer to this question. 6 out of 10 teachers stated that they initially expected to learn more about AI or more specifically about for education (3/10), 1/10 expected to discover AI tools for education, 2/10 expected to learn how to use AI tools, and 1/10 expected to get help on how to use AI tools in the classroom. None of the ten teachers had expected to learn something about the technical aspects of AI nor about the ethical issues surrounding its implementation. Afterwards, the teachers were asked whether their initial expectations had been met, which was the case either completely (4/10 teachers) or for the most part (6/10).

Completion and engagement

Most teachers completed a large part of the proposed training activities. Indeed, 9/10 teachers completed the MOOC, 7/10 completed the textbook, and 10/10 completed both the webinar and the face-to-face sessions. The questionnaire also probed for potential hurdles for participating in the AI4T professional learning pathway, including lack of equipment, technical issues and lack of administrative support. None of the teachers reported any such hurdles.

The level of engagement in the professional learning pathway was measured through the behavioural, cognitive, social and emotional connections that the participants made with the course content, the instructors and other learners (Deng *et al*., 2020). Teachers were presented with statements for each dimension and had to answer on a Likert scale ranging from strongly disagree to strongly agree. The answers to these questions were then converted into scores from 1 (strongly disagree) to 7 (strongly agree). Teachers reported a medium level of behavioural and cognitive engagement with an average score of 4.95 and 5.2, respectively. While the behavioural engagement corresponds to learners' observable actions such as taking notes, cognitive engagement corresponds to participants' mental investment in the learning process. Teachers also reported a medium level of social engagement with an average score of 4.1, and a rather high level of emotional engagement with an average score of 6.33.

Satisfaction

Teachers were overall very satisfied with the AI4T professional learning pathway in Luxembourg. Indeed, in the endline questionnaire, most teachers reported being "satisfied" or "very satisfied" with the MOOC (9/10 teachers), the textbook (7/10), the webinar (8/10) and the face-to-face session (10/10).

Most teachers reported that the AI4T professional learning experience positively influenced their ability to be efficient in their work (8/10), that it had great practical value for their work (9/10) and that it helped them improve their professional skills (8/10). The AI4T professional learning experience was judged to be relevant (10/10), to be appropriate for the teacher's teaching domain (10/10), to offer them an active role in their professional learning pathway (10/10), and to enable them to share professional experiences with other trainees (9/10). Teachers also rated the pedagogical team to have been very responsive to their questions (10/10).

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This overall satisfaction was confirmed in the interviews. Teachers liked the variety of the content and media (e.g., MOOC, face-to-face sessions): “I thought the variety and the combination of the different supports was great.“ While there was a consensus regarding the quality of the learning experiences, some felt it to be too short nonetheless (e.g., “But the 6 hours, well that was only to go through it very roughly“), or too long (e.g., “It is dragged out“). Others felt that the learning experience could be rendered more efficient and more specific to their domain (e.g., “It could have been more compact and focused on natural sciences“). Finally, the exchanges of practical experiences among teachers seem to have been particularly appreciated (e.g., “And then also how one or the other deals with it in their class afterwards… I thought that was very interesting, when they also said what they did there and how they implemented it”).

Conclusion

Overall, the results of the study indicate that the teachers’ expectations were met by the AI4T professional learning pathway. Although most teachers completed most of the activities that were proposed and expressed their satisfaction with the AI4T learning pathway, they nevertheless suggested various ways in which the AI4T professional learning pathway may be further improved in the future.

4.2. Teachers’ learning

Prior to engaging in the AI4T learning pathway, teachers completed a baseline questionnaire, which included questions about their self-rated knowledge regarding various aspects of AI. While most teachers rated their knowledge of AI to be “rather good” or “good” (8/10), only a very small number of teachers rated their knowledge as being rather poor (1/10) or poor (1/10). Teachers also reported their familiarity with various AI technologies (e.g., machine learning, neural networks) on a scale ranging from 1 (totally unfamiliar) to 5 (very familiar). Based on their answers, we computed an AI familiarity score by averaging the ratings across questions; the average familiarity score was 2.32, which indicates a medium-to-low familiarity level. Furthermore, teachers were overall quite accurate in classifying digital tools as either including or not including AI.

After completing the AI4T learning pathway, the same teachers reported an increased knowledge of AI. They all evaluated their AI knowledge to be “rather good” (3/10), “good” (6/10) or “very good” (1/10). Their familiarity with AI technologies had also increased from 2.32 to 3.62 as did their ability to classify digital tools as either including or not including AI.

