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ARETE – DELIVERABLE (D6.8)

WP 6 – Report on Evaluations for Pilot 4

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 856533

Deliverable number:	D6.8
Due date:	Feb 2023
Nature[1]:	R
Dissemination Level:	PU
Work Package:	6
Lead Beneficiary:	OU
Beneficiaries:	All ARETE partners

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Nature:
R = Report, P = Prototype, D = Demonstrator, O = Other
Dissemination level
PU = Public
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Document History

Version	Date	Description
0.1	7/10/2022	First Draft
0.2	7/02/2023	Second Draft
0.3	23/02/2023	D6.8 for consortium review

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Table of Contents

Executive Summary

This document reports on the evaluation of Pilot 4. This includes a summary of research methods and corresponding data, which features the most significant insights for this pilot. Pilot 4 aimed to accelerate the uptake of AR in education by providing an authoring tool and learning management system to teachers: it also seeks to evaluate the state of development of the authoring tool and assess how it helps teachers in designing specific XR-enabled tasks and associated XR learning experiences that support their students to learn.

Pilot 4 recruitment of teachers took place in May and June 2022 (M31 and M32). Teachers' onboarding and training as well as the pre-experience data collection were carried out between June and July 2022 (M32 and M33). Pilot 4 deployment with teachers' usage of the MirageXR toolkit took place in July and August 2022 (M33 and M34), whereas the post-experience surveys and post-experience interviews were carried out between August and September 2022 (M34 and 35).

In line with the ethical guidelines established by the External Ethics Advisory Board, prior to their selection, teachers were informed about the goal and scope of Pilot 4 via an information sheet (see Annex 1). In addition, participants were required to sign an ad-hoc consent form (see Annex 1) to be allowed to take part in the study.

Pilot 4 data was collected from the pre-experience and post-experience surveys, as well as the interviews. Detailed information on ARETE Pilot 4 data flow and storage is included in Annex 2 (data flow diagram) as well as Annex 3 (Record of Processing Activities).

1 Introduction

The technical work behind Pilot 4 aims specifically at accelerating the uptake of AR in education by providing an authoring tool and learning management system integration to teachers. The pilot seeks to evaluate the state of development of the authoring tool and viewer and assess critically – both quantitatively and qualitatively – in what ways and how well the tool ecosystem supports teachers in designing specific XR-enabled learning tasks and associated XR learning experiences.

The implementation of Pilot 4 is organized as follows:

1. Teachers were recruited via (a) the Scientix Network[2] EUN's network of ministries of Education, (c) one open call[3] launched through social media and (d) teachers' education programmes at consortium partners.
2. Teachers are onboarded, and Pre-experience surveys are conducted.
3. Teachers are trained via the ARETE moodle[4]
4. Teachers designed an XR learning experience of their own and share it via the ARETE Moodle Platform[5].
5. Additional face to face-workshops were conducted, presenting the toolkit to a wider target group of teachers and students who fill in paper and pencil-surveys.
6. Post-experience surveys and interviews were carried out.
7. The data analysis was conducted.

This deliverable reports on the findings from Pilot 4, conducted within the framework of Work Package 6 (WP6). It, however, also briefly reiterates information on the recruitment of teachers, as well as their onboarding and training.

This report addresses mainly the evaluation of data. The following subsections report on the types of data generated, research questions applied to the study, detailed information about the teacher's demographics, pre-post survey data, a detailed evaluation of participants' expectations and attitudes. This report also offers details about the teachers' technology acceptance, evaluating the teacher's cognitive process when using the authoring tool. Finally, the closing sections of this report offer full analysis and evaluations of the pedagogical underpinning of pilot 4, and the barriers and limitations of the pilot.

[2] http://www.scientix.eu/home

[3] https://www.surveymonkey.com/r/ARETE_OC_Pilot_4

[4] https://arete.ucd.ie/login/index.php

[5] https://arete.ucd.ie/login/index.php

2 Pilot 4 Data: Types and formats of data generated

Table 1 reports on the five main data collections available from Pilot 4, explaining their provenance, data types and storage formats.

Table 1 Types and formats of data generated for pilot 4

Pilot	Types and formats of data generated / collected
Pilot 4	In pilot 4, data were collected from five sources: 1) Survey data 2) Interview data 3) Product data 5) Log data
	1) Survey Data: ● **Tabular survey data:** Survey data were collected from teachers 'pre- and post-intervention' with the online survey tool SurveyMonkey and exported, stored in suitable formats such as SPSS files or .csv/.xlsx files and analyzed descriptively using SPSS and R. The survey data are anonymous as no personal data are collected which could be used to identify individuals.
	2) Interview Data ● **Transcripts:** In addition to the surveys, online interviews were conducted by UNW and UDUR with a convenience sample of n=11 participants. The interviews were realized as online interviews, using the online web-conferencing tool MS Teams organized by EUN. The interviews were recorded by EUN, shared with UNW and UDUR, transcribed by UNW and UDUR in an anonymized format, and by a qualitative - thematic analysis. Recordings are deleted after analysis; only anonymized transcripts are stored.
	3) Data generated from paper and pencil survey ● **Additional tabular survey data from outreach workshops:** The MirageXR toolkit was also presented to teachers and students in additional face to face-workshops. In this context, data were collected from students in pen and paper surveys, which were digitalized and analyzed in the format of SPSS data.
	4) Data from the designed AR learning activities ● **ARLEM files:** Some, but by far not all, trial participants uploaded their learning experience archive produced to the ARETE server. These archives are stored in IEEE P1589-2020 ARLEM format, which includes

	two JSON arrays for activity and classroom environment, and includes all the media asset files for the produced AR learning experiences. ● **Design artefacts:** Many pilot participants shared on the pilot training course, as part of the scheduled activities, design artefacts to obtain feedback by other fellow teachers. This included posting an empathy map about the learners they target, a problem statement for the learning experience to be created, an activity map that maps out where the action happens, and an augmentation plan, devising which media types (aka 'augmentations') are planned to be used in which action step. These design artefacts are stored in the training course forum, typically as png.

3 Evaluation introduction and research questions

The research methodology for the evaluation in Pilot 4 has been designed with an interdisciplinary focus, combining the research perspective of both Human Computer Interaction (HCI) and educational research.

From the HCI perspective, the following research interests are addressed:

1. What do teachers experience in their user journey from interacting with the training material to actual deployment of the MirageXR app for preparing learning content?
2. What improvement suggestions do teachers identify based on their interaction experience with the MirageXR app?

From the perspective of educational research, the following research questions are addressed:

1. How do teachers evaluate their experiences with the MirageXR toolkit?
2. Which impact do teachers expect on teaching and learning processes when using an AR toolkit to create their own learning experiences?

In order to explore these questions, the research methodology builds on a mixed methods approach with qualitative and quantitative measures applied before the start of the intervention and afterwards, without a control group. The main target group for these research activities is a convenience sample of teachers who volunteered to fully participate in the ARETE Pilot 4 study (cf. *Section 4*). Additionally, participants of further MirageXR-related workshops filled in either both surveys or the post survey only.

Measures applied to include online surveys that were filled in pre- and post-intervention (cf. *subsection 5.1*), online interviews with selected participants (cf. *subsection 5.1.2*), and paper and pencil surveys for students (cf. *Section 6*). In the following, the research instruments are presented, the implementation is described, and the results are summarized.

4 Teacher surveys

Pre- and post-surveys were conducted to assess relevant personal prior experience, expectations, experiences, and opinions in a systematic and effective way both from the perspectives of educational research and HCI research. The surveys were designed as online surveys making use of the "SurveyMonkey" online survey tool. Participation was voluntary and entirely anonymous, meaning that participation was tracked only country-wise and not per person. In favour of a rigorous data and privacy protection strategy and against the background of the limited timeframe for the intervention, participants did not receive a personalized ID. This approach enhances acceptance and simplifies the data privacy policies; at the same time, it means that comparisons from pre- to post-survey results can be done groupwise only and not individually, which is acceptable for the research purposes in Pilot 4.

Participants were asked to fill in the pre-survey before they started working with the training materials and the app and were reminded to fill in the post survey after the intervention phase, i.e., the time they were supposed to work with the MirageXR toolkit. As in the whole Pilot 4, teachers could work on the surveys independently and in accordance with their own schedules.

In the analysis of survey responses, the data collected were summarized descriptively. Open inputs were analyzed by a qualitative content analysis using an inductive coding approach (cf. Mayring, 2014) based on the responses: to achieve a summary of the input given, the responses were first coded by inductively developed codes and then grouped with regard to their focus. Statements could be related to more than one code and category. The numbers in brackets indicate the number of codes assigned to this category.

4.1 Pre-Surveys

4.1.1 Methodology

The pre-experience survey includes questions about demographics, relevant previous experience, expectations for the pilot study, and attitudes towards AR.

The items on **demographics** start with a single choice-item about participants' gender, an open question regarding their age, and a single choice-item about their country of residence to collect basic information about the sample. In the following, a single-choice item is used to quantify the years of teaching experience into four categories ranging from "no experience" to "> 10 years of experience". The participants' school form and subjects are assessed by multiple choice-items to further clarify the pedagogical backgrounds participants bring along, including the option to explain their own background by open input.

