Teachers’ Attitudes and Technology Acceptance Towards AR Apps for Teaching and Learning

Jennifer Tiede
Institute of Pedagogy
University of Würzburg
Würzburg, Germany
jennifer.tiede@uni-wuerzburg.de

Silke Grafe
Institute of Pedagogy
University of Würzburg
Würzburg, Germany
silke.grafe@uni-wuerzburg.de

Eleni Mangina
School of Computer Science
University College Dublin
Dublin, Ireland
eleni.mangina@ucd.ie

***Abstract*—Teacher attitudes and technology acceptance towards Augmented Reality (AR) are important constructs because their development has an impact on the teachers’ use of AR applications in classroom practice. The present study focusses on these two constructs and analyses them from a theoretical and empirical perspective. In this context, results from a pre-test from the European H2020 project ARETE are introduced. In this study, n=129 teachers from 13 countries responded to an online survey which included questions on demographic data as well as two scales to measure teacher attitudes towards AR and teacher technology acceptance towards AR. The results show a mostly highly motivated sample and very positive attitudes towards AR among the participating teachers. An analysis of correlations and predictors was performed by calculating the Pearson Correlation coefficient and a regression analysis, which indicated that teacher attitudes and technology acceptance towards AR are highly correlated. Additionally, the teachers’ previous experience with AR and, in case of technology acceptance, the self-assessed expertise in using digital media for teaching and learning are significant predictors for the two constructs in question.**

Index terms—Augmented Reality, teacher attitudes, TAM, international research, pilot study, ARETE

I. INTRODUCTION

Teacher attitudes towards any medium are relevant to the successful integration of this medium in teaching and learning processes because they help understanding the teachers’ opinion on the medium in question. Similarly, the well-researched construct of technology acceptance gives valuable insight into the teachers’ predispositions towards using the medium in class. Hence, both attitudes and technology acceptance influence the teachers’ actions in classroom practice. For this reason, it is important to carefully monitor and evaluate teachers’ attitudes and technology acceptance as well as their development when implementing a new medium.

Within the ARETE H2020 project, three different Augmented Reality (AR) apps are piloted in Elementary school classes across Europe. Affirmative teacher attitudes and technology acceptance towards AR are considered a key condition for the successful integration of the AR apps into teaching and learning processes and are therefore monitored closely by means of pre and post online surveys (n=129), along with demographic data and preconditions.

In the following paper, the ARETE research on teacher attitudes and technology acceptance will be contextualized, the scales applied to measure both constructs will be introduced and exploratory pre-test results regarding teacher attitudes and technology acceptance towards AR will be presented. The data allow for conclusions on factors that influence the teachers’ attitudes and technology acceptance.

Overall, the procedure described in the following will provide an important basis for further analysis of pre-test and post-test data and at the same time introduce a methodology for a thorough evaluation of teacher attitudes and technology acceptance within related contexts of AR in teaching and learning or further innovative media offers. The focus is on the methodology of attitude and technology acceptance measurement and on an exploratory analysis of correlations and predictors impacting the results.

Against this background, the following two research questions will be addressed in the following paper:

1) How can teachers’ attitudes and teachers’ technology acceptance towards AR be defined and measured?

2) Which predictors have an impact on teachers’ attitudes and technology acceptance towards AR?

II. STATE OF RESEARCH

A. Teacher Attitudes Towards Augmented Reality

According to related research, AR has the potential to stimulate student motivation and to support learning processes with various benefits [1]–[4]. However, as with any medium, there is a complex network of factors influencing whether its integration into teaching and learning processes will be successful. Among these factors, teacher attitudes play a key role.

There is a long tradition of researching the role of teacher attitudes in educational research. According to Allport [5], they are defined as “a mental and neural state of readiness, organized through experience, exerting directive or dynamic

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influence upon the individual's response to all objects and situations with which it is related". Richardson [6] summarizes this as "predispositions that consistently affect actions". There is empirical evidence that these attitudes towards a medium indeed influence the teachers' technology integration in class as they are a strong predictor for ICT use [7]–[9]. Consequently, it is helpful to understand these predispositions when discussing the integration of a new medium into classroom practice. Yet, most studies concerning attitudes and AR tend to focus on the learners' perspective, i.e. students and preservice teachers in particular [10].