Subsequent teacher interviews provided additional insights. Some teachers reported a better understanding of how AI works (e.g., “First of all, really understanding the concept, what’s behind it, how it’s built or how it works, how it’s trained. That’s a lot clearer”), an increased awareness of the presence of AI in their environment (e.g., “You become more and more conscious where it is already present today“) and stated having drawn some practical value out of the learning pathway (e.g.,“I learned about different tools that I didn’t know about before” and “It helps you answer questions that students have, with all these weird thoughts, you can debunk them and say that it is not like that. I thought that was good because you can answer clearly“).

Conclusion

Overall, the results of this study indicate that teachers who participated in the AI4T professional learning pathway benefited from this learning experience in multiple ways: the teachers reported an increased knowledge of AI after the training, increased familiarity with AI technologies and an increased ability to classify digital tools as either including or not including AI.

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4.3. Teachers' perceptions

Prior to engaging in the AI4T learning pathway, teachers reported an overall positive attitude towards AI. They reported a high level of enjoyment regarding learning about AI and using AI in their job, with an average score of 6.02 on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). Coherently, their anxiety levels regarding learning about AI and using AI in their job were notably low, averaging at 2.3 on the same scale. An open question in the questionnaire asked teachers to specify which emotions (if any) they associated with AI. While there was a large range of different responses, the most commonly cited emotions were "curiosity" (6/10), "excitement" (4/10), "worry" (4/10) and "hope" (3/10). Furthermore, the teachers perceived the utility of AI for teaching to be high (with an average score of 5.49 on a scale ranging from 1-low utility to 7-high utility) and AI tools to be rather easy to use (with an average score of 5.48 on a scale ranging from 1-hard to use to 7-easy to use).

The teachers were asked similar questions after completing the AI4T learning pathway and provided comparable answers. Their enjoyment score remained high (decreasing from 6.02 to 5.7 on a 1 to 7 scale) and their anxiety associated with the use of AI in their job remained low (increasing from 2.3 to 2.5 on a 1 to 7 scale). The set of emotions cited by teachers remained quite variable both on an intra- and inter-individual level. The most frequently cited emotions were "excitement" (3/10) and "hope" (3/10).

Subsequent teacher interviews provided additional insights. Teachers reported having been interested in the topic of AI even prior to enrolling in the AI4T study (e.g., "I signed up for it, because I think it is an interesting topic.") and that their interest was even amplified by the current events, including the recent success of ChatGPT (e.g., "Yes, I mean it is present everywhere at the moment anyway."). However, some teachers reported that their perception was unaltered by the AI4T learning experience (e.g., "I don't really think it [the perception] has changed much now, because I was already interested in it before…").

Conclusion

Overall, the results of this study indicate that the teachers in Luxembourg have a largely positive perception of AI for education, despite of having some concerns. Their initial perception remained relatively unchanged after the completion of the AI4T professional learning pathway.

4.4. Teacher's intention to use AI & use of AI

Prior to engaging in the AI4T learning pathway, 4/10 teachers reported already using AI tools in an educational context (either themselves or their students), 10/10 teachers reported their intention to use AI tools for their work outside of the classroom, to use AI tools during class sessions and to make their students use AI tools.

More specifically, all the mathematics (3/3) and language teachers (5/5) stated having already used search engines. Whereas one math teacher had already used Socratic, two language teachers had

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already used intelligent personal assistants or automatic translators. Additionally, before engaging in the training, some teachers mentioned having already used Midjourney and Dall-E.

After completing the AI4T professional learning pathway, all 10/10 teachers reported having used AI tools in an educational setting and all reiterated their intention to use AI tools for their work both outside and inside the classroom and to make their students use AI tools. Furthermore, they all stated having a good understanding of the ethical issues when using AI tools.

More specifically, after the training, all mathematics teachers (3/3) declared having used search engines, intelligent personal assistants and ChatGPT. One math teacher had also used Checkmath. Whereas all language teachers (5/5) reported having used search engines, some have additionally used intelligent personal assistants (1/5), automatic translators (3/5), Duolingo for schools (2/5) and ChatGPT (4/5). Additionally, after the training, some teachers reported having already used Photomath, Wolfram Alpha and EdPuzzle.

Interviews conducted at the end of the study provide additional insights into the teachers' intentions to use AI tools for education. Some teachers emphasised the potential of such tools to reduce tedious work (e.g., "I think there are great opportunities in there to maybe have to do fewer of those tedious repetitive tasks."), to get more diagnostic information on the student's learning progress (e.g., "I wanted to try out Kahoot as a diagnostic evaluation after the different chapters or before an exam, because it is a good way to see: Where are the questions where most students still have weaknesses?") and to personalise the learning process (e.g., "And you could have more interactive games, and things like that built into apps, which also adapt to the student…").

