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Augmented Reality in the Classroom—Mentor Teachers' Attitudes and Technology Use

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Abstract: The education sector is becoming increasingly interested in augmented reality (AR) technology. Research has revealed that AR offers a multitude of benefits in supporting learning. Nevertheless, the implementation of AR in the classroom remains limited. As teachers play a pivotal role in the integration of AR in the classroom, it is essential to understand their perspectives to comprehend the factors hindering the widespread adoption of AR at schools. However, few studies have explored teacher attitudes towards integrating AR into educational practice. The present questionnaire study thus seeks to elucidate the perspectives of 158 mentor teachers in German-speaking Switzerland on the implementation of AR in the classroom. The findings suggest that although mentor teachers have a moderately positive attitude towards AR, they have only limited experience with the technology and appear to lack the requisite technical and pedagogical skills and resources. Furthermore, certain teacher characteristics impact the perception of AR as a useful tool and its integration into teaching practice. Teachers seem to require enhanced information, training, and support if augmented reality (AR) is to become a prevalent feature in schools in the future. To this end, further studies need to consider teacher characteristics in more detail.

Keywords: augmented reality; mentor teacher; survey; teacher characteristics; teacher attitudes; technology use



Citation: Wyss, C.; Bäuerlein, K. Augmented Reality in the Classroom—Mentor Teachers' Attitudes and Technology Use. *Virtual Worlds* **2024**, *3*, 572–585. <https://doi.org/10.3390/virtualworlds3040029>

Academic Editors: Kenneth Y T Lim and Michael Vallance

Received: 30 August 2024

Revised: 18 November 2024

Accepted: 2 December 2024

Published: 13 December 2024



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1. Introduction

Digitalisation has brought about significant changes in various areas of our everyday lives. In the area of education, digital media are considered to have great potential for changing the way we teach and learn. Educational technologies are expected to enhance school performance, reduce learning gaps, improve learning outcomes, increase motivation, make teaching more efficient and innovative, and facilitate the monitoring of educational outcomes and processes [1,2].

Developments in computer-based learning date back to the 1960s, intensifying with the introduction of the PC in the early 1980s [3]. While digital devices were initially considered primarily as instructional aids, they have increasingly been perceived as “cognitive tools” since the mid-1980s, enabling both communication and student-centred teaching and learning processes [4]. Internationally, a strong consensus on the importance and necessity of digitalising education has emerged, and over the past decade, there has been growing activity at many levels to promote the digital transformation of education [1]. In addition to supplying schools with the necessary hardware and software, measures have also been taken at the system level of education, such as the allocation of financial resources, training and further education programmes, education policy regulations, and curricular adjustments [3,5–7]. Although meeting these basic requirements is an important prerequisite for the integration of digital technology in the classroom, teachers play a key role in integrating and accepting technology in education [8].

Teachers are responsible for creating and providing learning opportunities for learners. In so-called supply–use models (see Figure 1), it becomes apparent that the design of a

teaching programme is influenced by various factors. Thus, features of the education system and the school context (e.g., school equipment or financial resources) determine how teaching can be realised. In addition, the composition of the classroom (including its size and heterogeneity), the socioeconomic status (SES) of the students, and the subject being taught are also relevant learning factors [9]. However, the way teaching is arranged and learning opportunities are provided is mainly determined by the characteristics of the teacher (e.g., competencies, personal prerequisites, and abilities). Nowadays, supply–use models underpin instructional effectiveness research. They take into account that teaching does not only have a causal and unidirectional effect on students’ learning and learning outcomes, but that learning outcomes are determined by a variety of conditions and complex interactions [10].

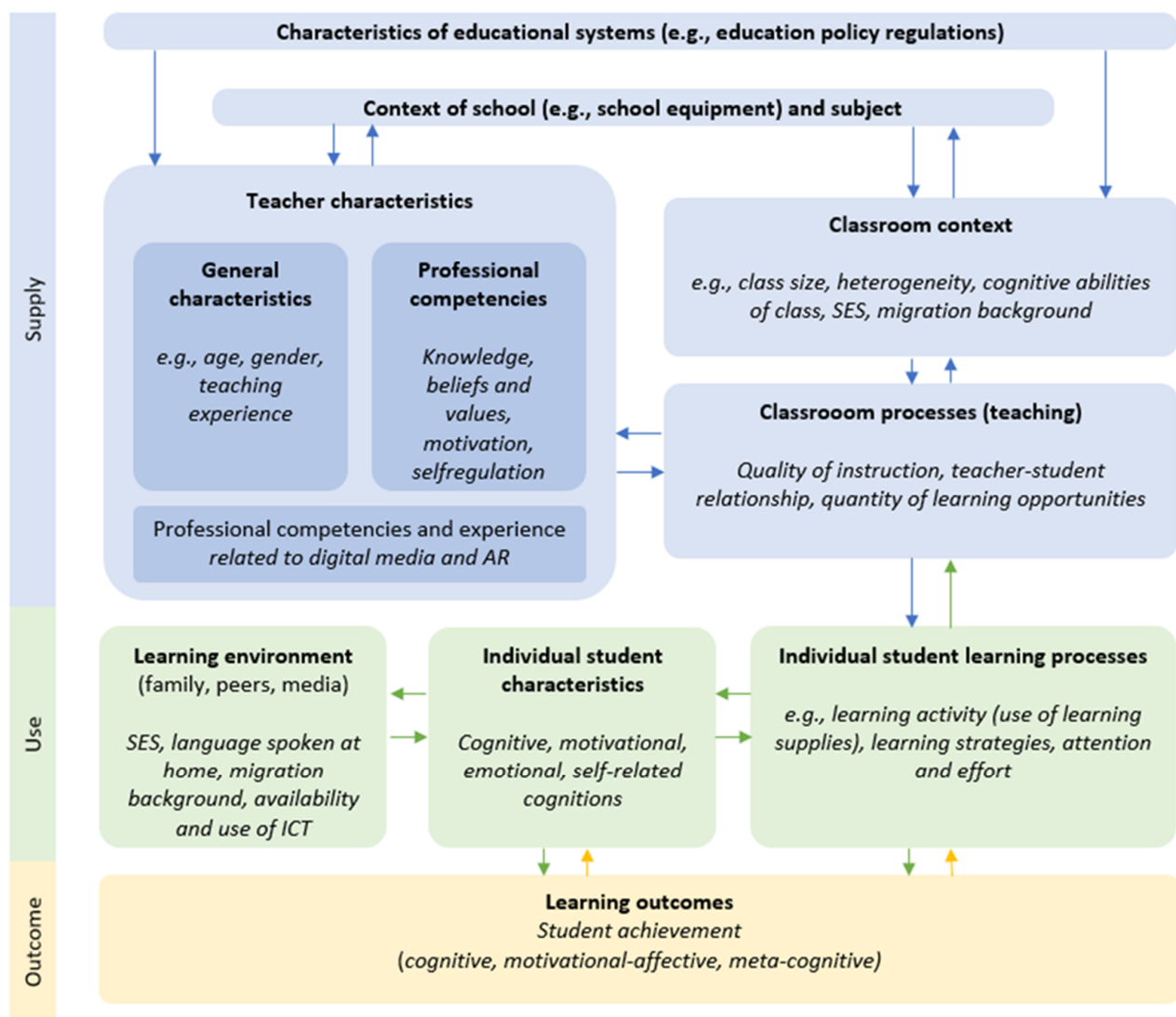


Figure 1. Multilevel supply–use model adapted from Brühwiler and Blatchford [11] and Seidel [12].