The level of expertise in using digital media and the previous experience with AR in different contexts are important predictors for the teachers' attitudes towards AR and/or their technology acceptance towards AR, which in turn have an impact on the integration of AR into classes (Tiede, Grafe & Mangina, 2022; Xue, Sharma, and Wild, 2019). Hence, they are

also included in the pre-survey as indicators of **relevant previous knowledge**: The level of expertise in using digital media is assessed by a 5-point Likert scale ranging from 1 (very poor) to 5 (very good), and the previous experience with AR is assessed by 4 related single choice-items. These four questions serve to capture the experience in different contexts (heard about AR, use in leisure time, use for teaching & learning, use for content creation) on a scale from 0 ("no / I don't know") to 2 ("Yes, 5 or more times in the last 3 months"). These four questions are conditional and individualized, meaning that e.g., teachers are only asked to describe their experiences with creating AR-enhanced teaching and learning scenarios when they confirm having created such experiences in the past.

An additional open question asked for a summary of what AR means to the participant in one sentence. This additional question was asked to enable us to understand how participants interpreted the term "Augmented Reality", which could cover a range of meaning, depending on individuals' experience and exposure to AR. Two items on **user expectations** are included in the pre-survey: one open item asks for a one-sentence summary of the users' expectations, while the expected ease of use of the toolkit is assessed by a 5-point Likert scale ranging from 1 (very easy) to 5 (very difficult).

Teacher attitudes were measured with a scale which has been developed based on instruments available from the related research. It includes central dimensions 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 (Tiede et al., 2022). The scale consists of 21 items that require self-assessment of statements on AR for teaching and learning on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree; cf. ibid.). As it is the case with all items in pre- and post-surveys, there are no right or wrong answers, but subjective feedback and input is required.

In previous exploratory analyses from Pilots 1 and 2, the scale of teacher attitudes reached a very high internal consistency with a Cronbach's α of 0.93. The discrimination power of all items ranges between 0.38 and 0.77; hence, the items can be accepted to appropriately represent the construct of teacher attitude towards AR (Tiede et al., 2022)

4.1.2 Results

Demographics

Overall, N=135 responses were collected in the pre-survey. The adjusted sample of complete responses includes n=116 teachers from 21 countries (83 females, 33 males; aged 46.8 on average, SD 7.0). **Countries** with the highest participation in the pre-survey are Greece (22), Romania (15), Italy (11), Turkey (9), Spain (7), and Portugal (7).

According to the pre-survey, a clear majority of teachers are **very experienced** and have more than 10 years of teaching experience (cf. Fig. 1). There were no preservice teachers or teachers without any experience in the sample.

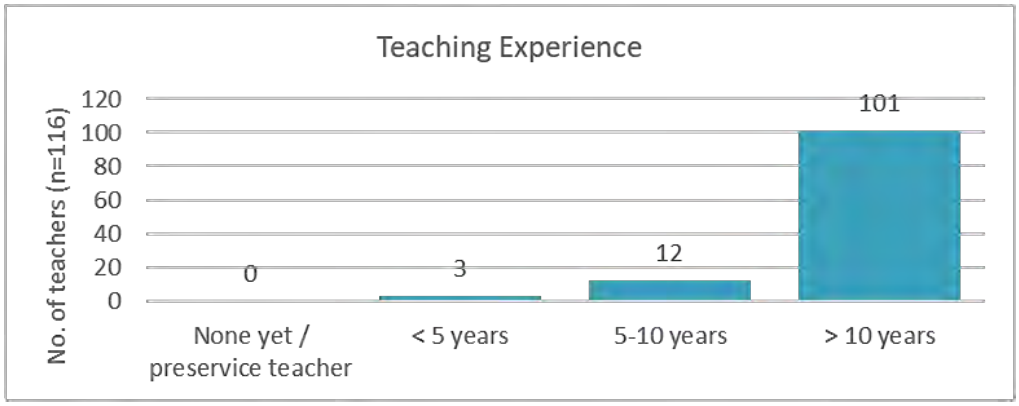


Figure 1 Teachers' teaching experience according to pre-survey

Most teachers teach in secondary (84 / 72.4 %) or primary (33 / 28.4 %) schools. Other institutions include Higher Education (18 / 15.5 %) and preschool/kindergarten (5 / 4.3 %). N=3 Persons (2.6 %) explained another context in an open text field: “Adult Education/ Teacher Training”, “Kindergarten + ICT Teacher Education”, and “Vocational Training”.

A majority of the teachers teach **STEM subjects**. As displayed in Fig. 2, a number of further subjects are also mentioned in the pre-survey:

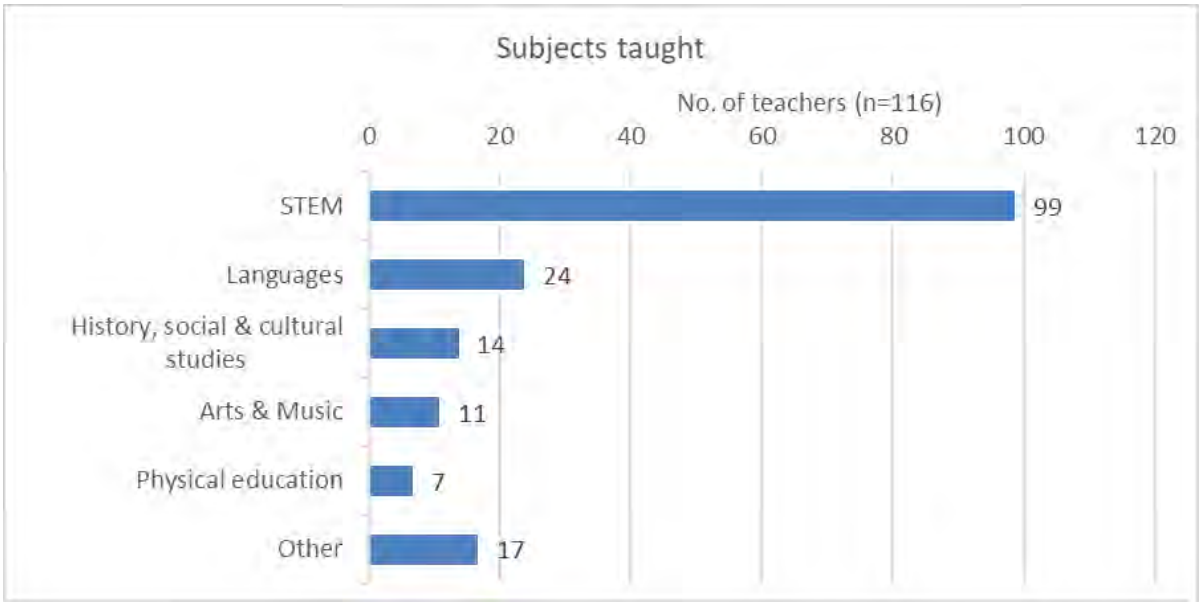


Figure 2 Subjects taught by educators according to pre-survey

The open responses given for “other” subjects list:

- Computer Science / ICT (6 / 5.17 %),
- Primary school subjects (4 / 3.45 %),
- Laboratory of competencies / skills (2 / 1.72 %),
- Biology (2 / 1.72 %),
- Environmental / Health Education (1 / 0.86 %),
- Home Science (1 / 0.86 %),
- Kindergarten curriculum (1 / 0.86 %).

Relevant previous experience

Teachers rated their level of **expertise in using digital media for teaching and learning** as quite high: on a scale from 1 (very poor) to 5 (very good), the average score was 4.6 (SD .6), which shows a high self-confidence in the respective competencies (cf. Fig. 3).

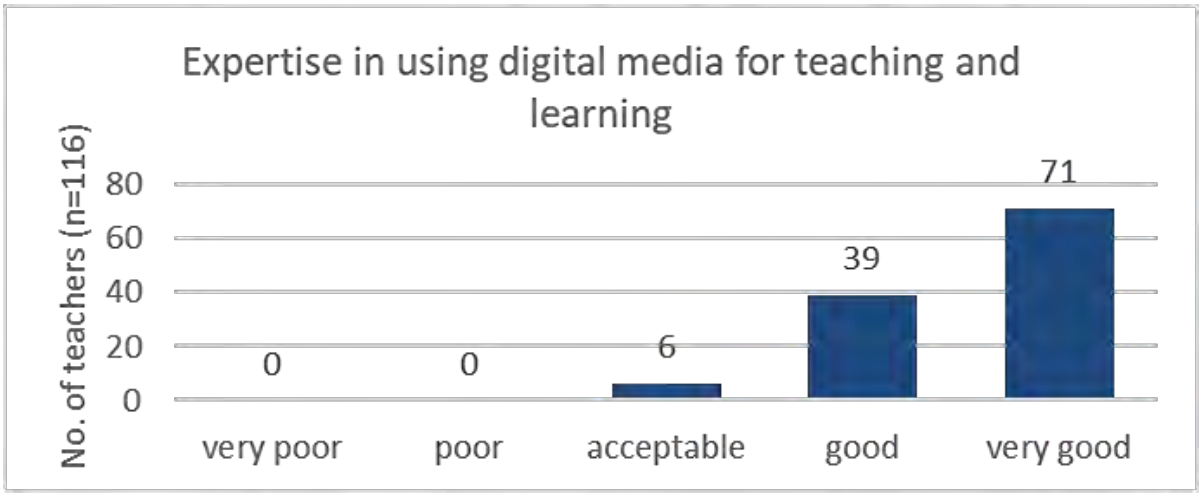


Figure 3 Self-Assessed expertise in using digital media for teaching and learning according to pre-survey