Conclusion

Almost half of the teachers from Luxembourg had already used AI tools in their teaching practice prior to engaging in the AI4T professional learning pathway. Furthermore, teachers unanimously expressed a clear intention to use AI tools within the context of their work both before and after the AI4T professional learning pathway.

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5. School leader results

Among the schools that had participated in the AI4T project, five school leaders volunteered to complete a questionnaire at the end of the study. One of those school leaders did, however, skip multiple questions.

Difficulties encountered & support for professional learning

All school leaders reported an overall good technical infrastructure and ICT support within their school. For instance, all students were reported to have access to ICT devices (4/4 school leaders), the internet connection was reported to be good (4/4), and teachers were reported to have access to ICT support in their school within the hour (3/4) or within the day (1/4).

School leaders' attitude towards AI and the AI4T project

Most school leaders rated their knowledge of AI to be rather poor (2/5): with only one school leader self-rating their knowledge to be good (1/5) and the remaining two providing no response at all. Similarly, when asked if they knew any AI tools that could be used for teaching and learning, only two school leaders responded with "yes," one responded with "no," and the remaining two provided no response at all. All three respondents stated that they had provided teachers access to and information about the AI4T professional learning pathway and two of the three responding school leaders stated that they had even encouraged teachers to take part in the AI4T study. Finally, none of the school leaders reported that the teachers in their school had encountered any issues relating to their participation in the AI4T project, which would have required them to intervene.

AI integration in the school

Two out of the five school leaders did not respond to this question. Out of the three who did respond, two reported that the integration of AI was a priority in their school and one reported it was not. Although the three responding school leaders reported that their school had a committee or task force to discuss and plan the use of AI within their school, they themselves had invested less than a day during the respective year in planning, maintaining or administering AI in their school. Finally, while all three respondents reported that ethical concerns played a role in the adoption of AI within their school, only one of them had communicated on ethical guidelines and data protection with the school staff and none of them with parents.

Conclusion

Given the very limited sample size of school leaders in Luxembourg, no hard conclusions can be drawn. This being said, it appears that the participating schools were well equipped to support the adoption of AI tools within their teaching practices and that most school leaders were rather supportive in this regard. The school leader's relative lack of communication with teachers and parents on the ethical guidelines surrounding the implementation of AI tools in education despite of recognising their importance, may suggest the need to provide them a useful manual on these topics. Substantiating such speculations would obviously require a larger follow-up study with school leaders.

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6. Student results

After the intervention, the students of participating teachers were asked to complete a questionnaire as we believed their answers may provide useful insights regarding the teachers' school context.

Student use of AI

Most students reported having used AI tools, both generic tools (40/46) and tools specifically designed for education (45/46), at least once during the respective school year with their AI4T participating teacher. When probing about which specific tools they had used in class, search engines were overall the most frequently cited in both students of mathematics teachers (23/24) and language teachers (12/16). Furthermore, among a proposed list of AI tools, there was no specific tool that was systematically implemented by mathematics or language teachers during their lessons: the most cited AI tools among students of math teachers were intelligent personal assistants (5/24) and CheckMath (3/24), and among students of language teachers, automatic translators (9/16) and intelligent personal assistants (4/16).

Student attitude towards AI

The student's attitude towards AI was assessed along the affective, the behavioural and the cognitive dimensions. Regarding the affective dimension, most students reported being impressed by the abilities of AI (39/46), with many students reporting feeling excited by the successes of modern AI (24/46). However, many students also reported feeling worried by AI (18/46), with some students even reporting a dislike of AI (9/46). Regarding the behavioural dimension, about half of the students reported being interested to discover new AI tools for learning (27/46), wanting to use more AI tools in the classroom (27/46) and their intention to use AI tools for learning in the near future (26/46). Among the remaining students, about two third expressed a neutral position (e.g., neither wanting nor not wanting to discover new AI tools for learning, 15/46) and one third expressed a negative position (e.g., not wanting to use AI tools more often in the classroom, 6/46). Finally, regarding the cognitive dimension, most students agreed that, in general, AI would be useful for education (31/46) but only about half of the students believed that AI would offer a more personalised teaching (22/46) or increase teaching quality (18/46). Some students reported that the use of AI may, in fact, dehumanise education (20/46), increase inequalities and discriminations (11/46) and threaten the protection of personal information (19/46).

