Teachers' development of competence in managing generative AI technology: findings from a qualitative interview series

Michael Jemetz
University of Vienna
Doctoral School Computer Science
Faculty of Computer Science
Vienna, Austria
HTL Pinkafeld
Pinkafeld, Austria
michael.jemetz@univie.ac.at
0009-0002-7416-9485

Renate Motschnig
University of Vienna
Faculty of Computer Science
Vienna, Austria
renate.motschnig@univie.ac.at
0000-0003-1685-8338

***Abstract*—This research full paper strives to shed light on educators' ways of dealing with the rapid advances in generative AI tools, which have opened up new challenges and opportunities for learners and educators alike. Both are confronted with the opportunity of supporting themselves in the completion of a wide range of tasks in this new reality. The study presented here aims to identify different strategies teachers use to develop their competences in responding to students' AI usage and in utilizing this new technology for their own professional tasks. Strategies are identified through a series of semi-structured qualitative interviews with a diverse group of nineteen teachers from two vocational and three general education secondary schools in urban and rural areas of Austria. The participants are mainly teaching technical and language subjects and range from technical experts teaching IT to general education teachers who are faced with the need to quickly adapt to learners with different levels of digital and AI competences. The findings of a qualitative content analysis of the gathered data are contextualized with previous work on educators' digital competence development and comparisons are drawn. It was found that a major contribution to the educators' skills in handling generative AI technology was made through self-regulated learning facilitated by various resources ranging from academic literature to social media and experimentation, as was the case with general digital skills. Nevertheless, the desire to be formally supported in further developing AI competence through training was voiced with requirements for this training being that the content is up-to-date, contains practical examples, and is delivered by experts. In addition, open, inclusive forms of seminars were suggested. These findings aim to inform curriculum designers, teacher educators, professional development trainers and administrators. Furthermore, struggling educators will find a starting point for self-organized work on their AI competences and pointers to potentially useful resources both for their teaching and their own learning in the field.**

Keywords—AI competence; GenAI, teacher's competence; competence development, self-regulated learning, LLMs

I. Introduction

As generative AI (GenAI) technology becomes more sophisticated and easily accessible, educators are confronted with a new teaching reality where these powerful tools are readily available to their learners as well as to themselves. In order to adapt to that teaching situation and to utilize the potential that comes with it, educators will certainly require new competences in working with these tools as well as in managing their teaching in this new context.

As with other competences relevant to their profession, educators need to acquire these new sets of knowledge and skills. Understanding how they go about acquiring these specifically, which factors can hinder or aid in this process and whether there is a difference to the acquisition of general digital competences is central in lying the groundwork for enabling proficient and effective teaching with GenAI. Therefore, we strive to examine which strategies educators apply when developing their AI-related skills[1] and what the factors are that influence their competence development in this context. The findings are intended to speak to curriculum designers, politicians, teacher educators, professional development trainers and administrators who want to mindfully navigate the social- and digital transformation.

II. Background

A. AI literacy and the importance thereof in teaching

With the rapid development of GenAI systems – mostly pertaining to Large Language Models (LLMs) and image generators – in terms of their capabilities and availability, applications of these systems have become subject of study in increasingly many contexts ranging from societal challenges like combating climate change [1] or working towards an inclusive society [2,3], medicine [2,4] to entertainment [3,5]. The field of education is no exception. The utilization of AI for learning and teaching has become interest of numerous studies [6,7], but also other applications in the domain of education, such as utilizing generative AI for learning analytics [8], have been researched in recent years.

In reaction to the rapid advances in and the growing influence of GenAI, several competence frameworks modelling the knowledge and skills required to manage working with GenAI technology – both in general contexts as well as in education – have been developed over the last years [9,10]. Likewise, many of the most widely-known digital competence frameworks – again both general and teaching-specific ones – have been adapted to include AI literacy in some capacity as it was argued that new AI related skills and knowledge are related to overall digital competence [11 – 13]. Regardless of individual representations, there seems to be a consensus that working with GenAI tools in schools requires a new set of competences from educators [11 – 13]. A crucial

This project was funded by the Austrian Ministry of Education, Science and Research under the grant number B3-16.

[1] The terms "AI-related competences", "AI competences" and "AI literacy" are used specifically in relation to GenAI in this paper.

question in this dynamic context is how teachers may acquire these new digital, AI-related competences and what factors contribute to or hinder this development.

B. Educators' competence development

The development of educators' competences in the contexts of computing and digitalization as well as in general and in formal, institution-guided settings, as in initial teacher training and in teacher professional development, has been an area of interest in education research for decades [14 – 17].

However, other forms of knowledge and skill acquisition were also found to be essential in this area [14, 18 – 20]. D. Masoumi & O. Noroozi [14] provide an overview of the different strategies used specifically for professional digital competence ("PDC") development of early career teachers. These include formal courses in the contexts described above but also mentoring and self-organized approaches.

The development of teachers' AI-related competences specifically and how it may be supported through training has been subject of studies only in recent years [21]. Different methodological approaches to equipping educators with these competences have been proposed and evaluated [22]. The manner in which educators are developing those new AI-related competences in reality and which support structures are effective in facilitating this development has not been investigated in sufficient detail so far.

C. Research questions

Consequently, the aim of this paper is to answer the following research questions:

(1) What are the teachers' attitudes towards AI, and which use cases for GenAI-technology do they discern?

(2) How do teachers develop their AI competence in practice and in how far do the practices of developing AI competence overlap with results from Masoumi & Noroozi [14]?

(3) What are the main factors that contribute to the development of teachers' AI competence and in how far do these factors overlap with those identified by Masoumi & Noroozi [14]?

(4) What differences are there between teachers of technical and non-technical subjects?

III. METHODOLOGY

A. Research Design

This research project employed a series of semi-structured interviews for data collection and followed the qualitative content analysis method for evaluating the gathered data.

B. Expert Interviews

For data collection, educators were contacted through the school and university channels available to the authors. Overall, a total of 19 teachers from five different schools participated in the interview series. Of the five schools, three are general education secondary schools, while the other two are vocational upper secondary schools with different technical departments. Of each of the school types, one school is located in an urban area while the others lie in rural areas.