A well-researched instrument in this context is the Augmented Reality Applications Attitude Scale (ARAAS), developed by Küçük *et al.* [11]. It was confirmed in further studies [12] and also adopted to other national contexts [13], [14]. The scale addresses the attitudes of preservice teachers towards the use of AR apps in initial teacher education and differentiates between three dimensions which are "Relevance", "Satisfaction" and "Reliability". However, due to its focus on the preservice teachers' perspectives as learners, it is not ideal for assessing the attitudes of in-service teachers as facilitators and organizers of learning processes; for example, Diaz Noguera *et al.* [13] list the following items that illustrate the focus on the learners' perspective: "AR applications make my learning difficult because they confuse my mind" or "AR has changed my attitude as a student, not only in this module, but generally in all subjects".

Yet, teacher attitudes towards AR have also been assessed repeatedly in related literature. Different foci and methods have been applied: for example, Tzima *et al.* [3] ask in a qualitative study with a small sample of teachers whether teachers would use a specific AR application as teaching tools, whether students would be interested, and whether they would come up against practical issues, and summarize the results on these opinions as "attitudes". Parsons and MacCallum [10] assessed in-service teachers' attitudes towards free AR and VR tools, also applying a non-standardized, self-developed scale without further specifying the scale metrics. Lham *et al.* [15] applied a self-developed scale, reporting its high internal consistency but not elaborating on the scale development or its theoretical foundations. Similarly, Yakubova *et al.* [9] used a non-standardized survey to collect information on the attitudes towards AR and VR of special education teachers.

As these studies show, teacher attitudes towards AR have been measured in current literature but there is a lack of coherent and standardized scales with a thorough examination of scale metrics and predictors. Hence, all the sources examined offer evidence of the perceptions of teachers in specific contexts but are questionable in their theoretical foundation and transferability. This status implies the research desideratum to examine more closely how teacher attitudes towards AR can be defined and measured with a valid approach.

B. Teacher Technology Acceptance Towards AR

The Technology Acceptance Model (TAM) is a well-established model for user acceptance of information systems [16]. Rooted in social psychology, it is considered a valid measure to explain and predict user behaviour for respective technologies [17], [18]. The TAM postulates that a person's attitude toward using a technology depends on the perceived usefulness of the technology and on the perceived ease of use. The resulting attitude leads to a behavioural intention to use the technology, and this intention influences the actual technology use [16].

There are different updates and extended versions of the original TAM and various TAM-based standardized scales to measure the technology acceptance of persons in different contexts. An overview of respective developments, studies and publications in educational contexts can be found in [19], [20].

Against the background of the varieties of contexts for TAM measurement scales, it is noteworthy that instruments for measuring teachers' TAM towards AR are rather scarce. However, the scale developed by Ibili *et al.* [21] measures the technology acceptance of teachers in relation to an AR tutoring system. Based on a broad literature review and a thorough statistical analysis, the resulting scale adds the factors of "Satisfaction", "Anxiety" and "Social Norms" to the original dimensions to capture the construct of technology acceptance in a valid way.

As the literature review reveals, the constructs of teacher attitudes towards AR and technology acceptance towards AR are linked closely. The difference between the two refers to their focus: the construct of teacher attitudes is focussed on the predispositions within a teacher and the teacher's general perceptions about the medium. The survey applied in the following study asks, e.g., whether teachers find AR apps motivating or whether they believe such apps are helpful to support personalized learning. The TAM scale used on the other hand is about the teachers' attitudes towards *using* AR in educational contexts and about concrete intentions to apply the medium, for example in "I plan to use AR apps in the future" or in "Using AR apps is easy for me."

Hence, both constructs of attitudes and technology acceptance are interrelated and complement each other by combining attitudes towards the medium itself and towards using the medium. Based on this differentiation, it appears useful to look at both constructs when evaluating teachers' predispositions towards using the medium of AR in class even though the proximity of both constructs may cause certain overlaps.

III. Methodology

A. ARETE Study Context and Research Approach

In the ARETE project, a comprehensive research approach has been developed to draw valid conclusions on the effects of AR applications in teaching and learning processes both on students and teachers on a European level. There are four different pilot phases in the project with different apps and aims. The following paper refers to selected results from pilot phases 1 and 2. Details on the research designs of both pilots are explained in detail in [22] and [23].