Student ethical awareness and worries regarding AI

Students were asked to indicate whether they are aware of various societal debates revolving around AI. Most students reported being aware of potential privacy violations risks related to AI tools collecting data (32/46) and the potential use of AI for illegitimate intents (28/46); comparatively less students were aware of the debates around AI transparency (24/46), of the responsibility question if an AI tool commits a mistake (23/46) or of potential discriminations perpetuated by AI tools (17/46).

Conclusion

The results of this study indicate that the use of AI tools is already widespread among students of participating teachers. Furthermore, students expressed a large range of opinions regarding AI for education, both positive and negative, as well as concerns regarding the use of AI.

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7. Takeaways from teachers and school leaders

7.1. On professional learning about AI

The AI4T professional learning pathway was positively rated, and the teachers' reports seem to suggest it was effective and useful. Teachers particularly appreciated the variety of the content and learning modes (e.g., MOOC and in person) as well as the possibility to exchange their experiences with peers. Several routes to further improve the AI4T professional learning pathway may nevertheless be considered based on the conclusions that can be drawn from the survey data and the interviews. Based on the teacher's feedback, we suggest that the learning pathway could eventually be split in several modules, with a common core module serving as a general basis for all teachers and a second module, more practical, targeting the teacher's specific needs within a given domain (e.g., AI tools for geometry in Year 10).

It may also be important to consider the teachers' context, in particular their school leaders and their students. School leaders may benefit from resources to facilitate their work related to AI (e.g., guidelines regarding the use of AI tools for education), which could as well facilitate the work of the teachers within their school. Surprisingly, students expressed a variety of nuanced opinions regarding AI tools in education: while some students reported an overall positive attitude towards AI, others appeared clearly against the idea of using AI tools in the classroom. It may therefore be necessary to provide teachers with additional support to engage all of their students when using AI tools and possibly to also provide students with specific resources regarding the use of AI in schools.

7.2. On the development of AI tools

The results of this study suggest that while teachers are already using a variety of AI based tools in their work, in particular generic tools like automatic translators, there is a perceived lack of tools specifically designed for particular topics and needs (e.g., learning trigonometry versus history of art).

Based on the teacher interviews, we suggest that offering teachers a portfolio of selected, high-quality tools per discipline, ideally with suggestions on how to use them in the classroom, would be particularly useful. If such tools do not exist, it would be recommended to co-create them with teachers and students following national study programs. Furthermore, we suggest that offering teachers the possibility to exchange their experiences on those tools and their possible uses via an online platform may further motivate them to engage with AI tools for education and with other teachers. This, in turn, may iteratively lead to the development of more effective teaching practices and a more organic adoption of AI by the teachers.

7.3. On addressing ethical issues associated with AI

AI for education raises a large range of ethical and legal questions, some of which were clearly perceived by many participants, including school leaders, teachers and students. These issues are complex, and many people using AI tools may not be aware of them nor have clear ideas of how to

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concretely deal with those issues in their schools or classrooms. Given the complexity and generality of those concerns it would make sense to develop clear and concrete national guidelines and policies to ensure AI can be safely used in schools and avoid overloading teachers and school leaders with the burden of figuring out how to address those issues on their own.

Appendices

Table A: monitoring of the data cleaning process in Luxembourg

	Teacher baseline	Teacher endline	School leader	Pupils
Number of answers (non-empty)	45	12	10	49
Number of answers without duplicates	32	12	5	48
Number of answers who completed at least 3 (pupils) or 5 pages (teachers) of the questionnaire	31	12	5	46
Number of answers from the first wave of the AI4T study	19	12	5	46
Number of answers who completed all questionnaires	10	10	5	46

Table B: summary of the psychometric properties of the scales for the teacher questionnaire (based on the data from all countries)

Name of the scale	Psychometric properties
Context	
Self-efficacy for integrating technology into the classroom	The scale includes 5 items. The Cronbach alpha is 0.93. The item-total correlations (Kendall's tau) are comprised between 0.76 and 0.78. There is one underlying factor that explains 72% of the variance. The factor loadings for each item are comprised between 0.84-0.86.
Reactions to the professional learning pathway	
Learner engagement	The scale includes 11 items. The Cronbach alpha is 0.86. The item-total correlations (Kendall's tau) are comprised between 0.41 and 0.55. There are four underlying factors. The first one explains 21% of the variance. On