Of the nineteen participants, three were teaching computer science at a general education secondary school (labelled as group GT (general education school, technical subjects)) while fifteen were teaching various subjects at a vocational secondary school during data collection. Of them, eight are qualified to teach technical subjects from the fields of computer science and information technology (group VT (vocational, technical subjects)). One teaches computer science but was not formally trained for it. He is grouped in with the teachers who are qualified for non-technical subjects (group VG (vocational school, general education subjects)).

The group is distributed relatively evenly in terms of gender. Ten of the nineteen participants are female, nine are male. Overall, the interviewees' teaching experience varied from under one to over 35 years at the time of data collection. A detailed overview over the individual participants is presented in Table I. 18 of the 19 participants have used dedicated GenAI tools for professional tasks at least once. 12 reported dedicated usage of such tools in their lessons[2].

TABLE I. PARTICIPANTS IN THE INTERVEIW SERIES

ID	gender	subjects	experience	region
VT1	male	Programming, Data Science & AI, Project management	6 years	rural
VT2	male	Database Systems, Applied Computer Science, Computer Architecture, Game Development & VR[a], Programming[b]	6 years	rural
VT3	male	(Web and Mobile) Programming, Geography[b]	7 years	rural
VT4	female	Data Science & AI, Applied Mathematics, Project Management	10 years	urban
VT5	male	Media Technology, Project Management	6 years	urban
VT6	male	Foundations of Computer Science, Network Technology, Computer Architecture[b]	21 years	rural
VT7	male	Applied Computer Science, Computer Architecture, Game Development, Foundations of Computer Science, Network Technology, Database Systems, History	4 years	rural
VT8	female	(Web and Mobile) Programming, Media Technology, Computer Architecture[b]	9 years	rural
VG1	male	English, Ethics[c]	11 years	rural
VG2	female	English, French[c]	18 years	rural
VG3	female	English, Religious Education, Ethics	19 years	rural
VG4	male	Construction, Applied Computer Science[d]	< 1 year	rural
VG5	female	English, German	1 year	rural
VG6	female	German, Russian[c]	35 years	rural
VG7	female	English, German	36 years	rural
VG8	female	German, Ethics, Philosophy & Psychology[c]	3 years	urban
GT1	male	Computer Science, Geography	3 years	urban
GT2	female	Computer Science, Geography, English[e]	< 1 year	rural
GT3	female	Computer Science, Philosophy & Psychology, Ethics	5 years	rural

[a.] did not teach this subject at time of data collection, but was involved in planning for the year after
[b.] did not teach this subject in the term during which data was collected, but has taught it in the past
[c.] qualified to teach this subject, but had not taught it outside of training by the time of data collection
[d.] out of field (was not formally trained for that subject but is usually supported by a teacher who is)
[e.] was undergoing training for this subject during data collection and has not yet taught it beyond that

The first author conducted the expert interviews following the principles laid out in [23] and [24]. This was done in order to create an atmosphere where the participants were likely to speak freely and share their experiences more openly. The interview guide presented in Table II served as a loose guideline and while all educators were asked all questions, the order was varied in accordance with the flow of the interviews and the educators were given the freedom to go on tangents or add anything they considered important at any point during the talks. The interview guide was originally formulated in German and translated into English for this paper, as for the interviewees' convenience eighteen of the interviews were conducted in German and only one was held in English. The

[2] for information on individual participants' usage of specific GenAI tools, see Table XI in the appendix

individual interviews took between 32 and 67 minutes, averaging at approximately 47 minutes.

TABLE II. INTERVIEW QUESTIONS RELEVANT TO THIS PAPER

ID	question
Q01	Do you think AI is a disruptive technology? To what extent do you think this label is warranted?
Q02	How many years have you been teaching so far?
Q03	What subjects are you teaching?
Q04	Did you notice that your students are using AI in the classroom?
Q05	How do you manage this? How do you respond to that? Do you think that anything could help you manage these situations better?
Q06	Do you use AI for your professional tasks? Why / why not? What tasks do you use them for?
Q07	Did you notice that your colleagues use AI for other tasks?
Q08	Do you have any resources for work with AI that you find useful? Where did you get them from?
Q09	Did you attend any professional development courses dealing with AI?
Q10	Would you be interested in (further) professional development courses on the topic? Why / Why not?
Q11	Do you use AI outside of your professional tasks? Why / Why not?
Q12	Do you think that AI adds or subtracts value to the teaching profession? Did you notice any other changes? How do you feel about that?

The broader term "AI" was deliberately used during the interviews and only specified after the initial answers were given or when interviewees expressed uncertainty. This was done to not limit responses. The tools used by the teachers and their learners were elicited to check if they matched our research interests. All participants reported on LLMs (mostly chat-bots and assistants) being used by them or their learners[3].

Whenever possible, the interviews were recorded for documentation purposes. One educator opted out and a life transcription was made during the interview instead. AI-aided transcriptions [25 – 27] of all recordings were created and checked by the first author.

All participants who were willing to read the transcriptions of their interviews received them for review. This not only further positioned them as co-authors of the data and gave them control over how much they share, as a means to further establish a safe environment for them to express their experiences, but also served as a tool for participant validation [23]. Furthermore, the interviewer used active listening [28] during all the interviews as an additional first measure for participant validation [23]. Also, all participants were available for further questions per e-mail or in person.

Transcriptions were screened during the data collection process. As the later interviews tended not to bring up new topics, the data was considered sufficient and theoretical saturation [29] was reached to a high degree.

C. Data analysis

The whole corpus of transcripts encompassing a total of 109351 words was then screened for passages relevant to the research interests in this project and shortened accordingly by the first author yielding 28942 words over all extracts which were included in the corpus of this study. After this pre-processing was completed, a qualitative content analysis as described in [30, 31] and utilizing open coding as proposed in [32] was conducted by the team utilizing the spreadsheet application MS Excel, the file-sharing server of their university and several small software tools written by the first author. This approach was chosen as the team already had experience with it and due to the availability of the tools used.

[3] for more information, see Table XI in the appendix

The identification of units of analysis – which we defined as meaningful, coherent statements, be they a phrase, part of a sentence, a sentence or even a few sentences – for three interviews was done by both authors during a meeting. The other interviews were processed individually and then discussed in two follow-up meetings. Based on the 804 units of analysis defined in this process, both authors independently built upon an initial category system that was deductively derived [30, 31] from the findings of Masoumi and Noroozi [14], adding inductively generated categories [30, 31] after engaging with the data. The resulting category lists were discussed in two meetings and combined into a refined system, which was used in the coding of the identified units.