The possibilities for structuring teaching have changed considerably in recent years. The advent of computers, laptops, and mobile phones, as well as other technologies and the development of various software and applications, have created new opportunities for teaching and learning. In recent years, the technology of augmented reality (AR) has received increasing attention. In contrast to virtual reality (VR) technology, which completely immerses the user in a synthetic world, AR technology directly or indirectly augments the real world with computer-generated content in real time. In this way, AR technology enhances the sense of reality by creating a hybrid world combining the user’s view of the

real environment with digital information and objects. Various types of augmentation are possible, such as text, audio, images, video, or 3D objects [8,10,13–15]. Although the first AR application developed specifically for educational institutions was introduced almost 30 years ago [16], the technology has only become widespread in recent years thanks to the advent of smartphones and tablets. The production of AR-specific devices such as smart glasses (e.g., Google Glass or Microsoft HoloLens) has further increased interest in the technology [17].

Today, AR applications are successfully used at different levels of education in a variety of educational settings and environments, and there is consensus in the scientific community that AR applications can improve learning processes, motivation, and effectiveness [8]. Studies were conducted at all school levels as well as with different types of learners (e.g., elderly people, students at vocational schools, and learners with special needs) and also for a variety of learning content [8]. In recent years, these findings have been synthesised in multiple literature reviews and meta-analyses (e.g., [18–25]). From these studies, it can be concluded that the use of AR in education offers many advantages to support learning, and there is a consensus that the technology has enormous potential. Thus, it can be shown that AR can support kinaesthetic learning, improve visual and spatial awareness [19,26], and trigger the motivation and interest of learners [27]. By using AR, students attribute more relevance to learning activities, gain more confidence in engaging with the learning activities, pay more attention, and experience more satisfaction and enjoyment [18,27–29]. In addition, AR can increase collaboration among learners and between learners and teachers. This also enhances problem-solving, creativity, critical thinking, information processing, and communication skills, and improves learning transfer (e.g., [15,17,18,26,30–32]).

As the information above shows, there are already many studies that have focused on the use of AR in education. However, only a few studies have addressed the teacher's perspective [33–35]. As previously outlined, “teachers can be key gatekeepers” in integrating technology into the classroom [36]. Therefore, in order to implement AR technology in the educational sector and exploit its potential, it is important to consider the teachers' point of view (cf. Figure 1). The results of previous studies on the use of AR in teaching show that the application of AR is still quite limited. Although teachers in studies usually showed a positive attitude towards AR [35,37–39], existing evidence suggests that many teachers are rather reluctant to use such technologies [36,40,41]. The reasons stated include a lack of infrastructure (hardware, software, or internet access), but also a deficit of technical and pedagogical skills among teachers [8,33,42,43]. Also, teachers' self-efficacy may influence their decision to use technology in the classroom [44,45]. Although teachers make their own choices about how to teach, these choices are made within the context of the school or the culture of the whole society, and teachers are, therefore, directly or indirectly influenced by contextual factors [44]. Indeed, social norms and motivational support have been identified as important factors influencing teachers' integration of technology [34]. Social norms, such as an individual's subjective belief that they should or should not use a new technology, have an important influence on intentions, especially in the early stages of technology adoption [46]. Providing teachers with motivational support to use technology in the classroom, including teacher collaboration, technology leadership from school administrators, and professional development opportunities, has also proved to be critical [34]. Previous studies found that teachers' attitudes towards technology have a strong influence on their intentions to use digital media in the classroom [7,34,46]. Clearly, many internal and external teacher-related factors play a role in the integration of technology. Overall, these findings confirm that teachers play a key role in the integration and acceptance of digital media in education. Nevertheless, research on teachers' acceptance of AR is still in its infancy [41], and further investigation into this area is therefore of particular importance.

It was thus our intention to develop and conduct a survey to gain insight into AR usage from the perspective of the teacher. In order to better understand why teachers have a positive or critical attitude towards AR and why they use or refuse to use the technology

in the classroom, teacher characteristics (see Figure 1) were identified and included in the analysis. The following research questions (RQs) are being pursued in this regard and will be addressed in this paper:

RQ1: What attitudes do teachers have towards the use of AR in the classroom?

RQ2: How common is the use of AR technologies in the classroom?

RQ3: How do teacher characteristics affect the use of AR in the classroom?

Of the 158 mentor teachers who completed the survey, around 60% had heard or read about AR. However, a significant number had never come across this technology. The attitude of mentor teachers towards the use of AR in classrooms was moderately positive on average. Reservations that appear to influence the use of AR seem to result mainly from a deficit of personal knowledge, a shortage of infrastructure and resources, and a lack of suitable materials and apps. Only 25 teachers had used AR in the classroom one or more times, with only 4 stating that they had used the technology in the classroom more than five times. Some teacher characteristics appear to have an influence here. Mentor teachers who have a higher level of digital literacy and those who perceive digital media as more useful are also more likely to have heard or read about AR. Mentor teachers who consider digital media to be more useful also have a more positive attitude towards the use of AR in the classroom and are more likely to use AR in the classroom. In addition, mentor teachers who have better digital literacy also employ AR more frequently in the classroom. These findings highlight the importance of keeping teachers on the agenda if AR is to become more embedded in educational processes. After all, even the best educational technology is ineffective if teachers do not use it. More attention should therefore be paid to this issue in educational and research contexts in the future.