Teachers were also asked to specify their **previous experience with AR** in four items. The results are summarized in Figure 4:

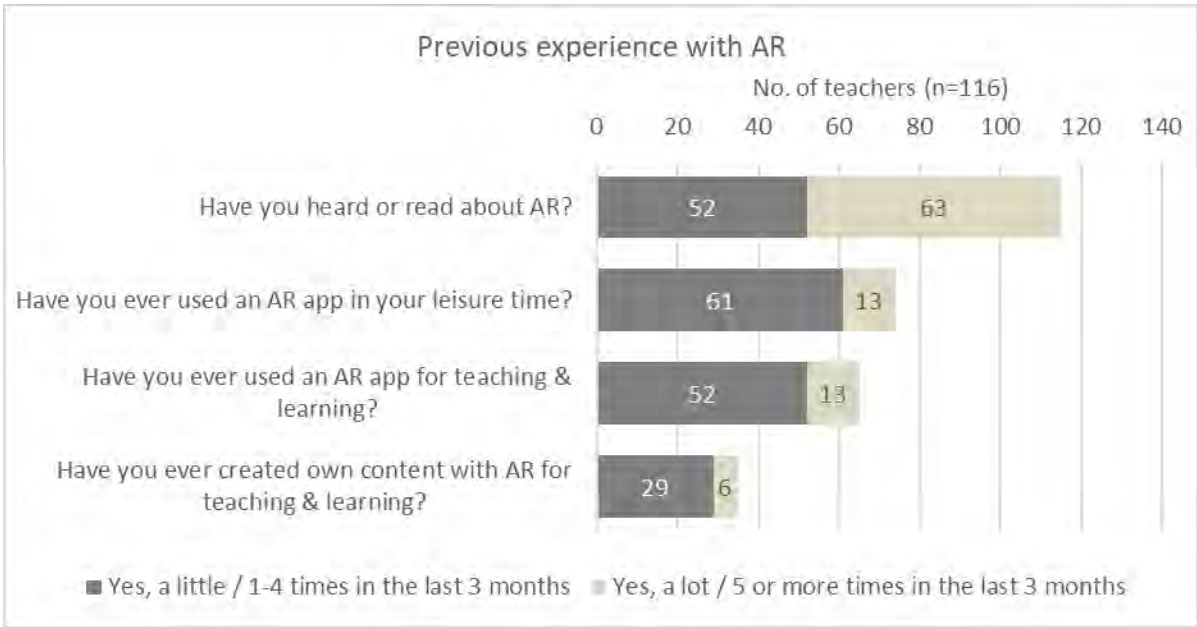


Figure 4 Teachers' previous experience with AR according to pre-survey

When the teachers were asked to summarize in one line about what augmented reality means to them, the teachers explained their positive or very positive feedback as follows.

Positive

- "To enrich the "reality" with digital content."
- "Augmented Reality allows adding objects to a real context when viewed through a smartphone or tablet
- "An interactive experience between the physical world and the virtual world"
- "A different way to see the digital tools that we can use in the pedagogical procedure"

Very Positive:

- "Something new and useful to learn"
- "To revive any content and make it interesting"
- "With Augmented Reality lessons can become more interactive, because AR can enable teachers to show virtual examples of concepts as well as add gaming elements to provide textbook material support."
- "Being able to see or enjoy a digitally supported experience that provides additional information and experience. For instance, using QRC, layer, or VR goggles"
- "Development of the new world"

The participants' responses seem to indicate that they are open to digital technology and very interested in deploying it for teaching and learning.

In a close-ended question the teachers(n=116) were asked about how easy they think it will be to use the AR toolkit to create their own AR content, most of them replied (n=61) with an option as neither easy nor difficult. The participants' feedback shows that they are willing to use the AR toolkit to develop their own content and use it for teaching and learning purpose.

Expectations

With an open question, teachers were asked to describe their **expectations** for the pilot study in one sentence. The following main expectations for the pilot study were identified in the qualitative content analysis:

1. Expectations with regard to *pedagogy and educational value* (92): Teachers described that they expect to learn how to use the toolkit (or AR in general) for educational purposes (44). They also wanted to improve their own teaching methods (18), to discover a new resource for teaching (17), and to engage students and enhance student learning (13).
2. Expectations with regard to *technology skills* (46): Statements in this category describe that teachers wanted to develop their own digital or AR-related skills, competencies, and knowledge (23). Furthermore, they expected to create an own AR learning experience or own AR content (16), try out a new tool or discover something new in general (4), or learn how to operate the MirageXR toolkit (3).
3. Expectations with regard to the *overall pilot experience* (23): Some statements were comparably general in their focus and showed that teachers expect learning and acquiring new or enhanced knowledge on a general level (12), that they are looking forward to a fun, interesting and new experience (9) and that they are hoping for a new inspiration, new ideas and new resources (2).
4. Expectations with regard to *collaboration and a social focus* (8): A number of teachers prioritized a social focus in their responses and described that they wanted to acquire skills and knowledge to pass these on to colleagues (3), to share information with their students (3), and to exchange with each other (2).

The definition of expectations was amended by a **rating of the expected ease of use**: teachers were asked how easy they think it will be to use the AR toolkit to create their own AR content on a scale from 1 (very easy) to 5 (very difficult). The average rating was 2.64 (SD .73). The results are shown in Fig.5:

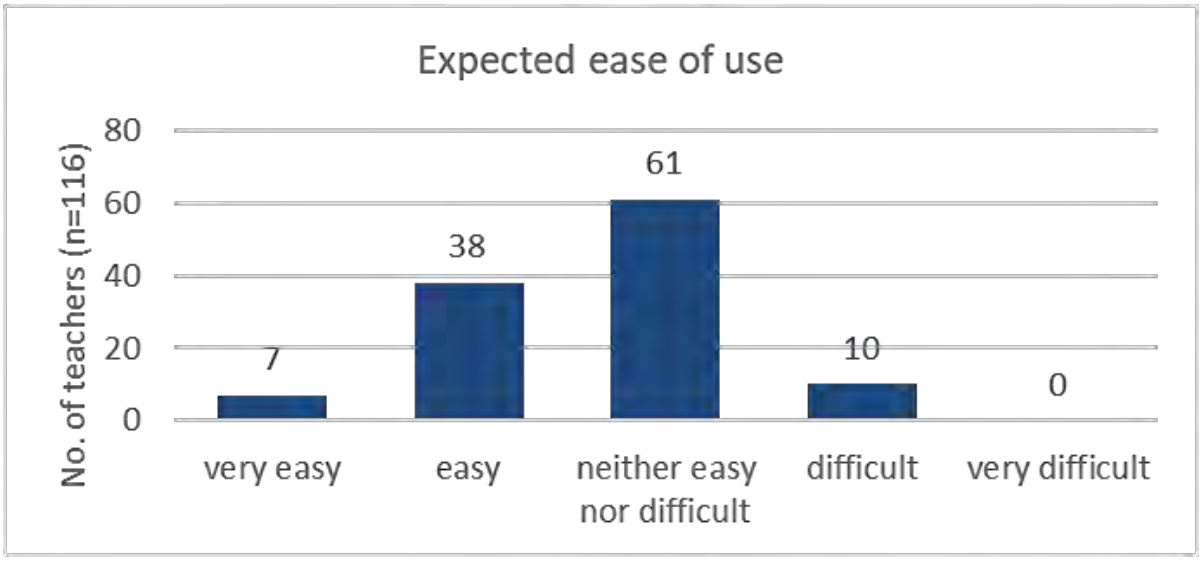


Figure 5 Expected ease of use according to pre-survey

Attitudes towards AR

The findings related to teachers' attitudes towards AR prior to the intervention are illustrated in Fig.5, in detail. Overall, teachers showed rather positive attitudes, with an average rating of 4.20 (SD .60) on a scale from 1 (strongly disagree) to 5 (strongly agree). Only 1 out of 116 teachers in the pre-survey gave an average rating of below the medium value of 3.