The coding process was started by a calibration phase in which all units from six interviews – two from each group of participants – were coded by both authors. This first coding yielded an agreement of 70 percent between the authors. The mismatched codes were discussed during a meeting where an agreement of 100 percent was reached for the units under discussion and the coding framework was adapted another time based on the insights gathered during the collaborative coding. The remaining units were consecutively categorized individually, results were collected in a shared document, and another meeting was held, where uncertainties were discussed, and full agreement was reached. This way, a high degree of inter-coder-reliability was ensured [30, 31].

IV. RESULTS AND INTERPRETATION

A. Category system

Based on the research interest, factors contributing to as well as strategies used for AI competence development in teachers were chosen as two of the main categories. Further, the information sources used by the educators, their learning goals and needs as well as their application of GenAI were analyzed. A detailed description of the developed category system can be seen in Table III.

TABLE III. TOP-LEVEL CATEGORIES IDENTIFED IN THE ANALYSIS

category	description	examples	units
Factors supporting or hindering development [14]	any contextual or internal factors that allow, support or hinder the development of AI competence in educators. See Table IV.	see Table IV	432 (54%)
Strategies for competence development [14]	any manner of competence development that educators employ for their AI literacy. See Table V.	see Table V	111 (14%)
Information sources	anything relating to where the interviewee found new information facilitating (or otherwise relevant to) their AI literacy development	"Yup. Colleagues, said: 'That's what I've already done …' " (VG1), "I found that in an ethics schoolbook …" (VG8)	72 (9%)
Learning goals (and needs)	what the interviewee wants to learn about GenAI and if they require support in doing so or not	"… how you can use it" (VT7), "I wouldn't really find the theoretical side all that interesting." (VT3)	83 (10%)
AI app-lication areas	for which tasks and purposes the educators utilize GenAI tools (or plan to do so)	"I occasionally use Midjourney for creative purposes" (VT5), "When I create a handout, I just copy in the text and say 'In English please!'" (VG8)	60 (7%)

Since factors contributing to or hindering digital competence development in educators were already identified by Masoumi and Noroozi [14] and AI literacy is considered

closely related to digital competences [11,12], these factors were carried over from their work. The factor of leadership was not identified as present in the data analyzed and therefore omitted.

In addition to these outer influences, the attitudes, emotions, experiences, knowledge, and skills of educators as well as their expectations of the effects of GenAI use were identified as relevant factors in the analysis. Table IV provides an overview.

TABLE IV. FACTORS SUPPORTING OR HINDERING DEVELOPMENT

category	description	examples	units
Attitudes, emotions, knowledge, skills & motivational factors	the interviewee's own views and motivation (not the views and motivation of their colleagues (see "Institutional culture")) but also their background knowledge, skills and previous experiences	"I'm not scared of AI. I'm scared of using it. And […] where does fear come from? Fear comes from the unknown." (VG1), "… because I always found it fascinating" (VG3), "the famous ChatGPT or whatever it is – I don't know all of these tools" (VG2)	199 (46%)
Expected effects of AI use	the expected or perceived usefulness or effects of AI usage according to the interviewee	"But what new things should that lead to in English lessons? Other than you getting new support tools, nothing much can happen there." (VG2), "I would say AI is an enabling technology." (VT8)	36 (8%)
Institutional culture [14]	the norms, values, habits and expectations at the school that the educator works at (including the attitudes of colleagues)	"… it's […] not always easy […] in this surrounding to have open-mindedness …" (VG1),	36 (8%)
Workload [14]	how much time is available for competence development and what other activities demand the interviewee's time	"You have to try it out and go over it and that is a very time-consuming story." (VT1)	25 (6%)
Availability & accessibility of resources [14]	the access to technology and digital or material resources available to the educator and how they affect the competence development (not including human resources and courses), materials handed out by institutions (if they are not part of a development opportunity)	"Of course, it would be great if I – as a teacher – could draw upon a pool of resources that helps me teach AI competences […] a bit better" (VT5), "Material exists and it's sufficient at the moment." (VT6)	51 (12%)
Technical & pedagogical support (initiatives and offers) [14]	any support structures than might help educators develop their competences (including technical and pedagogic support as for instance development opportunities such as courses but not digital and material resources) and their availability	"As far as I know, there are no concrete courses offered where I teach …" (GT2), "We had a course at our school once." (VT7), "… but that has to be a lecturer who outsmarts me, […] who knows more about that than I do." (VT2)	85 (20%)

The competence development strategies identified by Masoumi and Noroozi [14] were also carried over from their work but slightly adapted. For the purposes of this paper, development opportunities of any kind were grouped together regardless of whether their main focus was AI literacy or not. This was done as the topic of AI literacy was often contextualized in other courses and interviewees were not always clear about the focus of courses. Furthermore, mentoring was not found to be a relevant factor in terms of teachers' AI competence development in this study and therefore was not considered in the category system. Aside from the previously identified strategies, we also found that incidental exposure to information or resources regarding AI literacy is a main contributor in fostering educators' competences or at least a starting point thereof. Furthermore, the utilization of resources played an important role in competence development. Table V provides an overview of the strategies identified in the review.