ARETE Pilot 1 is an exploratory study about supporting English literacy attainment of students who underperform in reading and spelling. There are 9 teachers with 34 students from grades 4, 5 and 6 participating in this pilot, which runs from September 2021 to March 2022. These classes are either from Ireland or English-speaking classes from Italy and Luxembourg. Seven intervention group classes, i.e., 26 students, work with an AR-enhanced literacy learning program over a school term on a daily basis. Two classes, i.e., 8 students, form the control group without access to the app between pre and post testing. An additional historical control group will be used for the analysis of pre and post test data at a later stage.

The students' spelling and reading abilities are assessed by standardized pre and post testing. Selected teachers are interviewed pre and post intervention and all teachers fill in an online survey pre and post intervention on demographics, attitudes, technology acceptance and, in the post survey, on their experiences with the app [22].

ARETE Pilot 2 aims to support knowledge acquisition and retention in Mathematics and Science with two AR-enhanced apps. There is one app from the content area of Geometry and a second app about Geography. Students in this pilot are in grades 4 and 5 and come from 11 European countries. Within the school term from September 2021 to March 2022, teachers in Pilot 2 can integrate their app (either Geometry or Geography) into their classes as long and as often as they consider appropriate. There are 120 teachers in the pilot 2 sample who completed the pre survey, teaching approx. 2,400 students. 60 classes are in intervention group, working with the app, and 60 classes are in the control group and do not have access to the app between pre and post testing but teach in their traditional ways.

The students' knowledge gain through the apps is evaluated through standardized knowledge tests in pre, post and retention testing in Pilot 2. The tests are based on the Trends In International Mathematics and Science Study (TIMSS) [24]. Teachers complete the same evaluation steps as in pilot 1: they respond to the same pre and post online survey on demographics, attitudes, technology acceptance and, in the post survey, on experiences with the app [23]. Furthermore, there are interviews and focus groups pre and post intervention for selected teachers from both pilots.

Within this scope of research activities in the ARETE project, the focus for the following analyses will be on the evaluation of pilot 1 and pilot 2 teachers' input from the online survey pre-test.

B. *Scale Metrics*

The online survey used in the pilots includes a scale for measuring teachers' attitudes towards AR and a second scale to measure teachers' technology acceptance towards AR. Additionally, it includes context questions on demographic data and on relevant conditions, as there are the teachers' previous experience with AR, their teaching experience and their self-assessed expertise in using digital media for teaching on learning.

Against the limited background of valid measurement instruments for teachers' attitudes towards AR, a new scale was developed based on the research background of available instruments from related research. Main factors were included that reoccur in related scales, such as the impact of AR apps on student motivation, classroom engagement, learning achievements and its role in teaching and learning activities. Additionally, the game-based learning research background was considered in the scale development process as it is comparatively broad and offers useful parallels [25], [26]. The items were adapted to match the AR context. The final scale consists of 21 items for agreement with statements on a scale from 1 (strongly disagree) to 5 (strongly agree). Examples of items from this scale are "[Apps which include Augmented Reality] are fun for the students", "They help increase content knowledge acquisition" or "They can be used as rewards when students do well in class".

The internal consistency of the scale is very high with a Cronbach's α of 0.93. The discrimination power of all items ranges between 0.38 and 0.77; hence, the items appropriately represent the construct of attitude to be measured.

The second scale is based on the Teacher Technology Acceptance Model (TAM) and thus has a stronger focus on the intention of using AR in class. Given the large variety of available scales to measure TAM, relevant scales were reviewed in the selection process and prioritized with regards to:

1) Validation: the selection of a scale took into account whether the validation procedure was described in the paper and whether the scales had satisfying reliabilities;

2) Target group: scales measuring the technology acceptance of teachers were prioritized;

3) AR reference: scales applying the TAM in studies focusing on AR were prioritized.

On this basis, the scale of Ibili *et al.* [21] was considered most appropriate for the ARETE research and selected dimensions of it were used.

The scale consists of 12 items for agreement with statements on a scale from 1 (strongly disagree) to 7 (strongly agree; 2 reverse items). Two items from each of the following constructs were included: "Perceived Usefulness", "Perceived Ease of Use", "Anxiety", "Attitude", "Behavioural Intention", and "Social Norms".