2. Materials and Methods

2.1. Study

The data used to answer the above research questions were collected from a supplementary survey in the project “Online-based self-learning courses for mentor teachers”. In this project, online courses for teachers and mentor teachers were designed, produced, and evaluated. The project is funded by the organisation swissuniversities and is being carried out in German-speaking Switzerland from 2021 to 2025. The data used here were collected as part of the first and last of three questionnaire surveys with mentor teachers who have used the online courses. Mentor teachers offer student teachers insight into the real world of the teaching profession and help them bridge the gap between theory and practice. Because they hold key responsibilities and make a significant contribution to the training of qualified future teachers [47], it is vital to learn about their experiences and attitudes. For this study, questions on the general characteristics of the participants and scales of general professional competencies were used from the first questionnaire in the project, while information on AR-related professional competencies, as well as further general professional competencies, were taken from the third questionnaire. At the end of the third questionnaire, the participants were asked whether they were willing to answer further questions on the topic of AR. Only those participants who answered “yes” were presented with the respective questions.

2.2. Participants

Of the 188 mentor teachers who completed the third questionnaire, 158 (84.04%) voluntarily answered the supplementary questions on AR. This study is based exclusively on data from these 158 individuals. The age of these mentor teachers ranged between 23 and 63 years ($Md = 40$, $SD = 9.32$), and their teaching experience ranged between 3 and 42 years ($Md = 15$, $SD = 8.98$). Regarding gender, 98 (62.03%) were female, 59 (37.34%) were male, and 1 was diverse (0.63%). Only 11 (6.96%) of the teachers worked in kindergartens, while 40 (25.32%) worked in primary schools and 106 (67.09%) worked in lower secondary schools.

2.3. Questionnaire

Based on the supply–use model (cf. Figure 1), questions and scales were selected for the present study that capture mentor teachers' general characteristics and professional competencies. Wherever possible, established and validated scales were employed. Since the questionnaire was in German, all the item examples given in this article have been translated into English by the authors.

The *general characteristics* collected in the survey were gender (male, female, diverse), age (in years), and teaching experience (in years). In addition, the school level (kindergarten, primary school, lower secondary level) of each teacher was recorded.

To assess *professional competencies*, scales were used to assess general teacher self-efficacy, motivation for participation in further education, and readiness for innovation (for details, see Table 1). Although two of the scales on motivation for participation in further education by Rzejak et al. [48] do not have satisfactory values for Cronbach's alpha, they were included in the data analysis since they originate from a validated survey instrument. The scale on readiness for innovation by Quellenberg [49] was adapted for personal innovation instead of innovation at school.

In addition to these general areas, we were also interested in teachers' *professional competencies related to digital media and AR*. Regarding digital media, teachers' digital literacy and perceived usefulness of digital media were assessed (for details, see Table 1). Regarding AR, the mentor teachers' awareness of the existence of AR was queried via the question (similar to Tzima et al. [8]), "Have you heard or read about augmented reality (AR)?" The response format was Yes/No. If they answered "no", the survey was completed. If they answered "yes", an open-ended question about their understanding of AR followed (based on Holzapfel et al. [50]): "What do you understand about augmented reality (AR)?" Subsequently, the participants were presented with a definition of AR based on Müser and Fehling [51]. The definition in the questionnaire (translated here by the authors) was as follows: "Augmented reality (AR for short) involves integrating digital content into the real environment in a representation. The real environment remains unchanged and is expanded with virtual elements in real-time, interactively and with precise positioning". After the definition, questions on participants' experience with AR followed. The mentor teachers were asked, "How often have you used AR in teaching?". The single-choice response options to this question (based on Silva et al. [43]) were 1 = Never used or considered, 2 = Considered but not used, 3 = Used once, 4 = Used more than once but no more than five times, and 5 = Used more than five times. If they had never used AR in teaching, the participants were asked why not (open-ended). If they had used AR in teaching, they were asked why and which apps they had used (both open-ended). Next, the mentor teachers were asked to complete scale-based questions on their attitude towards AR (for details, see Table 1). Furthermore, mentor teachers' technology acceptance of AR was assessed using three single items. Two items were selected, translated into German, and adapted by the authors from the subscale "behavioural intention" of the scale "technology acceptance" by Tiede et al. [52] and Ibili et al. [46]. The third item was adapted from a self-assessment scale regarding the use of AR and VR in the classroom by Holzapfel et al. [50].

Table 1. Overview of the scales. All scales comprised the same 5-step response format (1 = "do not agree at all" to 5 = "totally agree").

Professional Competencies			
General teacher self-efficacy <i>slightly adapted from Schmitz and Schwarzer [53]</i>	10 items	Item example: "I have the confidence to get the students excited about new projects."	$\alpha = 0.74$
Motivation for participation in further education <i>Rzejak et al. [48]</i>			

Table 1. Cont.

Professional Competencies			
Subscale “social interaction”	4 items	Item example: “I generally take part in further education because I want to exchange ideas with colleagues.”	$\alpha = 0.88$
Subscale “adjustment to external expectations”	4 items	Item example: “I generally take part in further education because I am obliged to do so.”	$\alpha = 0.57$
Subscale “development orientation”	4 items	Item example: “I generally take part in further education because I want to be up-to-date.”	$\alpha = 0.67$
Self-regulated learning <i>slightly adapted from Chrobak [54]</i>	10 items	Item example: “I can define suitable learning steps for myself.”	$\alpha = 0.78$
Readiness for innovation adapted from Quellenberg [49]	7 items	Item example: “I am committed to real innovation and development.”	$\alpha = 0.76$
Teachers’ professional competencies related to digital media and AR			
Digital literacy <i>Zahn et al. [55]</i>	6 items	Item example: “I have adequate resources to use digital media in my work.”	$\alpha = 0.81$
Perceived usefulness of digital media <i>Zahn et al. [55]</i>	4 items	Item example: “Digital media are helpful for my work.”	$\alpha = 0.88$
Teacher attitude towards AR <i>Tiede et al. [52]</i>	21 items	Item example: “They are motivating for the students.”	$\alpha = 0.91$
Technology acceptance towards AR: Subscale “behavioral intention” <i>adapted from Tiede et al. [52]</i> <i>and Ibili et al. [46]</i>	2 single items	“I plan to use AR apps in class in the future.” “I intend to use AR apps in class in the future.”	
Item from a self-assessment scale on the use of AR in the classroom <i>adapted from Holzapfel et al. [50]</i>	1 single item	“I would like to learn how to create learning environments using AR.”	

2.4. Data Analysis

As only one person identified as diverse, only men and women were included in the gender comparison. In addition, for the school level comparison, only primary school and lower secondary school teachers were compared, as only a few participants stated that they teach at the kindergarten level. Moreover, the ordinal 5-point scale on the frequency of AR use in teaching was dichotomised to provide a clearer picture of how many mentor teachers had never used AR in the classroom, how many teachers had used it at least once, and how this use or non-use is related to other characteristics and attitudes. Level 1 and level 2 were summarised as “No AR use”. Levels 3–5 were summarised as “AR use”.