TABLE V. STRATEGIES FOR COMPETENCE DEVELOPMENT

category	description	examples	units
Active exploration to develop PDC [14]	educators actively working on their competences on their own without any institutional guidance (including research (searching materials, but not using them) and experimentation)	"It was actually trial and error. It was just … I just tried it out." (VT02)	56 (50%)
Incidental exposure to the topic	finding or being given information about AI without actively seeking it out or being informed about it in school or in a formal setting (accidentally finding a use case for AI)	"That mostly happens by chance, when I hear that this and that tool is available now" (GT1)	8 (7%)
Resources as a way of developing competences	using materials to learn and develop their competences on their own (outside of courses), using material for their teaching	"That's why I usually take most things from books" (VT1)	14 (13%)
Taking advantage of development opportunities [14]	educators taking part in formal as well as informal organized development opportunities such as courses or internships, engaging with a community (of practice) with the intent to develop their AI or other professional competences	"I've not had any seminars yet, nope." (VG1), "Other than that, I have listened to a few – two or three – online lectures." (VG2)	33 (30%)

B. Educators' attitudes towards and expectations of effects of GenAI usage

Overall, 85 units of analysis were identified as statements about the interviewees' attitudes towards GenAI systems or the usage thereof in school contexts. Of these, 44 were positive with educators stating that they are interested in the new technology and want to utilize it. 43 statements conveyed a somewhat mixed attitude with 24 of them being neutral or stoic acknowledgements that GenAI will need to be considered in teaching, four being that the interviewee doesn't mind the availability of GenAI. The remaining statements in the mixed group were generally in favor of GenAI but with a critical view on it. Calls for careful consideration and regulations were grouped in here. A total of eleven negative statements were identified as well. Here, educators stated that they are not interested in GenAI at all, see it as a threat to human interaction or believe that it will make their job more difficult as they would have to deal with it in addition to their already existing duties. An overview is presented in Table VI.

TABLE VI. ATTITUDES OF EDUCATORS TOWARDS AI

subcategory	number of units	number of interviewees
positive attitude towards AI	44	12
neutral accepting of importance	24	10
critical attitude towards AI	6	4
completely indifferent attitude towards AI	4	3
negative attitude towards AI	11	6
sum	85	

These attitudes partially go hand in hand with the educators' expectations of the effects of GenAI use. Positive effects were expected by eight of the interviewees, whereas six of them said that they did not believe the positive impact of GenAI applications on their area of work to be substantial.

Two educators reported expecting no positive or negative effects whatsoever and two others stated that they were worried that the availability of GenAI may detract value from their profession. Table VII summarizes the expectations.

TABLE VII. EDUCATORS' EXPECTATIONS OF AI USAGE'S EFFECTS

subcategory	number of units	number of interviewees
positive effect expected	16	8
limited or no effect expected	13	8
negative effect expected	2	2
sum	31	

In terms of use cases, 35 statements could be identified as professional applications mentioned by the educators, while seventeen units of analysis related to private use. The use cases in the professional domain were mostly related to supporting teaching with AI (n=31), but also covered other professional tasks (n=4) such as creating media for the public representation of one's school or supporting administrative tasks through self-made AI-supported software. Three applications identified by the teachers were related to teaching their learners about AI. The private use cases entailed research for different interests, creative applications such as AI art, generating sample texts for speeches and social media posts, learning languages and just playing around with the systems for entertainment. Fig. 1 provides an overview.

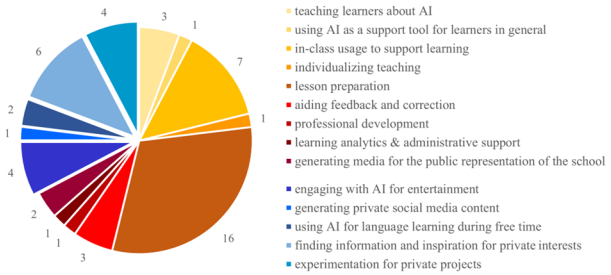

Fig. 1. Professional and private AI Use Cases identified by Educators.

C. Factors Influencing Teachers' AI Competence Development

In terms of factors that influence the interviewees' AI competence development, a total of 396 units of analysis were coded as relevant. Of these 396 statements, 199 – distributed over all interviewees – related to attitudes, emotions, skills, knowledge, and motivation of individual teachers, 36 to the schools' institutional culture and 25 to the workload that teachers have to manage. The availability of resources was mentioned 51 times and of technical and pedagogical support 85 times. An overview is presented in Table VIII.

TABLE VIII. OCCURRENCE OF HINDERING AND SUPPORTING FACTORS

category	number of units	number of interviewees
attitudes, emotions, skills, knowledge & motivational factors	199	19
institutional culture	36	13
workload	25	13
availability & accessibility of resources	51	16
technical & pedagogical support	85	15
sum	396	

a) Attitudes, Emotions, Skills, Knowledge and Motivation: As discussed previously, the attitudes of educators might impact their competence development positively or negatively. All educators at least acknowledged the need for AI literacy in their profession. Two educators stated that they believe that negative attitudes prevented their colleagues from engaging with the topic. Aside from attitudes towards AI (n = 85), which all interviewees voiced, the educators also stated their attitudes towards development opportunities and materials and five educators voiced their attitudes on what they consider to be responsibilities of a teacher. There was an agreement that professional development should be pursued. However, interviewees did not agree on the degree to which technical competences should be worked on by teachers.

Emotions were mentioned less frequently (n=6). Only one educator admitted being afraid of using AI, while two others claimed that their colleagues expressed fear. The teacher, who stated his fear of usage reflected this emotion as a motivator for competence development but also acknowledged that these fears need to be addressed. Another teacher stated that she was frustrated and therefore stopped working on her AI competences for some time but was still willing to continue learning later.

Motivational factors were identified as hindering competence development in thirteen instances. Two of the educators stated that they would rather have more free time than work on their competences. Two other educators stated that that was reportedly the case for some of their colleagues as well. Overall exhaustion was mentioned by one teacher. Also mentioned was a lack of reasons for engaging with AI due to the educator's teaching not being affected much by it or – in one case – because the interviewee was due to retire three months after the interview.

In addition to attitudes, emotions and motivation, the educators' knowledge and skills concerning GenAI and teaching was frequently mentioned (n=32) when it came to influencing factors. A lack of knowledge about the new technology, where to get help and how to approach GenAI usage was reported to be hindering competence development eighteen times by ten different interviewees. Six educators also stated that they did not pursue development opportunities as they found their own knowledge and skills to be sufficient for their needs. One of them did so on two separate occasions. On the other hand, six educators reported that they profited from their previous knowledge on teaching, computer science or data science specifically when developing their AI competences.

b) Institutional Culture: The individual teacher's attitudes, emotions and competences, however, are not the only aspects influencing their competence development. The institutional culture at their schools has been identified as a factor by twelve of the interviewees. This contextual influence can be hindering as well as supporting teachers in their development. In terms of hindering effects of institutional culture, an overall lack of interest in and motivation for professional development as well as negative attitudes towards new technology amongst their fellow teachers was mentioned by six educators. One of them stated that this made her reluctant to pursue development opportunities as she did not want to travel and learn alone. And while five educators reported a lack of support from their colleagues, four others shared that there was a habit of information sharing when it came to new developments and ways of integrating them into the classroom at their schools.