The original scale by Ibili *et al.* [21] also includes a scale for "Satisfaction", which was not used in the ARETE scale because it refers back to the experience with the Augmented Reality app. Thus, it is not applicable for a pre-testing before respondents could actually make experiences with the apps. The internal consistency of the resulting scale is high with Cronbach's $\alpha = 0.84$. All items have a discrimination power between 0.34 and 0.73. Therefore, all items were confirmed to appropriately represent the construct of technology acceptance.

In related literature, the different constructs described by the technology acceptance model are usually kept separated and analyzed without summarizing them to one score. For the research context within the ARETE project, it was considered useful to work with one score averaged over the different constructs because the focus of the study is not on the validation of a theoretical model but on the evaluation of the teachers' expectations for and experiences with using AR.

Hence, it is necessary to reduce the dimensions to one score of "technology acceptance"; this way, the score can be used as one out of several correleates to be applied in further analyses.

C. *Sample*

The sample consists of 129 participants from 13 countries. There are 95 women (73.6 %) and 34 men (26.4 %) in this group. No person ticked "other / do not want to say". Participants are aged 44 on average (SD 7.1; range: 27–63).

There are 3 teachers (2.3 %) with less than five years of teaching experience and only 14 teachers (10.9 %) with 5 to 10 years of teaching experience. A majority of teachers (112 teachers / 86.8 %) has more than 10 years of teaching experience.

According to their self-assessment, the teachers are very competent in using digital media in teaching and learning. On a scale from 1 (very poor) to 5 (very good), teachers rated their own expertise in using digital media in teaching and learning as 4.3 on average (SD 0.7). There are no teachers estimating their own expertise as "very poor" and only one teacher assessing it as "poor". A majority of teachers rated it as "good" (50 teachers / 38.8 %) or "very good" (61 teachers / 47.3 %).

To quantify previous experiences with AR, a sum score of three related items was calculated. The items were "Have you heard or read about AR?", "Have you used AR in your leasure time?", and "Have you used AR for teaching and learning?". All three could be answered with "no" (0 points), "a little" (1 point) or "a lot" (2 points). Hence, the sum score may range from 0 (no experience with AR at all) to 6 (maximum experience with AR).

The average total AR experience on this scale from 0 to 6 across all participants was 2.3 (SD 1.5). Values achieved range from 0 to 6, showing in accordance with the comparably high standard deviation that the sample is quite heterogeneous in their previous AR experiences: 10 persons are totally inexperienced with AR (7.8 %) and 5 persons indicated maximum experience (3.9 %). However, most teachers tend to be overall less experienced with AR.

All participants are teachers teaching classes 4 to 6. They all applied for participation in the ARETE project voluntarily, hence the sample is a convenience sample. The survey was obligatory to fill in for teachers before starting the pilot.

IV. Results

A. *Descriptive Results*

a) Teacher Attitudes: On a scale from 1 (strongly disagree) to 5 (strongly agree), teachers show most agreement with the following three statements about apps which include AR:

"They are motivating for the students" (mean 4.6; SD 0.6); "They are fun for the students" (mean 4.6; SD 0.5); "They can promote learning in STEM" (mean 4.6; SD 0.6).

Least agreement was achieved for the following three items:

"They bridge the gap between what students do at home and at school" (mean 3.9; SD 0.8); "They can promote literacy skills" (mean 3.9; SD 0.8); "Students are attuned to learning with AR" (mean 3.6; SD 1.0).

The average agreement with the statements concerning teacher attitudes is at 4.2 (SD 0.5), showing that the teachers have overall positive attitudes towards AR. Fig. 1 illustrates this average agreement.

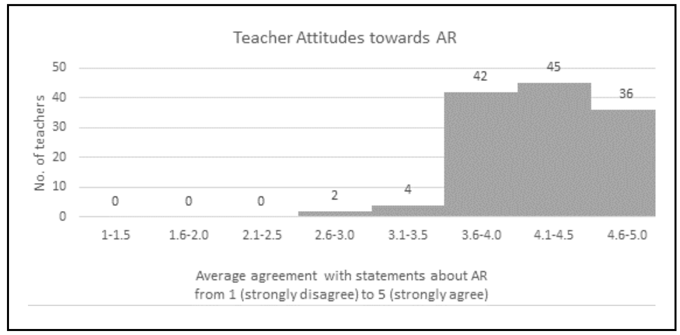

Fig. 1. Average agreement with statements about attitudes.

b) Teacher Technology Acceptance: On a scale from 1 (strongly disagree) to 7 (strongly agree), teachers showed most agreement with the following three statements about using apps which include Augmented Reality:

"It's a good idea to use AR apps" (mean 6.3, SD 0.7); "I plan to use AR apps in the future" (mean 6.3; SD 0.8); "I predict I would use AR apps in the future" (mean 6.2; SD 0.9).