The quantitative data were analysed using IBM SPSS Statistics Version 29. In addition to descriptive analyses, group differences and correlations were tested for statistical significance. Correlations with dichotomous nominal variables were tested using Pearson χ^2 tests, correlations with ordinal variables with Spearman correlations, and correlations between interval-scaled variables with Pearson correlations. Group differences were examined using t-tests for independent samples. Cohen’s d was used to indicate effect sizes. The answers to the open-ended questions were used to better interpret and validate the results of the closed questions and to support them with examples. As the survey was conducted in German, the quotes used in this article were translated into English by the authors.

3. Results

Of the 158 mentor teachers who agreed to answer the supplementary questions on AR, 95 (60.13%) indicated that they had heard or read about AR, while 63 (39.87%) indicated that they had not. However, after reviewing the definitions formulated by those teachers who had heard of AR in more detail, it became clear that not all of them had a precise or correct understanding of AR. Some mentor teachers only translated the term into German or claimed not to know exactly what AR is or how to describe it (e.g., “Augmented reality, but I don’t have an exact idea”). Others confused AR with VR or only provided a vague, partially correct, or completely wrong description (e.g., “Video-based learning content in real time”). The results reported below only include data from those mentor teachers who had already heard of AR, regardless of whether they were able to give a correct and differentiated description or not. Participants who stated that they had never heard or read about AR were not further questioned.

3.1. Teachers’ Attitudes Towards the Use of AR in the Classroom (RQ1)

The mentor teachers’ attitudes towards AR seem to be moderately positive on average (see Table 2). Moreover, the answers to the three single items show that the mentor teachers tend towards using AR in the classroom in the future and that they would like to learn how to create learning environments with this technology.

Table 2. Mentor teachers’ attitudes towards AR use in the classroom.

	Min	Max	Mean	SD
Teacher attitude towards AR	1.90	4.81	3.43	0.56
Item “I plan to use AR apps in class in the future.”	1.00	5.00	3.43	1.03
Item “I intend to use AR apps in class in the future.”	1.00	5.00	3.24	1.10
Item “I would like to learn how to create learning environments using AR.”	1.00	5.00	4.07	1.91

3.2. Frequency of AR Use in the Classroom (RQ2)

As shown in Figure 2, 70 of the 95 mentor teachers (73.69%) who had heard or read about AR had never used this technology for teaching; 40 of these mentor teachers (42.11%) had not even considered using it. Only four (4.21%) mentor teachers had used AR in the classroom more than five times. There was no correlation between the self-reported frequency with which mentor teachers use AR in the classroom and their age, gender, professional experience, or the school level at which they teach.

The answers to the open-ended questions as to why the mentor teachers used AR or why they did not reveal that they use the technology primarily because it offers a way to increase visualisation, vividness, and impressiveness. One mentor teacher, for example, stated, “I showed animals and their true size”. Another reason for the use of AR was the “curiosity to try something new” and the opportunity to offer new experiences to students “because it is a great addition to awaken a desire for new discoveries”. Mentor teachers who had not used AR in teaching stated that this was due to a lack of personal knowledge, infrastructure, and resources, or because apps and materials were not available. For example, one mentor teacher stated that “the necessary equipment, apps and training are lacking”. In addition, many mentor teachers seem to expect an unfavourable cost–benefit ratio, for example: “Effort and return are not yet in balance; there is a lack of suitable platforms that can be found quickly and efficiently”.

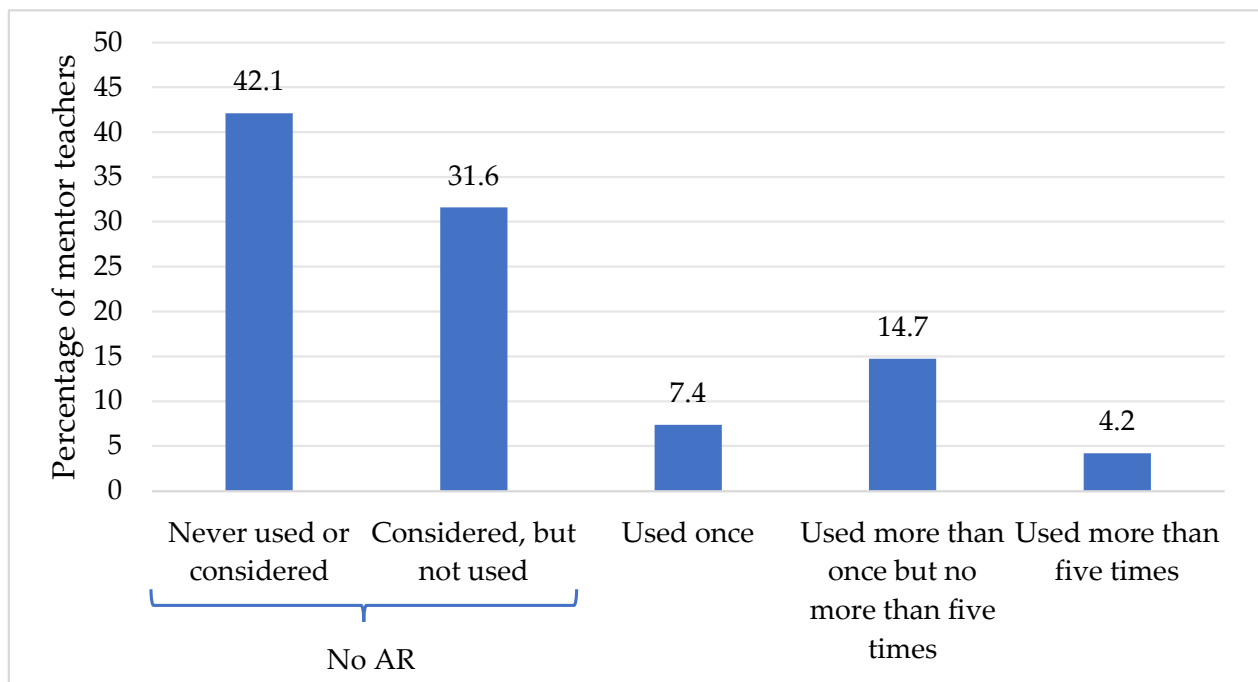


Figure 2. Frequency of the mentor teachers' AR use in the classroom.

3.3. The Relationship Between Teacher Characteristics and the Use of AR in the Classroom (RQ3)

In terms of *general characteristics*, gender, age, and teaching experience, as well as school level, were considered. As shown in Table 3, male mentor teachers are more likely than female mentor teachers to have heard or read about AR. On the other hand, women are more interested in learning to create learning environments using AR than men. However, there are no gender differences in the teachers' attitudes towards AR and the frequency of the use of AR in teaching.