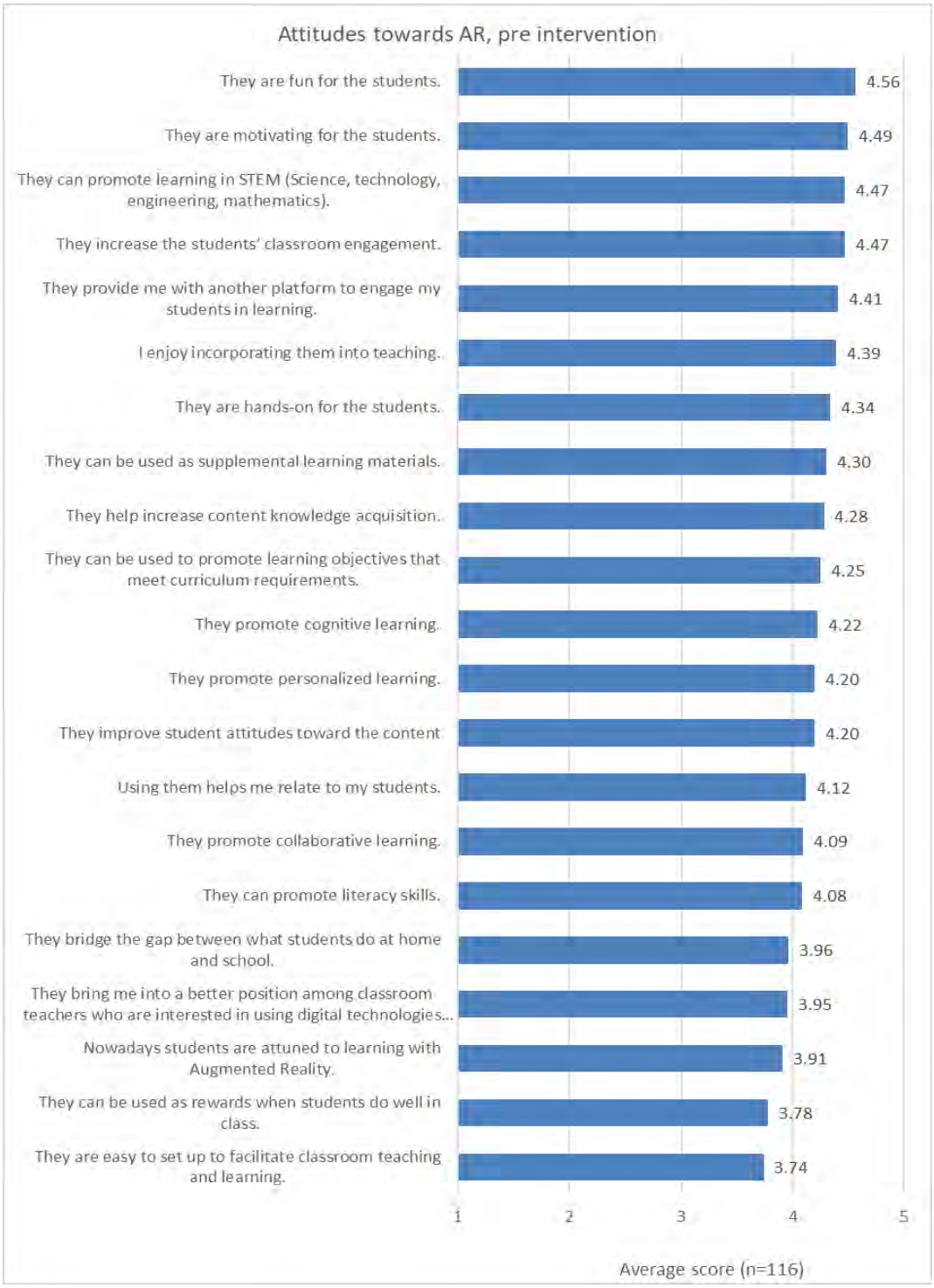


Figure 6 Teachers' attitudes towards AR according to pre-survey

In general, the responses showed that most participants had a positive outlook about the use of AR and other digital technology in education. The majority thought that AR could

support the creation of different solutions. The one-line response provided by the participants can be further divided into different categories of their understanding of AR before the use of Mirage XR app.

The participants' responses about the AR suggest that they are very motivated to use the AR toolkit for teaching.

Table 2 Categories of participants' interpretations of Augmented Reality

Category	Response by Participants
Creative and Engaging	"Augmented reality is used to enhance natural environments or situations and offer perceptually creative experiences." "It is creating an experiment using virtual media and virtual tools which can amplify the learning experience. It is extremely easy and engaging.
Inspire and motivate	"Star Trek generations in present" "Future" "It inspires and motivate students" "Development of new world"
Experience	"Extended Reality, add value to future "To enrich reality with real content" "Real world seen virtually"

Technology	"It means good preparation for the future with digital adaptability"
	"A way to infer reality through technology"
	"A different way to see digital tools"

4.1.3 Conclusion from the pre-survey

The pre surveys show that the sample of teachers who were recruited for ARETE pilot 4 shows a large variety in national backgrounds. With regard to professional practice, most teachers are quite experienced in teaching. There is a majority of STEM teachers and of secondary school teachers. In comparison with related research findings, these teachers are more experienced with using Augmented Reality than average teachers described in other studies (Tzima, Styliaras, & Bassounas, 2019; Pasalidou & Fachantidis, 2021; Yakubova et al., 2021). Their attitudes towards AR in teaching and learning are clearly positive on average.

4.2 Post Survey

4.2.1 Methodology

The post survey[6] included items about demographics, relevant previous experience, teacher attitudes and technology acceptance, the AR learning activity designed, and an evaluation of experiences.

In favour of groupwise pre- and post-comparisons, the post survey replicated most of the pre-survey items about **demographics** and **relevant previous knowledge**; however, the open questions on experience and both items on expectations for the pilot study were excluded because they refer to expectations participants had before working with the application. Also, the integration of questions about the experiences made with the MirageXR toolkit was prioritized for the post survey.

In addition to the **teacher attitude** scale used in the pre-survey, the **TAMARA** scale (Guest et al., 2018; Wild et al., 2017) was included to measure teachers' technology acceptance towards AR after having used the MirageXR toolkit. TAMARA (Guest et al., 2018; Wild et al., 2017) is a new metric scale for assessing technology acceptance of users for Augmented Reality technologies. It branches off earlier technology acceptance models (like TAM-3 and UTAUT2) but extends these existing models with items specific to, e.g., technology fit, learnability, and integration with other relevant information systems. TAMARA is a structural equation model, which can explain relations between groups of constructs, also providing a quantification of influencing factors (ibid.). The TAMARA scale includes 21 items for self-assessment of agreement on a scale from 1 (strongly disagree) to 5 (strongly agree).

[6] The post-experience survey is available at: ARETE Pilot 4_Teachers Post Survey.pdf

With regard to the **AR learning scenarios the teachers designed during the pilot study**, the following six questions were included in the post survey to contextualize the teachers' opinions and to learn more about the applicability of the toolkit for different contexts and purposes:

- An open question about the number of hours spent to design the AR learning activity
- A multiple choice-item about the target school level of the AR learning activity
- A multiple choice-item about the target subject of the AR learning activity
- An open question to summarize in one sentence what the AR learning activity is about
- A multiple choice-item about the cognitive processes that could be addressed by the AR learning activity (based on Bloom's established taxonomy (1956) in its revised version by Anderson & Krathwohl, 2001).
- A multiple choice-item about the potential main objectives of using the AR learning activity in class

Furthermore, six questions aimed to assess the teachers' **evaluation of their experiences made with the toolkit**:

- One rating of the overall experience with the AR toolkit on a scale from 1 (poor) to 5 (excellent)
- A single-choice assessment of the ease of use on a scale from 1 (very easy) to 5 (very difficult)
- A single-choice assessment of the fulfilment of expectations on a scale from 1 (expectations not met at all) to 5 (expectations greatly exceeded)
- An open question to explain in one sentence why the expectations were met or not
- A multiple-choice item about problems and drawbacks encountered when working with the app
- A scale about the usability of the toolkit

The standardised HARUS (Handheld Augmented Reality Usability Scale; Santos et al., 2015) was used as the scale for assessing the perceived usability of the toolkit. The HARUS scale consists of two sub-scales, namely the comprehensibility scale and the manipulability scale. Each sub-scale consists of eight statements to identify perceptual and ergonomic issues by asking users to indicate their level of agreement or disagreement on a Likert scale from 1 (strongly disagree) to 7 (strongly agree).

4.2.2 Results

Demographics

In the post-experience survey, n=81 responses were collected in total. The adjusted sample of teachers completing the survey includes n=64 participants from 18 countries (44 females, 20 males; aged 47.2 on average, SD 7.0).

Countries with the highest participation in the post survey are Greece (13), Romania (10), Turkey (8), Italy (7), Spain (6), and Portugal (5). Further countries listed by 2 persons (3.1 % each) are Croatia, North Macedonia, and Serbia. Countries mentioned by one person (1.6 % each) are Azerbaijan, Bulgaria, Cyprus, Czechia, Hungary, India, the Netherlands, Republic of Moldova, and Slovakia.

A clear majority of the sample are **very experienced** and have more than 10 years of teaching experience (cf. Fig. 7). Again, there are no preservice teachers or persons without any experience included in the sample.