Least agreement was achieved with the following items:

"I hesitate to use AR apps for fear of making mistakes I cannot correct" (reverse; mean 5.3; SD 1.7); "I feel apprehensive about using AR apps" (reverse; mean 5.1; SD 1.7); "I find it easy to get AR apps to do what I want it to do" (mean 5.0; SD 1.3).

The average agreement with the statements on technology acceptance is at 5.7 (SD 0.7). Hence, it can be concluded that the teachers in the sample all in all have quite a high technology acceptance. Fig. 2 shows this technology acceptance.

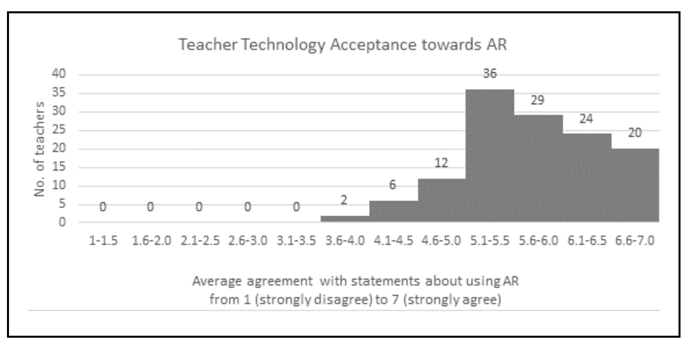

Fig. 2. Average agreement with technology acceptance statements.

B. Correlations

To deeper explore the sample in this study and to achieve an enhanced understanding of the constructs of teacher attitudes and teacher technology acceptance towards Augmented Reality, it is useful to analyse correlations of these constructs and certain predictors. “Gender”, “AR Experience”, “Teaching Experience” and “Expertise in using digital media in teaching and learning” were defined as potentially correlating predictors for the constructs of “Teacher attitudes towards AR” and “Teacher Technology Acceptance towards AR” based on related research findings [8], [21]. Fig. 3 illustrates the bivariate correlations identified in the data by calculating the Pearson correlation coefficient for every pair of variables after checking for significance ($p < 0.05$).

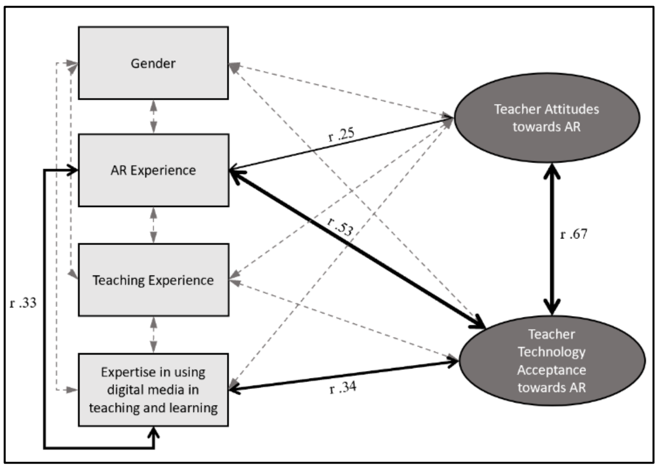

Fig. 3. Correlations between relevant constructs.

As Fig. 3 shows, there is a strong correlation between the constructs of teacher attitudes towards AR and teacher technology acceptance towards AR, $r = 0.67$, $p < 0.001$. There is also a strong correlation between previous AR experience and teacher technology acceptance towards AR, $r = 0.53$, $p < 0.001$. Teacher technology acceptance further correlates with the teachers’ expertise in using digital media in teaching and learning with a medium strong effect, $r = 0.34$, $p < 0.001$. Finally, there is a weak correlation between previous AR experience and teacher attitudes towards AR, $r = 0.25$, $p < 0.01$. Gender and teaching experience do not correlate with the dependent variables nor with any other factors ($p < 0.05$).