Table 3. Gender differences.

Male	Female	Test Statistic	Significance
<i>Heard or read about AR</i>			
41 out of 59 (69.49%)	53 out of 98 (54.08%)	$\chi^2 = 3.64$ df = 1	$p = 0.056$
<i>Interest in learning to create a learning environment using AR</i>			
M = 3.85 SD = 1.11 N = 41	M = 4.23 SD = 0.91 N = 53	t = 1.79 df = 92	$p = 0.077$ d = 0.37

With regard to age and teaching experience, there is no correlation between having heard or read about AR and the "teacher attitude towards AR" scale or the frequency of the use of AR in teaching. Comparing school levels, there is a tendency ($\chi^2 = 2.28$, df = 1, $p = 0.093$) for a higher proportion of primary school teachers (8 out of 20, 40.00%) to have already used AR in the classroom at least once than lower secondary school teachers (15 out of 70, 21.43%). There is no difference between the school levels in terms of having heard or read about AR, in the frequency of the use of AR in teaching, or teachers' attitudes towards AR.

In terms of *professional competencies*, there was no correlation between mentor teachers' general teacher self-efficacy or readiness for innovation and having heard of or read about AR, the use of or attitude towards the use of AR in teaching, or the three single items. Regarding the motivation for participation in further education, we found a positive

correlation between development orientation and the single item “I would like to learn how to create learning environments using AR” (see Table 4). Another positive correlation was found between the “self-regulated learning” scale and the “teacher attitude towards AR” scale.

Table 4. Correlations between mentor teachers’ professional competencies and their attitudes towards AR.

Professional Competency	Attitude Towards AR	N	r	p
Motivation for participation in further education: Development orientation	“I would like to learn how to create learning environments using AR”	93	0.21	0.043
Self-regulated learning	Teacher attitude towards AR	95	0.23	0.027

In terms of *professional competencies related to digital media*, we found a significant difference in the “digital literacy” and “perceived usefulness of digital media” scales between teachers who had heard about AR and those who had not (see Table 5), but not between mentor teachers who had used AR in the classroom and those who had not.

Table 5. Differences in professional competencies related to digital media between mentor teachers who had heard or read about AR and those who had not.

Heard or Read About AR	Not Heard or Read About AR	Test Statistic	Significance
<i>Digital literacy</i>			
M = 4.09 SD = 0.64 N = 93	M = 3.72 SD = 0.64 N = 62	t = 3.56 df = 153	p < 0.001 d = 0.58
<i>Perceived usefulness of digital media</i>			
M = 4.08 SD = 0.77 N = 93	M = 3.72 SD = 0.86 N = 62	t = 2.70 df = 153	p = 0.008 d = 0.44

Moreover, there is a significant correlation between the “digital literacy” scale and the frequency of use of AR in the classroom, and a modest correlation between this and the “teacher attitude towards AR” scale (see Table 6). Additionally, the “digital literacy” scale correlated with the two items on behavioural intention. Regarding the “perceived usefulness of digital media” scale, the correlations between the frequency of use of AR for teaching and the “teacher attitude towards AR” scale are both significant, as are the correlations with the two items on behavioural intention and the item on interest in learning how to create learning environments using AR.

Table 6. Correlations between mentor teachers’ digital literacy and their use of and attitudes towards AR.

Professional Competency Related to Digital Media	Use of and Attitude Towards AR	N	r	p
Digital literacy	Frequency of use of AR in the classroom	93	0.24	0.021
	Teacher attitude towards AR	93	0.20	0.053
	Behavioural intention: “I plan to use AR apps in class in the future.”	93	0.33	0.001
	Behavioural intention: “I intend to use AR apps in class in the future.”	93	0.22	0.034

Table 6. *Cont.*

Professional Competency Related to Digital Media	Use of and Attitude Towards AR	N	r	p
Perceived usefulness of digital media	Frequency of use of AR for teaching	93	0.28	0.007
	Teacher attitude towards AR	93	0.25	0.016
	Behavioural intention: "I plan to use AR apps in class in the future."	93	0.38	<0.001
	Behavioural intention: "I intend to use AR apps in class in the future."	93	0.35	<0.001
	"I would like to learn how to create learning environments using AR."	93	0.21	0.047

4. Discussion

Digital transformation has become a major concern for governments around the world, and education is expected to take a leading role in the digitalisation of society [1]. In order to comply with this agenda, educational systems and schools must ensure that the necessary conditions are in place, for example, by providing the appropriate financial resources, opportunities for further training, or curricular foundations. However, the extent to which digital transformation takes place in schools depends primarily on the teachers, who hold the key to working with digital technologies in the classroom [36]. The successful integration of technology is heavily dependent on how well it is perceived by teachers and their ability to align it with their goals, teaching strategies, and expectations [56]. It is therefore of particular interest to understand the attitudes and experiences of teachers towards digital technologies.

In this study, mentor teachers in German-speaking Switzerland were surveyed. The results of our survey show that the participants have a moderately positive attitude towards AR but only limited experience with it. Only around 60% said that they had already heard or read about the technology. Among those who had already heard or read about it, some still had an inaccurate or false understanding. In addition, almost 75% of them stated that they had never used AR in their teaching. Only four respondents reported that they had already used AR in the classroom more than five times. Although research into AR in education has been going on for three decades [57], it is quite surprising that the technology is still so unfamiliar to teachers. On the other hand, it is encouraging that the mentor teachers surveyed indicated that they would like to learn how to design learning environments with AR. Similar results have also been found in recent studies [34,43,44,58]. As AR-based educational applications become more widely available, and even low-cost smartphones support the visualisation of AR content, working with AR is becoming much more feasible [59]. However, further efforts are needed to ensure that teachers become familiar with the technology and learn how to use it in the classroom to implement meaningful learning scenarios. This last aspect is particularly important, since the use of media without pedagogical considerations does not usually lead to a change in practice, and thus potential, which is often referred to, cannot be reached [2,58]. A good option here could involve working more with co-design methodologies. This approach has been used only rarely to date, although the results of studies show various positive aspects, such as a positive effect on the teachers' attitudes, continued use of the materials after study, and positive outcomes for the learners [56].