c) Workload: Aside from social and internal factors, the workload of teachers was identified as a major hindering

factor for professional development. Sixteen of the nineteen educators mentioned that they did not find as much time for developing their competences as they would have needed due to other professional tasks requiring their attention. Using holidays for professional development was mentioned in three of the 25 statements made on the matter.

d) Availability & Accessibility of Resources: Yet, the availability and accessibility of resources and technical and pedagogical support were even more prominent among the responses. The availability of resources was thematized 36 times and their accessibility and quality in nine instances. A total of 25 statements were made by ten educators about technical resources and materials being available, while seventeen statements were made by ten interviewees about a lack of resources. Here, some educators reported that some materials were available, but others would be required. More specifically, GenAI tools and material dealing the technical background exist but are not always useful to them due to the level of detail they have, didactic resources are sparser, especially for non-technical target audiences and – according to one educator – are often of low quality.

e) Technical & Pedagogical Support: The availability of technical and pedagogical support and development opportunities was described as lacking sixteen times by eight educators, while 25 statements about development opportunities – mostly courses – existing were made by six educators. Again, some educators reported some opportunities being available to them, but also mentioned that they would require different forms of support than what was offered at the time.

Fig. 2 and Fig. 3 provide an overview of all hindering and supporting influence factors identified in this study.

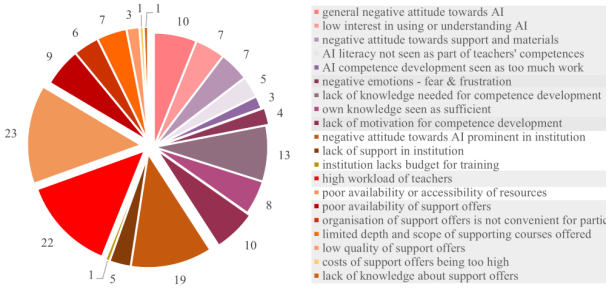

Fig. 2. Distribution of units on hindering factors reported by educators. [4]

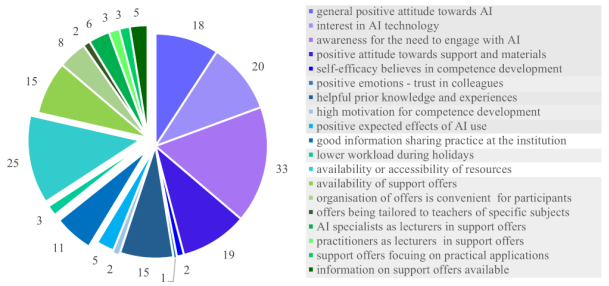

Fig. 3. Distribution of units on supporting factors reported by educators. [4]

Many (n=12) voiced their views on what qualities they would expect from development opportunities for them to be helpful. Expert lecturers were mentioned as important nine times by seven educators. Five educators stated on eight occasions that content should be practically oriented, geared to their teaching context and ideally presented by an experienced teacher. Also stated by five participants was that school internal seminars would be beneficial due to the ease of access and the familiar social environment. Additionally, four teachers highlighted the timeframe over which courses were held as important. One of them stated that sessions should not be too long but rather frequently held. The other three reported that many courses were too short. The location at which courses were held was mentioned by three interviewees as a factor that negatively impacted their interest in participation. One educator explicitly stated that she had only taken part in online courses so far while two others – who did not take any courses yet – stated that they would prefer participating digitally over travelling to a teacher college. Furthermore, three educators claimed that the content of the courses was too shallow for their needs. And while a wish for an exchange of experiences between teachers of different subjects was voiced by some (n=5), that alone was generally seen as insufficient on its own, as sharing expert knowledge is also considered a necessity for such seminars to be helpful.

General education teachers (n=2) voiced interest in learning from technical teachers and some of them stated their willingness to share their knowledge (n=4). And while four of the educators claimed to have learned about GenAI with and through their students, one of them specifically suggested also including the learners in such a seminar.

D. Educators' AI Competence Development Strategies

Overall, 111 statements were made about different competence development strategies. Active exploration was mentioned most frequently (n=56) and by all participants. Incidental exposure and utilizing resources were mentioned eight and fourteen times respectively. And while sixteen educators mentioned taking advantage of development opportunities a total of 33 times by sixteen participants, not all of the statements were about actually taking part in such a setting, but some were also negative. This will be explored in detail below. An overview of the statements on the different competence development strategies is provided in Table IX.

TABLE IX. OCCURRENCE OF DEVELOPMENT STRATEGIES

category	number of units	number of interviewees
active exploration	56	19
incidental exposure to the topic	8	6
resources as a way of developing competences	14	9
development opportunities	33	16
sum	111	

a) Active and Incidental Exploration to Develop PDC: In terms of competence development strategies, all interviewees reported engaging in active exploration, which was mentioned 56 times in total. While all participants stated that they approached GenAI through trial and error, only eight educators mentioned that they also did research and actively sought out information from different sources. Additionally, six teachers stated over eight units of analysis that they found information incidentally through social media or exchanges with colleagues, students, family or friends.

b) Resources as a Way of Developing Competences: All in all, fourteen educators reported using materials – whether they actively sought them out or found them by chance – for competence development, which was mentioned as a strategy

[4] Not all units on factors allowed us to clearly categorize the factors as hindering or supporting and were therefore omitted here.

14 times. These resources included traditional media (n=7) such as books and handouts as well as digital media accessed through the internet (n=29). The digital artefacts used included blogs, videos, social media posts and specialized websites.

c) *Taking Advantage of Development Opportunities:* While development opportunities were mentioned frequently, only five interviewees reported having made use of them. Table X provides an overview of statements on interviewees' participation in these development opportunities.

TABLE X. PARTICIPATION IN DEVELOPMENT OPPORTUNITIES

subcategory	number of units	number of interviewees
took advantage of a development opportunity	10	5
did not take advantage of a development opportunity	13	10[a]
sum	23	

[a] The other educators stated implicitly that they did not make use of any development opportunities (e.g. through mentioning that they were unaware of the availability of such offers or their attitudes)

Nine out of the ten mentioned development opportunities that educators took part in were institutionally organized courses offered by a teacher college or university. One was an informally organized knowledge exchange. Fig. 4 provides an overview of all the strategies interviewees have utilized so far.