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	the first factor, the factor loadings for each item are comprised between 0.66-0.94. The second factor explains 18% of the variance. On the second factor, the factor loadings for each item are comprised between 0.69-0.79. The third factor explains 16% of the variance. On the third factor, the factor loadings for each item are comprised between 0.57-0.84. The fourth factor explains 14% of the variance. On the fourth factor, the factor loadings for each item are comprised between 0.69-0.94.
Satisfaction with the utility of the Professional learning pathway	The scale includes 3 items. The Cronbach alpha is 0.92. The item-total correlations (Kendall's tau) are comprised between 0.82 and 0.87. There is one underlying factor that explains 79% of the variance. The factor loadings for each item are comprised between 0.85-0.94.
Participants' learning	
Knowledge of how AI works	The scale includes 5 items. The Cronbach alpha is 0.68. The item-total correlations (Kendall's tau) are comprised between 0.48 and 0.61. There is one underlying factor that explains 33% of the variance. The factor loadings for each item are comprised between 0.42-0.75.
Familiarity with AI technologies	The scale includes 5 items. The Cronbach alpha is 0.87. The item-total correlations (Kendall's tau) are comprised between 0.65 and 0.72. There is one underlying factor that explains 58% of the variance. The factor loadings for each item are comprised between 0.70-0.82.
Ability to identify AI tools	The scale includes 8 items. The Cronbach alpha is 0.77. The item-total correlations (Kendall's tau) are comprised between 0.31 and 0.59. There are two underlying factors. The first factor explains 31% of the variance. On the first factor, the factor loadings for each item are comprised between 0.67 and 0.89. The second factor explains 21% of the variance. On the second factor, the factor loadings for each item are comprised between 0.49 and 0.72.
Perceptions of AI	
Perceived ease of use of AI	The scale includes 4 items. The Cronbach alpha is 0.91. The item-total correlations (Kendall's tau) are comprised between 0.73 and 0.81. There is one underlying factor that explains 72% of the variance. The factor loadings for each item are comprised between 0.77-0.88.
Anxiety associated with use of AI and learning about AI	The scale includes 3 items. The Cronbach alpha is 0.90. The item-total correlations (Kendall's tau) are comprised between 0.74 and 0.83. There is one underlying factor that explains 69% of the variance. The factor loadings for each item are comprised between 0.73-0.91.
Enjoyment associated with use of AI and learning about AI	The scale includes 4 items. The Cronbach alpha is 0.90. The item-total correlations (Kendall's tau) are comprised between 0.79 and 0.85. The factor loadings for each item are comprised between 0.74-0.96.
Perceived usefulness of AI for education	The scale includes 10 items. The Cronbach alpha is 0.88. The item-total correlations (Kendall's tau) are comprised between 0.86 and 0.87. There is one underlying factor that explains 45% of the variance. The factor loadings for each item are comprised between 0.57-0.73.
Use of AI	
Use of AI	The scale includes 4 items. The Cronbach alpha is 0.9. The item-total correlations (Kendall's tau) are comprised between 0.79 and 0.82. There is one underlying factor that explains 69% of the variance. The factor loadings for each item are comprised between 0.77-0.88.
Frequent use of AI	The scale includes 4 items. The Cronbach alpha is 0.84. The item-total correlations (Kendall's tau) are comprised between 0.69 and 0.82. There is one underlying factor that explains 58% of the variance. The factor loadings for each item are comprised between 0.75-0.83.

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Ethical consciousness when using AI	The scale includes 3 items. The Cronbach alpha is 0.75. The item-total correlations (Kendall's tau) are comprised between 0.70 and 0.76. There is one underlying factor that explains 56% of the variance. The factor loadings for each item are comprised between 0.53-0.94.
Intention to use AI	The scale includes 3 items. The Cronbach alpha is 0.88. The item-total correlations (Kendall's tau) are comprised between 0.82 and 0.86. There is one underlying factor that explains 74% of the variance. The factor loadings for each item are comprised between 0.69-0.95.

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Table C: summary of the psychometric properties of the scales for the student questionnaire (based on the data from all countries)

Name of the scales	Psychometric properties
Attitude towards AI in education	The scale includes 8 items. The Cronbach alpha is 0.82. The item-total correlations (Kendall's tau) are comprised between 0.31 and 0.60. There are two underlying factors. The first factor explains 31% of the variance. On the first factor, the factor loadings for each item are comprised between 0.53 and 0.77. The second factor explains 12% of the variance. On the second factor, the factor loadings for each item are comprised between 0.53 and 0.64.
Concern about ethical issues raised by AI in education	The scale includes 5 items. The Cronbach alpha is 0.82. The item-total correlations are comprised between 0.58 and 0.68. There is one underlying factor that explains 48% of the variance. The factor loadings are comprised between 0.61 and 0.75.

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