Our study also provides information on whether the characteristics of teachers influence their use of AR. Since the characteristics of the teacher (e.g., skills, personal requirements, and abilities) have a major influence on how teaching is arranged (cf. Figure 1), it is important to learn how this could affect the adoption of AR. The results show that certain teacher characteristics are indeed influential, and according to our results, it is professional

competencies and experience related to digital media and AR that are particularly relevant. Thus, mentor teachers who have a higher level of digital literacy and those who consider digital media to be more useful are also more likely to have heard or read about AR. Furthermore, mentor teachers who consider digital media to be more useful also have a more positive attitude towards the use of AR in the classroom and are more likely to use AR in the classroom. These teachers are also more interested in learning how to use AR in the classroom and are more likely to use the technology in the future. In addition, mentor teachers who have better digital literacy apply AR more often in the classroom.

4.1. Limitations

One limitation of our study is that only mentor teachers in German-speaking Switzerland who agreed to participate were surveyed. Whether the results are representative of other regions of Switzerland—as well as other countries—or of teachers who do not work as mentor teachers or did not agree to participate remains unclear. Furthermore, only questionnaire data were used, which were predominantly quantitatively analysed. Follow-up interviews could have provided a deeper understanding of the questionnaire data.

4.2. Conclusions

Overall, there is still too little known about whether and to what extent schools and teachers are using AR as an addition to their lessons or training [59], and little is known about whether and how teachers' characteristics affect their use of digital media in the classroom [46]. Our study makes a valuable contribution to this under-researched field and provides indications for implementation and research efforts. Further studies focussing on the teachers' perspective are, however, of crucial importance. In addition to further research on teacher-related internal factors, future studies should also consider external factors such as school level in order to better explain the different influences of primary and secondary school teachers [44]. Further research is also needed to explore the details of the specific support provided by school-based actors, such as fellow teachers or school administrators, in driving change in technology use [44,45]. In addition, it would also be beneficial to consider both the teachers' and the students' perspectives and to explore supply and use, which are mutually dependent (cf. Figure 1). If our knowledge of these issues is improved, we can better support schools and teachers as well as educational authorities or educational technology developers, and thus promote the use of AR—or other digital media—and thereby also contribute to digitisation.

Author Contributions: Conceptualization, C.W. and K.B.; methodology, K.B. and C.W.; formal analysis, K.B.; data curation, K.B.; writing—original draft preparation, C.W. and K.B.; writing—review and editing, C.W. and K.B.; visualisation, C.W. and K.B.; project administration, C.W.; funding acquisition, C.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by swissuniversities, Pilotprogramme zur Stärkung des doppelten Kompetenzprofils beim FH- und PH-Nachwuchs (P-11), official project title «Onlinebasierte Selbstlernangebote für Begleitpersonen in der berufspraktischen Ausbildung von angehenden Lehrpersonen».

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki. No approval by the Institutional Ethics Committee was necessary, as all data were collected anonymously from capable, consenting adults. The data are not traceable to participating individuals. The procedure complies with the general data protection regulation (GDPR).

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in this study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors would like to thank the mentor teachers for their participation in the study. Special thanks go to the project team of the project 'Online-based self-learning courses for mentor teachers', that is, Samuel Krattenmacher, Schaffhausen University of Teacher Education,

Thomas Rey, St. Gallen University of Teacher Education, Nina Hüsler, FHNW School of Education, Anna-Lena Roos, St. Gallen University of Teacher Education, Eva Weingartner, St. Gallen University of Teacher Education, Alexandra Roggensinger, St. Gallen University of Teacher Education, and Angela Jochum, St. Gallen University of Teacher Education.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Ljungqvist, M.; Sonesson, A. Selling out Education in the Name of Digitalization: A Critical Analysis of Swedish Policy. *Nord. J. Stud. Educ. Policy* **2022**, *8*, 89–102. [\[CrossRef\]](#)
2. Player-Koro, C. Digitization of Schools and Education: The Case of Sweden. In *Understanding Media and Information Literacy (MIL) in the Digital Age A Question of Democracy*; Carlsson, U., Ed.; Department of Journalism, Media and Communication (JMG) University of Gothenburg: Göteborg, Sweden, 2019; pp. 127–132, ISBN 978-91-88212-87-0.
3. Eickelmann, B. Digitalisierung in der schulischen Bildung. Entwicklungen, Befunde und Perspektiven für die Schulentwicklung und die Bildungsforschung. In *Digitalisierung in der schulischen Bildung: Chancen und Herausforderungen*; McElvany, N., Schwabe, F., Bos, W., Holtappels, H.G., Eds.; Waxmann Verlag: Münster, Germany; New York, NY, USA, 2018; pp. 11–25, ISBN 978-3-8309-8757-4.
4. Petko, D.; Schmid, R.; Pauli, C.; Stebler, R.; Reusser, K. Personalisiertes Lernen mit digitalen Medien: Neue Potenziale zur Gestaltung schülerorientierter Lehr- und Lernumgebungen. *J. Für Schulentwickl.* **2017**, *3*, 31–39.
5. Hartong, S. Bildung 4.0? Kritische Überlegungen Zur Digitalisierung von Bildung Als Erziehungswissenschaftliches Forschungsfeld. *Z. Für Pädagogik* **2019**, *65*, 424–444. [\[CrossRef\]](#)
6. Petko, D.; Honegger, B.D.; Prasse, D. Digitale Transformation in Bildung und Schule: Facetten, Entwicklungslinien und Herausforderungen für die Lehre-rinnen- und Lehrerbildung. *Beiträge Zur Lehrerinnen Lehrerbildung* **2018**, *36*, 157–174. [\[CrossRef\]](#)
7. Petko, D.; Döbeli Honegger, B. Digitale Medien in der schweizerischen Lehrerinnen- und Lehrerbildung: Hintergründe, Ansätze und Perspektiven. *Beiträge Zur Lehrerinnen Lehrerbildung* **2011**, *29*, 155–171. [\[CrossRef\]](#)
8. Tzima, S.; Styliaras, G.; Bassounas, A. Augmented Reality Applications in Education: Teachers Point of View. *Educ. Sci.* **2019**, *9*, 99. [\[CrossRef\]](#)
9. Förster, M.; Maur, A.; Weiser, C.; Winkel, K. Pre-Class Video Watching Fosters Achievement and Knowledge Retention in a Flipped Classroom. *Comput. Educ.* **2022**, *179*, 14. [\[CrossRef\]](#)
10. Wyss, C.; Degonda, A.; Bühner, W.; Furrer, F. The Impact of Student Characteristics for Working with AR Technologies in Higher Education—Findings from an Exploratory Study with Microsoft HoloLens. *Information* **2022**, *13*, 112. [\[CrossRef\]](#)
11. Brühwiler, C.; Blatchford, P. Effects of Class Size and Adaptive Teaching Competency on Classroom Processes and Academic Outcome. *Learn. Instr.* **2011**, *21*, 95–108. [\[CrossRef\]](#)
12. Seidel, T. Performance Assessment and Professional Development in University Teaching. In *Incentives and Performance*; Welp, I.M., Wollersheim, J., Ringelhan, S., Osterloh, M., Eds.; Springer International Publishing: Cham, Switzerland, 2015; pp. 465–477, ISBN 978-3-319-09784-8.
13. Bower, M.; Howe, C.; McCredie, N.; Robinson, A.; Grover, D. Augmented Reality in Education—Cases, Places and Potentials. *Educ. Media Int.* **2014**, *51*, 1–15. [\[CrossRef\]](#)
14. Kesim, M.; Ozarslan, Y. Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia—Soc. Behav. Sci.* **2012**, *47*, 297–302. [\[CrossRef\]](#)
15. Nincarean, D.; Alia, M.B.; Halim, N.D.A.; Rahman, M.H.A. Mobile Augmented Reality: The Potential for Education. *Procedia—Soc. Behav. Sci.* **2013**, *103*, 657–664. [\[CrossRef\]](#)
16. Garzón, J. An Overview of Twenty-Five Years of Augmented Reality in Education. *Multimodal Technol. Interact.* **2021**, *5*, 37. [\[CrossRef\]](#)
17. Elmqaddem, N. Augmented Reality and Virtual Reality in Education. Myth or Reality? *Int. J. Emerg. Technol. Learn.* **2019**, *14*, 234. [\[CrossRef\]](#)
18. Akçayır, M.; Akçayır, G. Advantages and Challenges Associated with Augmented Reality for Education: A Systematic Review of the Literature. *Educ. Res. Rev.* **2017**, *20*, 1–11. [\[CrossRef\]](#)
19. Alzahrani, N.M. Augmented Reality: A Systematic Review of Its Benefits and Challenges in E-Learning Contexts. *Appl. Sci.* **2020**, *10*, 5660. [\[CrossRef\]](#)
20. Chang, H.-Y.; Binali, T.; Liang, J.-C.; Chiou, G.-L.; Cheng, K.-H.; Lee, S.W.-Y.; Tsai, C.-C. Ten Years of Augmented Reality in Education: A Meta-Analysis of (Quasi-) Experimental Studies to Investigate the Impact. *Comput. Educ.* **2022**, *191*, 104641. [\[CrossRef\]](#)
21. Garzón, J.; Pavón, J.; Baldiris, S. Systematic Review and Meta-Analysis of Augmented Reality in Educational Settings. *Virtual Real.* **2019**, *23*, 447–459. [\[CrossRef\]](#)
22. Garzón, J.; Kinshuk; Baldiris, S.; Gutiérrez, J.; Pavón, J. How Do Pedagogical Approaches Affect the Impact of Augmented Reality on Education? A Meta-Analysis and Research Synthesis. *Educ. Res. Rev.* **2020**, *31*, 100334. [\[CrossRef\]](#)
23. Garzón, J.; Acevedo, J. Meta-Analysis of the Impact of Augmented Reality on Students' Learning Gains. *Educ. Res. Rev.* **2019**, *27*, 244–260. [\[CrossRef\]](#)