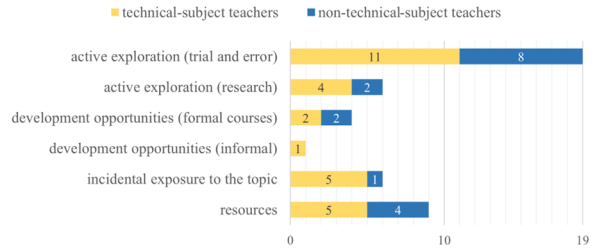

Fig. 4. Number of teachers utilizing Competence Development Strateies.

Out of the fifteen interviewees who did not utilize institutionally offered opportunities, five educators stated that they did not take part in courses on the topic due to various factors. Reasons included several of the hindering factors discussed before such as their workload, attitudes towards the topics and them considering their knowledge sufficient for the time being as well as the courses not meeting their needs. Furthermore, all educators who voiced their views about what they would want from development opportunities expressed their willingness to take part in courses or similar offers should they meet their expectations.

E. Differences between Teachers of Technical and Non-technical Subjects

One of the most striking differences between the teachers of technical and non-technical subjects was their views on what their role as a teacher is and how much technical knowledge they should have. All teachers of general-education subjects who made statements regarding their role (n=3) stated they saw themselves as users and therefore do not require in-depth technical knowledge. Teachers of technical subjects saw themselves in the role of technical experts (n=3).

Yet, of the technical subject teachers, only nine percent saw need for training, while of those teaching general subjects, 50 percent claimed to need support in their professional development. Another difference was that only technical teachers reported utilizing information from organizations such publishers of technical books or teachers' workgroups. One of them also voiced interest in technical training offered by external companies, which he, however, would not attend because the costs were too high and were not covered by his employer. Furthermore, incidental exposure to GenAI topics occurred more frequently for educators with technical backgrounds than for those without (see Fig. 4).

F. Comparison to General Digital Competence Development

Overall, similar factors contributing to and strategies for AI competence were identified in this study as were by Masoumi & Noroozi [14] for digital competences. The availability of resources and support as well as the institutional culture of educators' schools and the workload they have to manage were all found to be relevant in this context too. One major difference in terms of contributing factors is that leadership was not identified in this analysis at all. Furthermore, attitudes, emotions, motivational factors, knowledge and skills as well as expectations of the effects of GenAI usage were found to be relevant factors in this case.

When it comes to development strategies, most ways of fostering digital competences, namely, active exploration, and making use of development opportunities – also for other professional competences – were also identified as relevant for AI competences. Mentoring, however, was found not to be utilized for AI literacy by the participants but incidental exposure and the utilization of materials was.

V. DISCUSSION

A. Limitations

As all participating educators are teaching in schools situated in the same country and mostly share cultural backgrounds, the study is limited in that context. However, the intriguing correspondence of our findings with the results from the systematic literature review reported in [14] lets us assume that the data collected in this project yields recent insights into trends and provides a starting point for further investigation of the topic.

B. Findings and Implications

a) *Findings:* Based on the analysis performed and concerning our first research question, we found that educators' attitudes are mixed but overall positive with a strong notion that AI is an important topic that needs to be considered in teaching. Generally, educators identified a wide range of professional – mostly teaching-related – and private applications – such as idea generation and support for creative tasks, language learning and using the systems for entertainment – of GenAI as interesting or useful to them, however, they differed regarding the usefulness of these systems for their teaching.

Regarding the second research question, we found that teachers' AI competences are developed in a similar manner to their general digital competences, however, mentoring seems to not play a role in this area of competence development as of now. This may, however, well be due to the novel nature of these systems. Furthermore, incidental and experimental, explorative learning was found to be central in the AI literacy development of educators. The central role of self-regulated learning through trial and error may stem from the ease of use that current GenAI systems provide, which allows for playful engagement with the underlying technology. Still, development opportunities are utilized and

wanted, if they meet the needs of the teachers in terms of practical and in-depth content.

Similarly, and in response to the third research question, we found that individual educators' attitudes, their previous knowledge and their notions of GenAI usefulness as well as the workload they have to deal with in their professional life are key factors that influence competence development in this area. The institutional culture of their schools and the availability of high-quality resources and support – pedagogic as well as technical and formal as well as informal – also strongly influence AI competence development in teachers. This is largely in line with the factors contributing to general digital competences of teachers being developed. However, governance and leadership has not been identified as factors impacting teachers' AI competence development aside from emerging institutional practices being supported by leaders – yet in this study – which might again be related to the relative novelty of the field – while attitudes, emotional, motivational and knowledge related factors were not named as central contributing factors for developing general digital competences in [14].

Concerning the difference in approaches to AI competence development between teachers with a technical background and those working in general education subjects and did not undergo any technical training as formulated in research question four, it was found that the need for institutional support is much higher in teachers without a technical background. Furthermore, technical-subject teachers utilize materials from different organizations, which we did not find to be the case with general-education teachers. This might be because those with a technical background are more familiar with those organizations than their general education colleagues. The latter also have a lower chance of incidental exposure to the topic of GenAI than their technical colleagues. Only one general-education teacher (12,5%) reported incidental exposure leading to competence development while five technical teachers (45,5%) stated they happened to find information or gain insights by chance. This may potentially be due to technical teachers' social contacts and free time activities being more likely to yield such exposure.

b) Implications: The findings of this study are mostly aligned with those of Masoumi & Noroozi [14] as similar contributing factors and strategies were found to be applicable to the contexts of general digital competence development and AI literacy development. Thus, the current study strongly corroborates the results of [14] and at the same time points to focal aspects particularly applying in teachers' development of AI literacy such as availability of high-quality technical and pedagogical support and resources as well as active engagement with the new technology by teachers. Moreover, this study confirms the findings of Dobržinskienė [18] as experiences and active exploration were found to be central in this field as well. Intriguingly, self-regulated learning, supported by drawing upon resources and materials, proved key to competence development in the context of AI literacy. Nevertheless, quality institutional support is needed as well. Specifically, development opportunities with experience sharing, reflection discussions and in-depth knowledge delivered by experienced technical and teaching experts are in demand. Educators with strong technical backgrounds supporting general education teachers is a promising strategy here. Still, self-regulated learning has a crucial role because not all have access to high quality seminars and tools are accessible enough for self-organized experimentation by individuals.