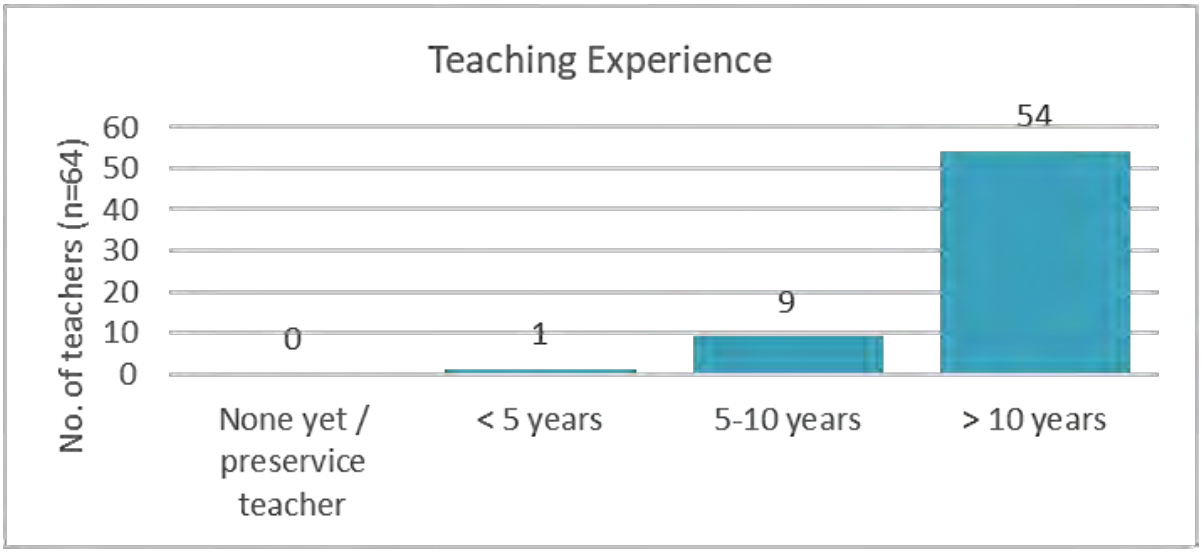


Figure 7 Educators' teaching experience according to post survey

Most teachers teach in secondary (44 / 68.8 %) or primary (20 / 31.3 %) schools. Other **institutions** include Higher Education (7 / 10.9 %) and preschool / kindergarten (4 / 6.3 %). N=3 Persons (4.8 %) explained another context in an open text field: “vocational school”, “teacher training”, and “ICT educator teacher”.

A majority of teachers in the sample teach **STEM subjects**. As displayed in Fig. 8, a number of further subjects are also mentioned in the post survey:

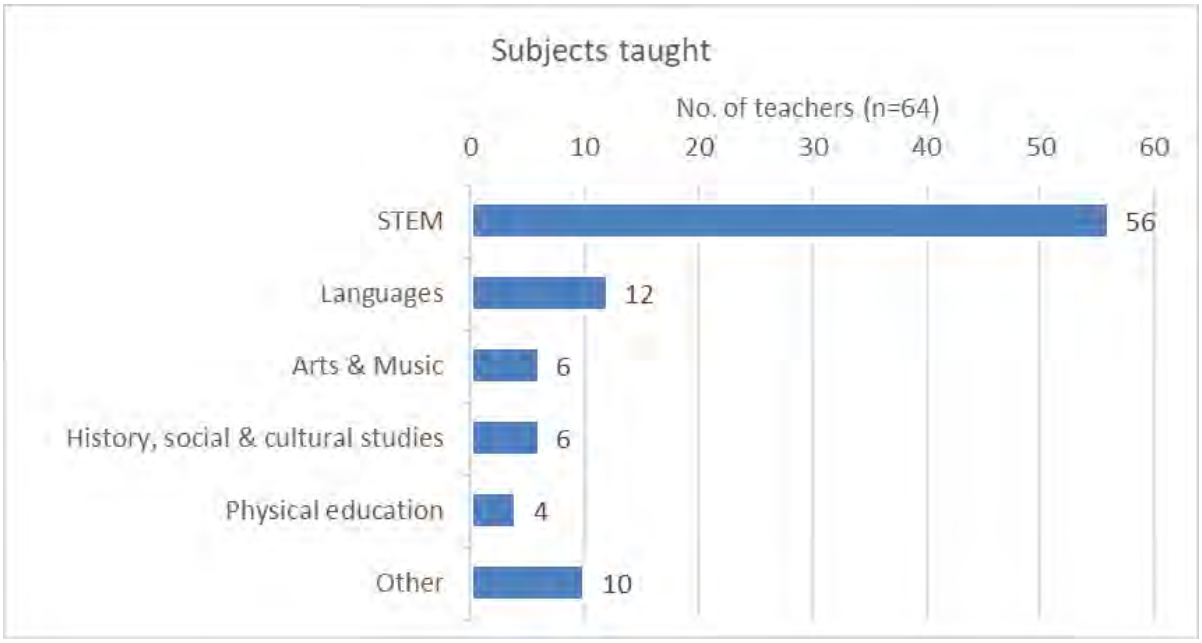


Figure 8 Subjects taught by educators according to post survey

The open responses in the category "other" include the following subjects: ICT / Informatics (3 / 4.7 %), primary school subjects (2 / 3.1 %), and the following subjects all being mentioned once (1.6 % each): Biology, Electrical Engineering, Electricity-Electronics, Geography and History, and Kindergarten curriculum.

Relevant previous experience

Teachers in the post sample rated their **expertise in using digital media for teaching and learning** on a scale from 1 (very poor) to 5 (very good) with an average score of 4.4 (SD .66). The results show a rather good self-assessed expertise (cf. Fig. 9).

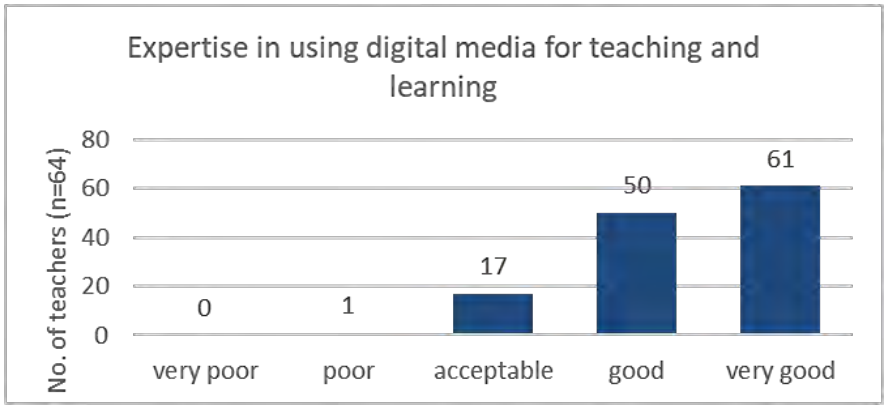


Figure 9 Self-Assessed expertise in using digital media for teaching and learning according to post survey

Teachers were also asked to specify their **previous experience with AR** in four items. The results are summarized in Fig. 10.

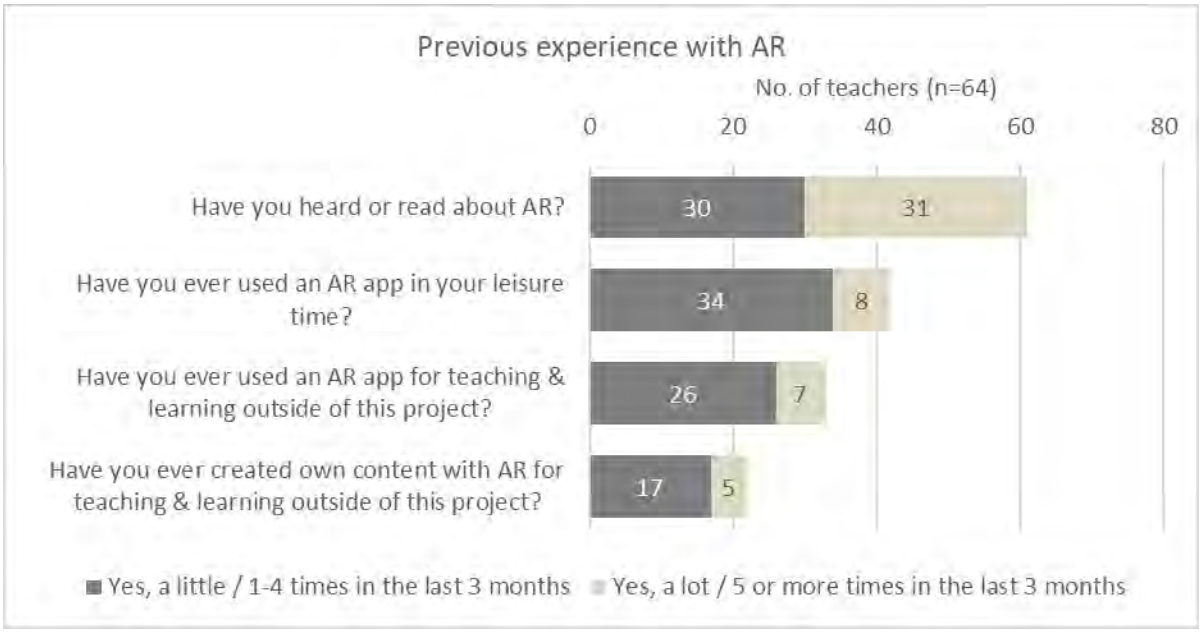


Figure 10 Teachers' previous experience with AR according to post survey

Teacher attitudes and technology acceptance

On the scale from 1 (strongly disagree) to 5 (strongly agree), the average value measured for teacher attitudes is 4.33 (SD .46). Values ranged from 3.19 to 5.0. All items received average ratings higher than the medium value of 3.