C. Regression Analysis

In case of teacher technology acceptance towards AR, two correlating factors were identified, namely “Previous AR Experience“ and “Expertise in using digital media in teaching and learning“. Hence, the roles of these two factors were analysed by means of a multiple linear regression after confirming by a Kolmogorov-Smirnov test that the data is normally distributed ($p > 0.05$).

When defining teacher technology acceptance towards AR as the dependent variable, again “Previous AR experience” and “Expertise in using digital media in teaching and learning” were confirmed to statistically significant predict teacher technology acceptance, $F(2, 126) = 27.68$, $p < 0.001$. Their standardized coefficient β is 0.47 in case of “Previous AR experience” and $\beta = 0.18$ in case of “Expertise in using digital media in teaching and learning”. It was confirmed that there is a low risk of collinearity of the predictors (all VIF values < 1.2). Also, the Durbin-Watson statistic revealed an acceptable level of 2.19, indicating that there is no autocorrelation. The R^2 of 0.31 indicates that 31 % of the teachers’ technology acceptance towards AR can be explained by the predictors analysed ($p < 0.001$). According to Cohen [27], the R^2 of 0.31 (adjusted $R^2 = .29$) is indicative for a high goodness-of-fit for the overall model.

The coefficients confirm that the previous AR experience has a bigger impact on the teacher technology acceptance, as it is approx. 2.6 times as high as the impact of expertise in using digital media in teaching and learning. Overall, it can be concluded that the higher a teacher’s previous experience with AR and his or her self-assessed expertise in using digital media in teaching and learning is, the higher his or her technology acceptance towards AR will be.

V. Discussion

With regards to the two research questions stated above, it was possible to develop or adapt and apply two scales for measuring teachers’ attitudes and teachers’ technology acceptance towards Augmented Reality and to validate their high internal consistency by the methodology introduced. In this context, “teachers’ attitudes towards AR” are understood as predispositions within a teacher and the teacher’s general perceptions about the AR medium while “teachers’ technology acceptance towards AR” is about the predispositions towards *using* AR in educational contexts and about concrete intentions to apply the medium.

In the analyses, it was found that a teachers’ AR experience and technology acceptance correlates with his or her attitudes towards AR and that “AR experience” and “expertise in using digital media in teaching and learning” are significant predictors for his or her technology acceptance towards AR.

Before discussing these findings, it is important to acknowledge certain limitations to the study. Centrally, the sample is a self-selecting convenience sample because teachers applied voluntarily to take part in the ARETE study on AR. Hence, the sample does not represent the overall average of teachers; instead, these teachers can be expected to have a higher interest in educational technology and Augmented Reality. Their voluntary participation in the pilots further implies a high motivation to explore new technologies and innovative practices. The very positive results for attitudes and technology acceptance in the pre-test, where teachers did not work with the AR intervention apps yet, prove that this group of participants is quite attuned to this innovative medium even though their previous experiences with it tend to be limited.

This high degree of homogeneity within the sample also shows in the low variety of teaching experience. The sample is mostly quite experienced and results, especially from the analysis of correlations, might look different in a more heterogeneous sample.

Furthermore, the survey of teacher attitudes and technology acceptance towards Augmented Reality is based on self-assessments. For the interpretation of results, it should be kept in mind that self-assessments may be biased and prone to confounding factors such as subjectivity and social desirability. Yet, they appear most suitable to collect data efficiently and anonymously from all teachers in this pilot context.

For the interpretation of the analyses, it is also important to take into account that the data come from 13 different countries. They may not be completely independent but have a nested structure. This cannot be confirmed here with the teacher data due to the very heterogeneous group sizes of teachers per country and the overall sample size. It will be considered though in the post test analysis of student data at a later stage, where the sample size allows for respective multi level analyses.

With regards to the descriptive results outlined above, the remarkably positive attitudes can be explained by the composition of the sample as described in the limitations. Within this frame, certain results stand out. First, it is noteworthy that the characteristic "AR apps can help promote STEM skills" was one of the items with the highest agreement while "AR apps can help promote literacy skills" was one of the items with the lowest agreement. In the ARETE project, AR-apps from the fields of STEM as well as literacy acquisition will be tested in pilots. However, 120 out of 129 teachers are involved in the pilot focussing in the two STEM apps. Therefore, it is likely that the teachers in the sample are more knowledgeable about AR and STEM and show respective expectations and attitudes. Against this background, it will be particularly relevant to look at the success of AR in literacy acquisition in the ARETE pilot study and in other related studies.