VI. Conclusion and Further Work

Based on the qualitative analysis of nineteen expert interviews, it was found that AI competences are largely developed in a similar manner to general digital competences and rely on similar factors, yet some differences in strategies and contributing factors exist. AI competence development has not been shown to rely on leadership or mentoring but rather on individual attitudes and notions of AI impact and requires – sometimes incidentally inspired and collaborative – active, self-regulated research, exploration and experimentation supported by high-quality resources and aid from – both technical as well as pedagogic – experts. Therefore, institutional support structures for professional development and initial teacher training in the field of AI-related digital competences needs to be developed and maintained in order to equip educators with the competences needed for their profession.

A larger-scale investigation of AI competence development in teachers with a broader and more diverse group of participants could yield more detailed information on the contributing factors and strategies discussed here and could therefore help inform the development of suitable support measures. Furthermore, utilizing design-based research to develop and evaluate concrete concepts for such institutional support – both in terms of development opportunities and materials and resources – could be a starting point for the implementation of high-quality support systems geared to the needs of practitioners in the field and produce good-practice examples. Last but not least, the omnipresent factors of exploration and self-regulated learning need to be nurtured and reflected allowing them to significantly complement other educational strategies.

Acknowledgments

This work was in part supported by the Austrian Ministry of Education under the project B3-16: dig!doc. The authors sincerely thank the Ministry, the Directorates of Education and the headmasters, heads of departments and teachers participating in the data collection, and the members of the dig!doc consortium, who provided valuable input and feedback, was well as F. Laschober and R. Jemetz, who helped with the automatic transcription, for their support.

Disclosure of Interests.

The authors have no conflicting interests to declare.

References

[1] F. Larosa, S. Hoyas, J. Garcia-Martinez, J.A. Conejero, F. Fuso Nerini, and R. Vinnuesa, "Halting generative AI advancements may slow down progress in climate research", Nat. Clim. Chang., vol. 13, pp. 497-499, May 2023. doi: 10.1038/s41558-023-01686-5.

[2] J. Avasarala, and S. Das, "Inclusion of race-neutral data as fundamental to preventing misguided AI modeling", Computers in Biology and Medicine, vol. 168, art. 107859, December 2023. doi: 10.1016/j.compbiomed.2023.107859.

[3] N. Dwyer, M. Harrison, B. O'Mara, and K. Harley, "Inclusive gaming through AI: a perspective for identifying opportunities and obstacles through co-design with people living with MND", Frontiers in Computer Science, vol. 6, art. 1379559, April 2024. doi: 10.3389/fcomp.2024.1379559.

[4] J. Lee, and D. Lee, "User perception and self-disclosure towards an AI psychotherapy chatbot according to the anthropomorphism of its

profile picture". Telematics and Informatics, vol 85, art. 102052, November 2023. doi: 10.1016/j.tele.2023.102052.

[5] S. Zheng, K. He, L. Yang, and J. Xiong, "Memory Repository for AI NPC", IEEE Acsess, vol. 12, pp. 62581-62596, April 2024. doi: 10.1109/ACCESS.2024.3393485.

[6] J. S. Jauhiainen, and A.G. Guerra, "Generative AI and ChatGPT in School Children's Education: Evidence from a School Lesson", Sustainability, vol. 15, art. 14025, September 2023. doi: 10.3390/su151814025.

[7] B. Memarian, T. Doleck, "ChatGPT in education: Methods, potentials, and limitations", Computers in Human Behavior: Artificial Humans, vol. 1(2), art. 1000222, December 2023. doi: 10.1016/j.chbah.2023.100022.

[8] E. Gedrimiene, I. Celik, A. Kaasila, K. Mäkitalo, and H. Muukkonen, "Artificial Intelligence (AI)-enhanced learning analytics (LA) for supporting career decisions: advantages and challenges from user perspective", Education and Information Technologies, vol 29, pp. 297-322, doi: 10.1007/s10639-023-12277-4, November 2023.

[9] T. Mikeladze, P.C. Meijer, and R.P. Verhoeff, "A comprehensive exploration of artificial intelligence competence frameworks for educators: A critical review", Eur. J. Educ., ahead of print, Arpil 2024. doi: 10.1111/ejed.12663.

[10] D. Long, and B. Magerko, "What is AI Literacy? Competencies and Design Considerations", CHI, art 3376727, April 2020. doi: 10.1145/3313831.3376727

[11] D.T.K. Ng, J.K.L. Leung, J . Su, R.C.W. Ng, and S.K.W. Chu, "Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world", Educational technology research and development: ETR & D, vol. 71, pp. 137-161, February 2023. doi: 10.1007/s11423-023-10203-6.

[12] G. Bekiaridis, and G. Attwell, Supplement to the DigCompEDU Framework: Outlining the Skills and Competences of Educators Related to AI in Education. Bremen, Germany: University of Bremen, Institute Technology and Education, January 2024. doi: 10.5281/zenodo.7808076

[13] R. Vuorikari, S. Kluzer, and Y. Punie, DigComp 2.2, The Digital Competence framework for citizens. With new examples of knowledge, skills and attitudes. Luxembourg: Publications Office of the European Union, 2022. doi: 10.2760/115376.

[14] D. Masoumi, and O. Noroozi, "Developing early career teachers' professional digital competence: a systematic literature review", European Journal of Teacher Education, pp. 1-23, June 2023. doi: 10.1080/02619768.2023.2229006.

[15] F.M. Røkenes, and R.J. Krumsvik, "Development of Student Teachers' Digital Competence in Teacher Education", Nordic Journal of Digital Literacy, vol. 2014(4), pp. 250-280, January 2014. doi: 10.18261/ISSN1891-943X-2014-04-0.

[16] L. Ni, G. Bausch, and R. Benjamin, "Computer science teacher professional development and professional learning communities: a review of the research literature", Computer Science Education, vol. 33(1), pp. 29-60, October 2021. doi: 10.1080/08993408.2021.1993666.