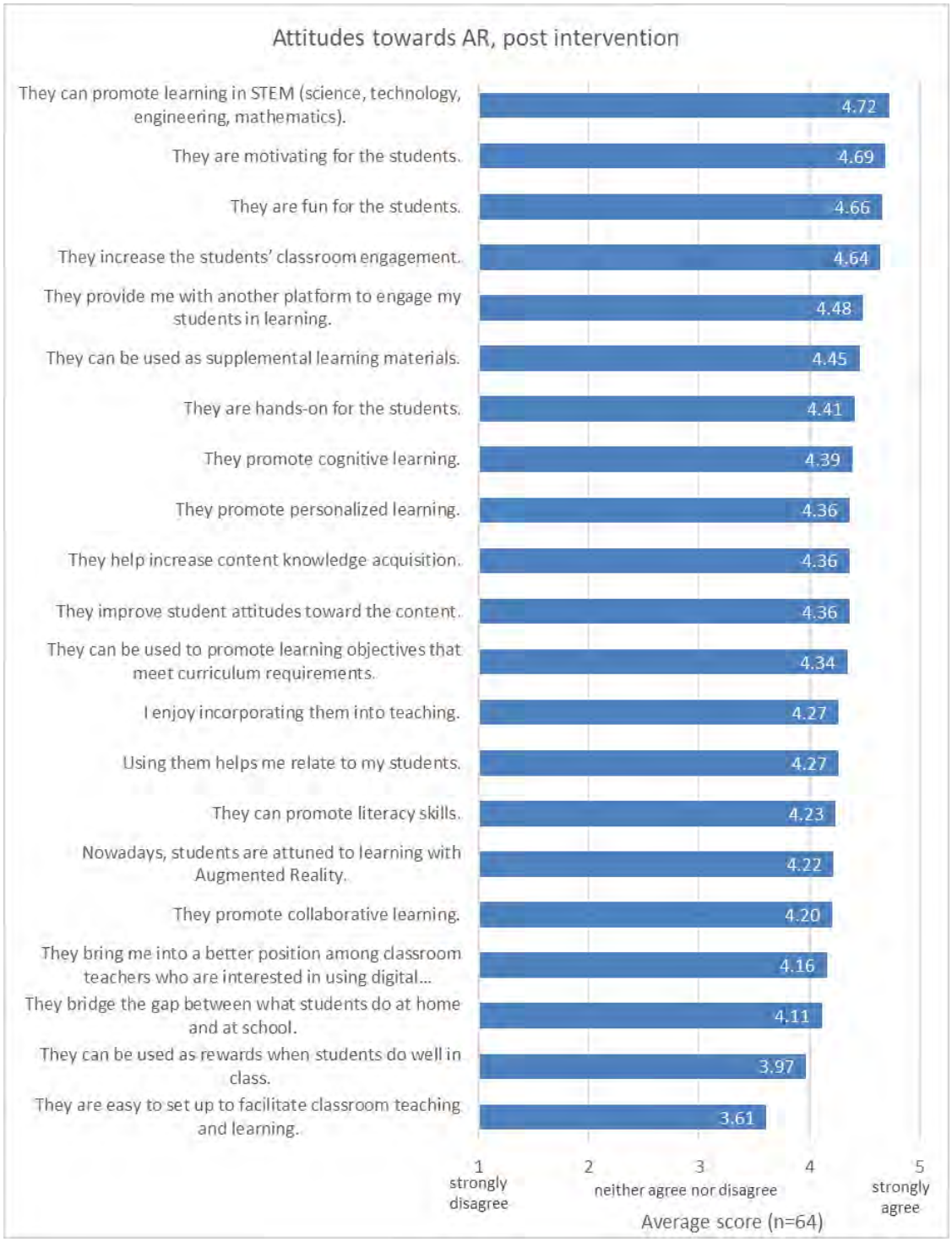


Figure 11 Attitudes towards AR according to post-survey

For **Technology Acceptance**, on a scale from 1 (strongly disagree) to 7 (strongly agree), the average score across all 64 teachers was 4.91 (SD 1.01; range 2.47 – 7.00).

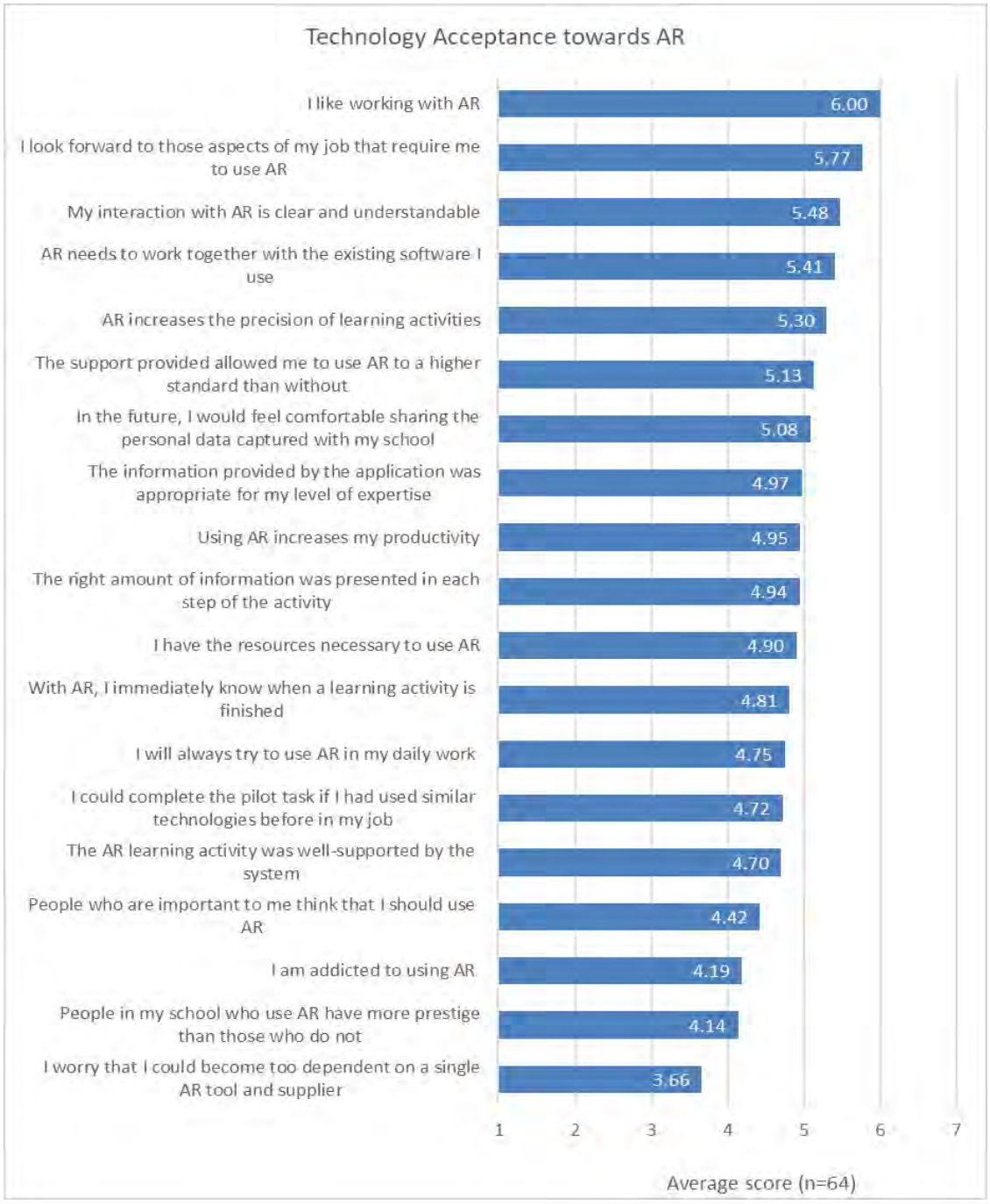


Figure 12 Technology Acceptance towards AR according to post survey

12 out of 64 teachers indicated a comparably low technology acceptance, with an average score of < 4.

17 of 18 items reached a score higher than the scale-middle of 4 (neither agree nor disagree). The item "I worry that I could become too dependent on a single AR tool and supplier" was the only item below the scale-middle, with an average score of 3.66 (SD 1.61).

AR learning activity

With regard to the **operating system** used when working with the MirageXR toolkit, slightly more teachers used Android (13 / 20 %) than iOS (9 / 14 %), based on the responses of 22 teachers. For the remaining n=42 teachers (66 %), no information is available on the operating system because this item was introduced late while the survey was already running (cf. Fig. 13).