24. Hantono, B.S.; Nugroho, L.E.; Santosa, P.I. Meta-Review of Augmented Reality in Education. In Proceedings of the 2018 10th International Conference on Information Technology and Electrical Engineering (ICITEE), Bali, Indonesia, 24–26 July 2018; pp. 312–315.
25. Sirakaya, M.; Alsancak Sirakaya, D. Trends in Educational Augmented Reality Studies: A Systematic Review. *MOJET Malays. Online J. Educ. Technol.* **2018**, *6*, 60–74. [\[CrossRef\]](#)
26. Dunleavy, M.; Dede, C.; Mitchell, R. Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning. *J. Sci. Educ. Technol.* **2009**, *18*, 7–22. [\[CrossRef\]](#)
27. Bacca, J.; Baldiris, S.; Fabregat, R.; Graf, S.; Kinshuk. Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *J. Educ. Technol. Soc.* **2014**, *17*, 133–149.
28. Radu, I. Augmented Reality in Education: A Meta-Review and Cross-Media Analysis. *Pers. Ubiquitous Comput.* **2014**, *18*, 1533–1543. [\[CrossRef\]](#)
29. Chiang, T.H.C.; Yang, S.J.H.; Hwang, G.-J. An Augmented Reality-Based Mobile Learning System to Improve Students' Learning Achievements and Motivations in Natural Science Inquiry Activities. *J. Educ. Technol. Soc.* **2014**, *17*, 352–365.
30. Yuen, S.C.-Y.; Yaoyuneyong, G.; Johnson, E. Augmented Reality: An Overview and Five Directions for AR in Education. *J. Educ. Technol. Dev. Exch.* **2011**, *4*, 11. [\[CrossRef\]](#)
31. Saidin, N.; Halim, N.A.; Yahaya, N. A Review of Research on Augmented Reality in Education: Advantages and Applications. *Int. Educ. Stud.* **2015**, *8*, 1–8. [\[CrossRef\]](#)
32. Altinpulluk, H. Determining the Trends of Using Augmented Reality in Education between 2006–2016. *Educ. Inf. Technol.* **2019**, *24*, 1089–1114. [\[CrossRef\]](#)
33. Perifanou, M.; Economides, A.A.; Nikou, S.A. Teachers' Views on Integrating Augmented Reality in Education: Needs, Opportunities, Challenges and Recommendations. *Future Internet* **2023**, *15*, 20. [\[CrossRef\]](#)
34. Jang, J.; Ko, Y.; Shin, W.S.; Han, I. Augmented Reality and Virtual Reality for Learning: An Examination Using an Extended Technology Acceptance Model. *IEEE Access* **2021**, *9*, 6798–6809. [\[CrossRef\]](#)
35. Banerjee, G.; Walunj, S. Exploring In-Service Teachers' Acceptance of Augmented Reality. In Proceedings of the 2019 IEEE Tenth International Conference on Technology for Education (T4E), Goa, India, 9–11 December 2019; pp. 186–192.
36. Heintz, M.; Law, E.L.-C.; Andrade, P. Augmented Reality as Educational Tool: Perceptions, Challenges, and Requirements from Teachers. In Proceedings of the Technology-Enhanced Learning for a Free, Safe, and Sustainable World; De Laet, T., Klemke, R., Alario-Hoyos, C., Hilliger, I., Ortega-Arranz, A., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 315–319.
37. Alkhatabi, M. Augmented Reality as E-Learning Tool in Primary Schools' Education: Barriers to Teachers' Adoption. *Int. J. Emerg. Technol. Learn. (IJET)* **2017**, *12*, 91–100. [\[CrossRef\]](#)
38. Arici, F.; Yilmaz, R.M.; Yilmaz, M. Affordances of Augmented Reality Technology for Science Education: Views of Secondary School Students and Science Teachers. *Hum. Behav. Emerg. Technol.* **2021**, *3*, 1153–1171. [\[CrossRef\]](#)
39. bin Salmee, M.S.A.; Abd Majid, F. A Study on In-Service English Teachers' Perceptions towards the Use of Augmented Reality (AR) in ESL Classroom: Implications for TESL Programme in Higher Education Institutions. *Asian J. Univ. Educ.* **2022**, *18*, 499–509.
40. Krein, U. What's Your Take on School Leadership and Digitalization? A Systematic Review of Publications from the Last 20 Years. *Int. J. Leadersh. Educ.* **2023**, *1*–22. [\[CrossRef\]](#)
41. Gittinger, M.; Mulders, M. A Hands-on Seminar Concept to Enhance Acceptance in Future Teachers Using Augmented Reality for Teaching. *Weizenbaum J. Digit. Soc.* **2024**, *4*. [\[CrossRef\]](#)
42. da Silva, M.M.O.; Radu, I.; Schneider, B.; Cavalcante, P.; Teichrieb, V. An Investigation on How Teachers are Using Augmented Reality in Their Lessons. *Braz. Symp. Comput. Educ. (Simpósio Bras. De Informática Na Educ.—SBIE)* **2018**, *29*, 625. [\[CrossRef\]](#)
43. da Silva, M.M.O.; Roberto, R.; Radu, I.; Smith Cavalcante, P.; Teichrieb, V. Why Don't We See More of Augmented Reality in Schools? In Proceedings of the 2019 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), Beijing, China, 14–18 October 2019; pp. 138–143.
44. Jung, Y.J.; Cho, K.; Shin, W.S. Revisiting Critical Factors on Teachers' Technology Integration: The Differences between Elementary and Secondary Teachers. *Asia Pac. J. Educ.* **2019**, *39*, 548–561. [\[CrossRef\]](#)
45. Ko, Y.; Shin, W.S. Exploring Teachers' Intention to Integrate Technology: A Comparison between Online- and AR/VR-Based Instruction. *Technol. Pedagog. Educ.* **2023**, *32*, 537–554. [\[CrossRef\]](#)
46. Ibili, E.; Resnyansky, D.; Billinghamurst, M. Applying the Technology Acceptance Model to Understand Maths Teachers' Perceptions towards an Augmented Reality Tutoring System. *Educ. Inf. Technol.* **2019**, *24*, 2653–2675. [\[CrossRef\]](#)
47. Heeralal, P.J.H. Student Teachers' Perspectives of Qualities of Good Mentor Teachers. *Anthropologist* **2014**, *17*, 243–249. [\[CrossRef\]](#)
48. Rzejak, D.; Küsting, J.; Lipowsky, F.; Fischer, E.; Dezhgahi, U.; Reichardt, A. Facetten Der Lehrerfortbildungsmotivation—Eine Faktorenanalytische Betrachtung [Facets of Teachers' Motivation for Professional Development—Results of a Factorial Analysis]. *J. Educ. Res. Online/J. Für Bild. Online* **2014**, *6*, 139–159.
49. Quellenberg, H. Studie zur Entwicklung von Ganztagschulen (StEG). Ausgewählte Hintergrundvariablen, Skalen und Indices der ersten Erhebungswelle. In *Zusammenarbeit mit dem StEG-Konsortium und den Mitarbeiter/Innen des StEG-Teams*; DIPF & GFPP: Frankfurt am Main, Germany, 2009; 151p.
50. Holzapfel, M.A.; Bakenhus, S.; Arndt, N.; Brückmann, M. Welche Einstellungen Und Werthaltungen Haben Sachunterrichtsstudierende Zum Einsatz Und Lernen Mit AR Und VR? In *Herausforderungen und Zukunftsperspektiven für den Sachunterricht*; Schmeink, K., Michalik, K., Goll, T., Eds.; Julius Klinkhardt: Bad Heilbrunn, Germany, 2023.