[17] F. Giraldo, "Language Assessment Literacy and Teachers' Professional Development: A Review of the Literature", Profile: Issues in Teachers' Professional Development, vol. 23, pp. 265-279, July 2021. doi: 10.19183/how.28.3.673.

[18] R. Dobržinskienė, G. Paurienė, and A. Stepanovienė, "Experiential learning as the precondition of teacher's professional competence development", Society. Integration. Education – Proceedings of the International Scientific Conference, vol. 5, pp. 98-108, May 2019. doi: 10.17770/SIE2019VOL5.3792.

[19] Z. Zhang, Y. Maeda, T. Newby, Z. Cheng, and Q. Xu, "The effect of preservice teachers' ICT integration self-efficacy beliefs on their ICT competencies: The mediating role of online self-regulated learning strategies", Computers & Education, vol. 193, art. 104673, February 2023. doi: 10.1016/j.compedu.2022.104673.

[20] L. Huang, S. Li, E.G. Poitras, and S.P. Lajoie, "Latent profiles of self-regulated learning and their impacts on teachers' technology integration", British Journal of Educational Technology, vol. 52(2), pp. 695-713, March 2021. doi: 10.1111/bjet.13050.

[21] K. Sperling, C.J. Stenberg, C. McGrath, A. Åkerfeldt, F. Heintz, and L. Stenliden, "In search of artificial intelligence (AI) literacy in teacher education: A scoping review", Computers and Education Open, vol. 6, art. 100169, June 2024. doi: 10.1016/j.caeo.2024.100169.

[22] A.C.E. Ding, L. Shi, H. Yang, and I.Choi, "Enhancing teacher AI literacy and integration through different types of cases in teacher professional development", Computers and Education Open, vol. 6, art. 100178, June 2024. doi:10.1016/j.caeo.2024.100178.

[23] C. McGrath, P.J. Palmgren, and M. Liljedahl, "Twelve tips for conducting qualitative research interviews", Medical Teacher, vol. 41(9), pp. 1002-1006, June 2023. doi: 10.1080/0142159X.2018.1497149.

[24] J.R. Denirici, "About Research: Conducting Better Qualitative Interviews", Journal of Human Lactation, vol. 40(1), pp. 21-24, February 2024. doi: 10.1177/089033442312136.

[25] M. Bian, J. Huh, T. Han, and A. Zissermann, "WhisperX: Time-Accurate Speech Transcritpion of Long-Form Audio". github.com/m-bain/whisper, 2023.

[26] Systran, "Faster whisper", huggingface.co/Systran/faster-whisper-large-v3, 2023.

[27] A. Plaquet, and H. Bredin, "Powerset multi-class entropy loss for neural speaker diarization", huggingface.co/pyannote/speaker-diarization-3.1, 2023.

[28] C. Rogers, and R.E. Farson, "Active listening" in Communicating in Business Today, M.A. Danzinger, and M. Cohen, Eds. Lexington: D.C. Heath & Company, 1987.

[29] J. Strübing, "Was ist Grounded Theory?." in Qualitative Sozialforschung, pp. 9–37, Wiesbaden: Springer VS, 2021.

[30] P. Mayring, Qualitative Inhaltsanalyse, 11th ed., Weinheim: Beltz, 2015.

[31] P. Mayring, and T. Fenzl, "Qualitative Inhaltsanalyse" in Handbuch - Methoden der empirischen Sozialforschung, N. Baur, and J. Blasius, Eds. Wiesbaden: Springer, 2019.

[32] C. Stamann, M. Jansen, and M. Schreier, "Inhaltsanalyse – Versuch einer Begriffsbestimmung und Systematisierung", Forum Qualitative Sozialforschung, vol 17(3), art. 16, September 2016. doi: 10.17169/fqs-17.3.2581.

APPENDIX

TABLE XI. GENAI TOOLS AND USES REPORTED BY INTERVIEWEES

ID	used GenAI-tools reported	private use	prof-essional use	allow students' use[a]	encourage students' use[a]	train own models[b]
VT1	ChatGPT	yes	yes	yes	yes[c]	yes
VT2	ChatGPT, GitHub-Copilot, image generators	yes	yes	yes	yes	yes
VT3	ChatGPT, GitHub-Copilot	yes	yes	yes	not yet	-
VT4	ChatGPT, GitHub-Copilot, MS Copilot, Mistral, Mixtral, Midjourney, DALL-E, …	yes	yes	yes	yes	yes
VT5	ChatGPT, GitHub-Copilot, Mid-journey, DALL-E, Firefly, Generative Fill	yes	yes	yes	yes	-
VT6	ChatGPT, image recognition	yes	yes	partially[d]	not yet	-
VT7	ChatGPT, GitHub-Copilot, MS Copilot, Search Engines, IDE Plug-Ins	yes	yes	yes	yes	-
VT8	ChatGPT, GitHub-Copilot, IDE plug-ins, Auto-Correct, MS Copilot, image generators	yes	yes	yes	yes	-
VG1	ChatGPT	not yet	yes	partially[e]	-	-
VG2	ChatGPT, Translators, Bing-AI, search engines	yes	yes	not explicitly	not yet	-
VG3	ChatGPT	yes	yes	yes	yes	-
VG4	ChatGPT, image generators	no	yes	partially[f]	yes	-
VG5	ChatGPT, image generators	yes	yes	yes	yes	-
VG6	ChatGPT	no[g]	yes	no	-	-
VG7	ChatGPT	no[g]	no[g]	yes	yes	-
VG8	ChatGPT	yes	yes	yes	not yet	-
GT1	ChatGPT, Midjourney	yes	yes	yes	yes	-
GT2	ChatGPT, Auto-Correct, image generators	yes	yes	yes	yes	-
GT3	ChatGPT, text generators, MS Copilot	no	no	yes	yes[c]	-

[a]… for specific in-class tasks. Usually with some contextualization to lead them to a reflected use.
[b]This was not specifically querried in the interviews. Only what participants reported unpromted.
[c]… but stress that they leave choice up to learners due to data security or legal concerns.
[d] … depending on school level of students and learning goals.
[e]… in tasks where digital devices are allowed, which is usually not the case in their lessons.
[f]… depending on the subject of the lesson.
[g]… but tried it out once or a few times and then stopped using it.