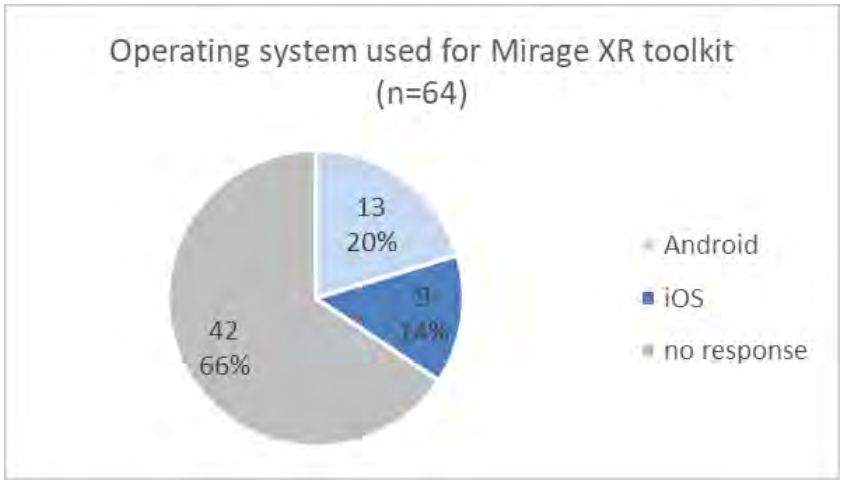


Figure 13 Operating systems used when working with the Mirage XR toolkit according to post survey

The self-reported amount of **time teachers spent designing an AR learning activity** in the pilot varied between 0 and 50 hours, with most teachers spending between 2 and 15 hours on this activity. The average time spent is 8:53 hrs (SD 8:32 hrs).

The distribution of self-declared time spent is shown in Figure 14.

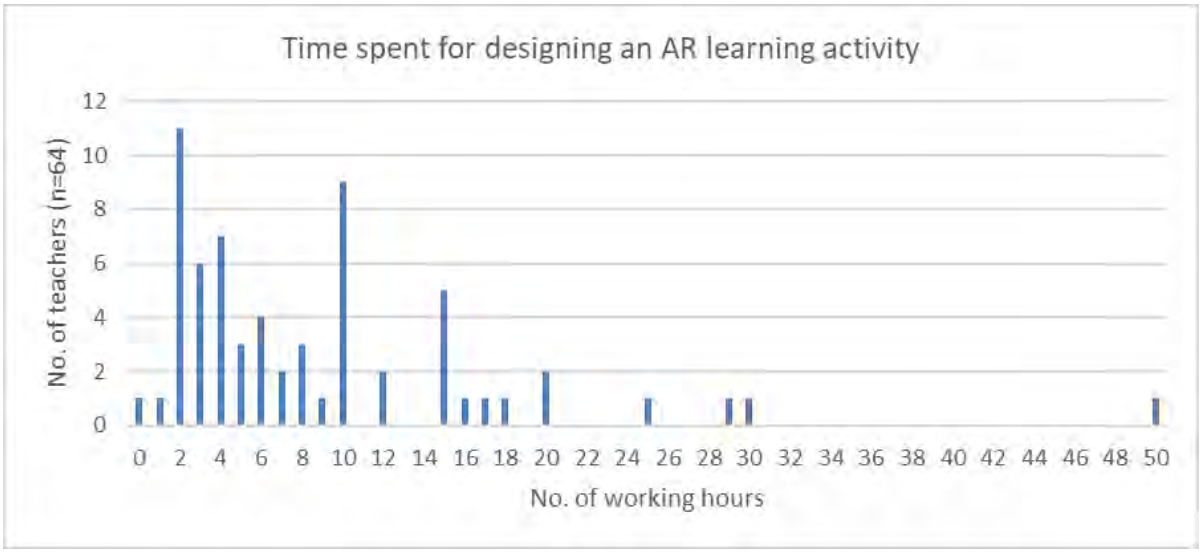


Figure 14 Time Teachers spent to design a learning activity using MirageXR toolkit according to post survey

When teachers were asked about the **educational target levels for their AR learning activities** designed with the MirageXR toolkit, the responses showed that secondary school settings were addressed the most by 43 persons (61 %), followed by primary school settings (18 persons / 25 %). Higher education and pre-school contexts were also addressed by 5 persons (7 %) and 4 persons (6 %; see Fig. 15).

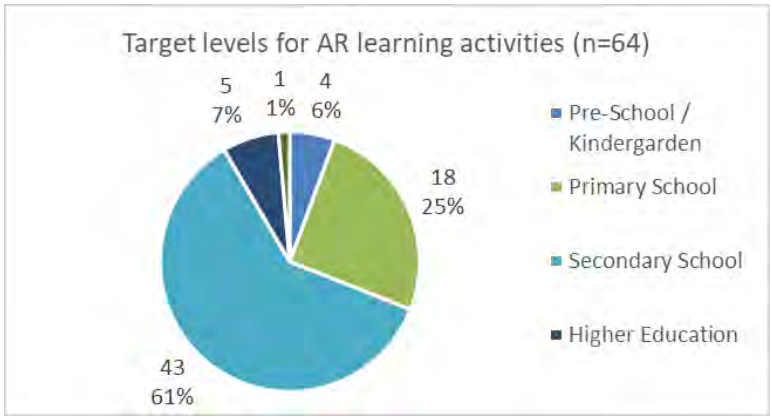


Figure 15 Educational contexts for which teachers designed AR learning activities according to post survey

Also, with regard to the **target subjects for the AR learning scenarios** designed with the MirageXR toolkit, teachers mostly referred to their own subjects as described above, as Fig. 16 Illustrates:

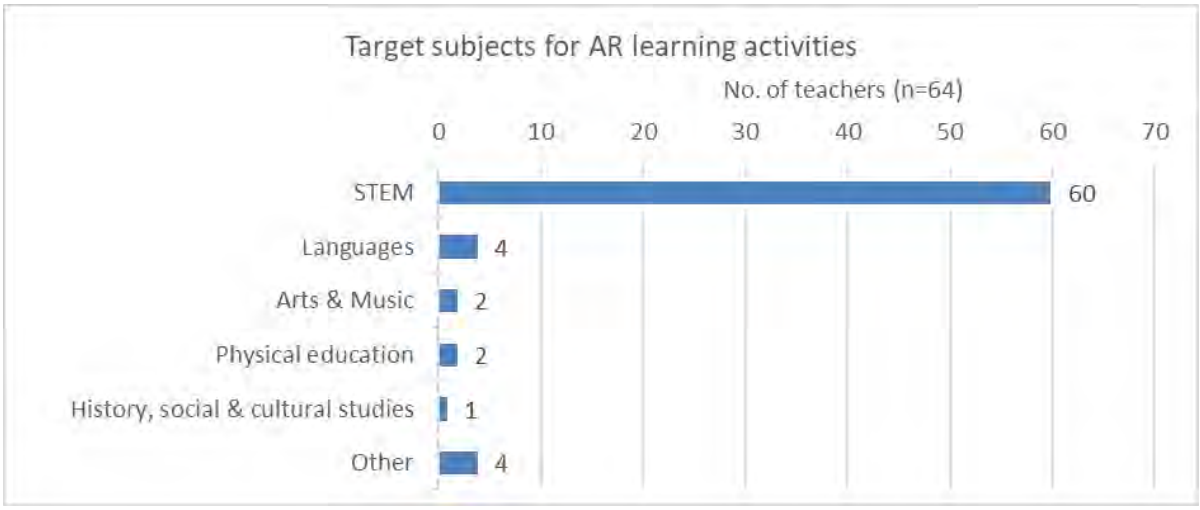


Figure 16 Subjects for which teachers designed AR learning activities according to post survey

This description of target subjects was amended by an open input for the question "please summarize in one sentence what your AR learning activity is about".

The responses confirm a strong focus on STEM activities. Selected examples for activities designed are:

- Physics: "Connecting electrical measuring devices in the virtual laboratory"
- Mathematics: "Learn geometric shapes (cube, prism, sphere, cone)"
- Chemistry: "Explore an atom's interior to discover the layout of its nucleus [sic!], protons, and electrons"
- Biology: "Bees and their role in human survival"
- Computer Science: "Explain what it is, what it is for and what you can do with an Arduino board"
- Robotics: "My activity is about the Edison robot with emphasis online tracking sensor"
- Earth Science: "It aims to facilitate the learning of geological issues"
- Astronomy: "My learning activity is about Space, Mars, and man's future missions on it"
- Language learning: "It is relevant to learning languages in a cultural context"
- Interdisciplinary: "CLIL [Content and language-integrated learning] activity on Ancient Greeks and important mathematics and scientific discoveries"
- Arts and design: "Simulating interior decoration app"
- Without specific subject reference: "Presenting your school"
- Some statements also described rather general goals, such as "hands on science" or "encouragement to study".

With regard to the learning scenarios designed, teachers were also asked to indicate which **cognitive processes** could be addressed by the AR learning activity they designed (cf. Bloom, 1956; Anderson & Krathwohl, 2001). The results are summarized in Fig. 17. Understanding and applying were the levels ticked the most. Yet, according to the teachers, all six levels could be addressed to some extent.