51. Müser, S.; Fehling, C.D. AR/VR.nrw—Augmented und Virtual Reality in der Hochschullehre. *HMD* **2022**, *59*, 122–141. [[CrossRef](#)]
52. Tiede, J.; Grafe, S.; Mangina, E. Teachers' Attitudes and Technology Acceptance Towards AR Apps for Teaching and Learning. In Proceedings of the 2022 8th International Conference of the Immersive Learning Research Network (iLRN), Vienna, Austria, 30 May 2022; pp. 1–8.
53. Schmitz, G.S.; Schwarzer, R. Selbstwirksamkeitserwartung von Lehrern: Längsschnittbefunde Mit Einem Neuen Instrument. *Z. Für Pädagogische Psychol.* **2000**, *14*, 12–25. [[CrossRef](#)]
54. Chrobak, A.M. Entwicklung von Online-Trainererfolg in Der Betrieblichen Weiterbildung Durch Die Förderung von Online-Selbstwirksamkeit,-Strategie Und Kohäsion. Ph.D. Thesis, Universität Trier, Trier, Germany, 2004.
55. Zahn, C.; Rack, O.; Mateescu, M. Fit4Digit. Ein Online-Assessment Zur Messung Digitaler Kompetenz in Organisationen. *Z. Für Führung Organ.* **2019**, *2*, 143–146.
56. Lima, C.B.D.; Walton, S.; Owen, T. A Critical Outlook at Augmented Reality and Its Adoption in Education. *Comput. Educ. Open* **2022**, *3*, 100103. [[CrossRef](#)]
57. Malone, S.; Garzón, J.; Kuhn, J. *Three Decades of Augmented Reality in Education: A Second-Order Meta-Analysis and Research Synthesis*. Open Science Framework. 2023. Available online: <https://osf.io/preprints/osf/amw4t> (accessed on 1 December 2024).
58. Pettersson, F. Understanding Digitalization and Educational Change in School by Means of Activity Theory and the Levels of Learning Concept. *Educ. Inf. Technol.* **2021**, *26*, 187–204. [[CrossRef](#)]
59. Kljun, M.; Geroimenko, V.; Čopič Pucihar, K. Augmented Reality in Education: Current Status and Advancement of the Field. In *Augmented Reality in Education: A New Technology for Teaching and Learning*; Geroimenko, V., Ed.; Springer Series on Cultural Computing; Springer International Publishing: Cham, Switzerland, 2020; pp. 3–21, ISBN 978-3-030-42156-4.

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