With regards to technology acceptance, the three items with the highest agreement refer to the domains of attitude and behavioural intention [21]. This focus is expectable, given the point in time right before the pilot where teachers are applying Augmented Reality apps. The three items with the lowest agreement are from the domains of anxiety and social norms. This could hint at uncertainties with the teachers regarding the use of AR, especially against the background of their relatively limited previous experience with AR. However, also these values are clearly on the side of agreement and thus do not show a descrepancy from the overall positive technology acceptance measured.

The correlations investigated are insightful on different levels, and it makes sense to have a closer look both at the correlations which are not significant and at those that are. With regards to non-significant correlations, the results show that gender and teacher attitudes and gender and teacher technology acceptance do not correlate, meaning that the gender does not have a statistically relevant impact on the result of attitudes and technology acceptance. Similarly, the teaching experience of the participants does not correlate with the two constructs in question. As Pozas and Letzel [8] summarize, the impact of gender on ICT-related constructs has been described with mixed results in related research; according to the established ICILS study, there are no general differences in the attitudes towards ICT of female and male teachers [28]. Hence, the results from this study confirm respective research results that the teachers' attitudes and technology acceptance do not depend on the teachers' gender.

With regards to significant correlations, it is expectable that teacher attitudes and teacher technology acceptance towards AR are strongly correlated, given the close relationship between the two constructs outlined above. In the network of relationships displayed in Fig. 3, previous AR experience plays a key role. It correlates both with teacher attitudes and teacher technology acceptance. The regression analysis conducted confirms that previous AR experience functions as a predictor for technology acceptance. As explained above, the sum score of "previous AR experience" consists of three items, namely "Have you heard or read about AR?", "Have you used AR in your leisure time?", and "Have you used AR for teaching and learning?".

Based on these results, it can be concluded that increasing opportunities for teachers to try out and use AR, be it in their leisure time or in professional contexts, will have a positive impact on their attitudes and technology acceptance towards AR, which in turn is expected to have a positive impact on the success of the apps use in class. This finding supports claims from related literature to enhance opportunities for teachers to engage with the innovative medium of AR [8]. Similarly, it appears useful to enhance opportunities for teachers to increase their expertise in using digital media in teaching and learning.

These conclusions are in accordance with the broad field of research on the media-related educational competencies, or digital pedagogical competencies, of teachers. Research has shown in various studies how classroom practice and teaching and learning processes benefit from enhanced respective competencies [29]–[31]. Also according to the Education and Training Monitor [32], teachers need to be equipped with the necessary skills to take advantage of the potential of digital technologies to improve teaching and learning and to prepare their students for life in a digital society. Although frameworks have been in place to address the role of teachers in the digital technology inclusion in educational systems (DigCompEdu European Digital Competence Framework for Teachers [33] and Common Framework for Teaching Digital Competence [34]), uneven ICT skills among teachers became more apparent during the COVID-19 school closures, even though from the data analysis in this paper the teachers show an acceptance for the AR technology.

Hence, the present study adds another facet to this desideratum to support teachers with enhancing their competencies in using digital media for teaching and learning by describing how these competencies can also contribute to teachers' technology acceptance towards AR and thus facilitate the success of integrating this innovative medium into teaching and learning processes.

Against the background of these pre-test findings introduced, it will be insightful to relate the findings to those from the post-test. Given the correlations and relationships of factors identified, it will be relevant to investigate whether, for example, the role of AR experience can be replicated and thus confirmed, or whether other factors come into play in the post test. Eventually, the comparisons of pre and post-test data, based on the data analysis of pre-test results, will bring to light the role of teacher attitudes and technology acceptance towards AR.

In the ARETE project, this knowledge will be contextualized with the results of student knowledge tests. This way, it will be possible not only to analyse the development of teacher attitudes and technology acceptance from pre-test to post-test, but also to draw conclusions on its impact on students' results. This research will ultimately contribute to an enhanced understanding of factors that facilitate a successful integration of AR into teaching and learning processes.

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