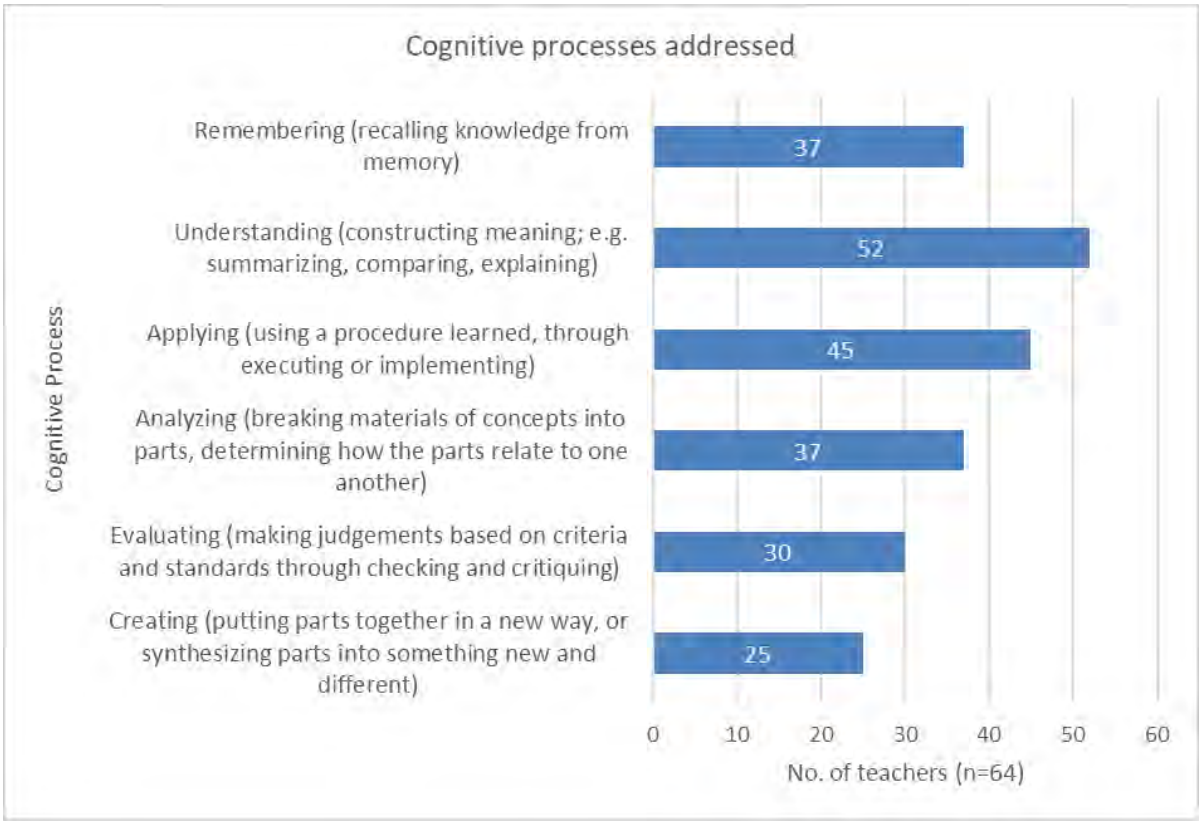


Figure 17 Cognitive processes addressed in AR learning activities designed by teachers according to post -survey

Teachers were also asked to tick their potential **main objectives** for using the self-designed AR learning activity with their students. A summary of the results is shown in Fig. 18. The findings suggest that teachers mostly want to use their learning activities to introduce and to practice contents and to support learning processes, but less so for communicative tasks, assessments, and break activities.

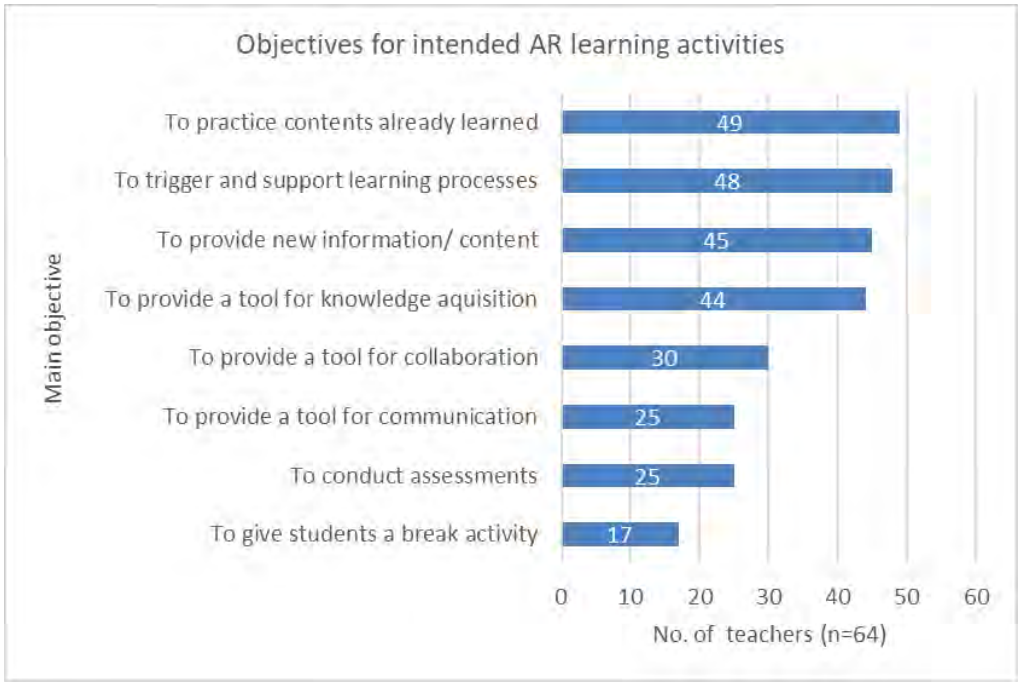


Figure 18 Main objectives for the intended AR learning activities in classroom contexts according to post survey

Teachers' self-assessed evaluation of experiences made with the toolkit in the pilot study

Teachers were asked for a **rating of their overall experience with the AR toolkit** on a scale from 1 (poor) to 5 (excellent). Fig.19 shows how the results are mixed, with an average rating of 3.58 (SD 1.14). The high standard deviation illustrates how differently teachers perceived the experience with the toolkit.

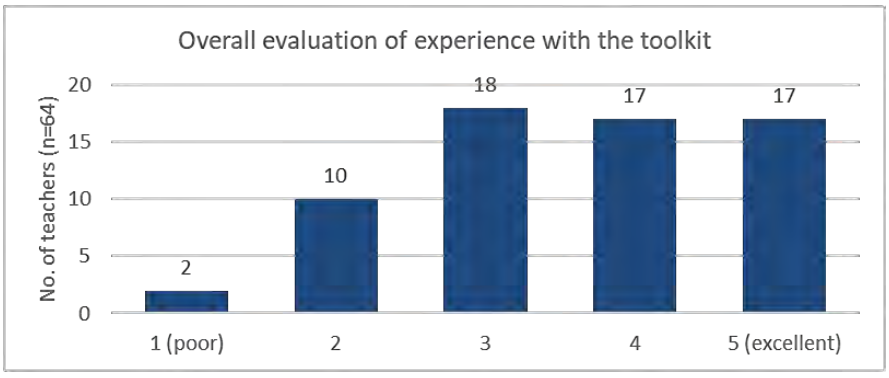


Figure 19 Teachers evaluations of experience with the toolkit according to post survey

Regarding the **ease of use**, teachers could rate their impression on a scale from 1 (it was *very easy* for me to create my own AR content) to 5 (it was *very difficult* for me to create my own AR content). The results are displayed in Fig. 20; as in case of the overall evaluation, teachers' opinions vary and cover ratings from "very easy" to "very difficult". However, the largest group of teachers found it "neither easy nor difficult". The mean rating is 3.22 (SD .93).

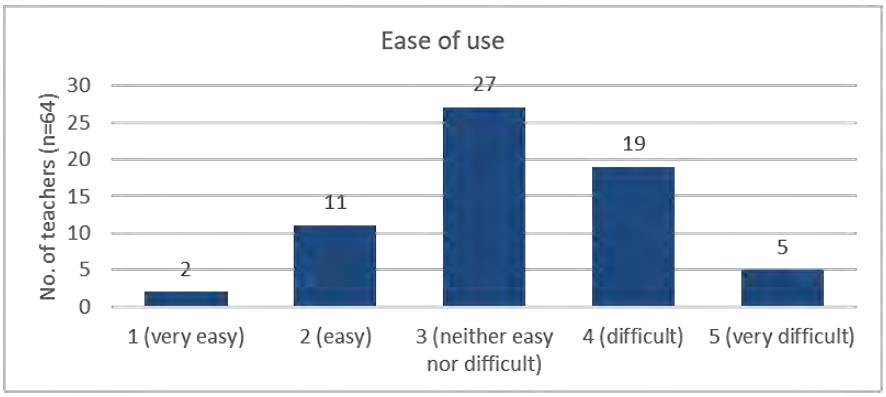


Figure 20 Teachers' evaluation of ease of use of the toolkit according to post survey

In the pre-survey, teachers had been asked about their expectations for the pilot study (cf. section 5/5.1). In the post survey, teachers were asked to assess the **extent to which these expectations were met**. The scale ranged from 1 (expectations not met at all) to 5 (expectations greatly exceeded; cf. Fig. 21). Again, responses varied and ranged from "not met at all" to "greatly exceeded". The mean value is 3.16 (SD 1.21). Interestingly, experiences seem to be varied, as 24 reports 'not fully met', while 26 report that it was 'exceeded' or even 'greatly exceeded'.

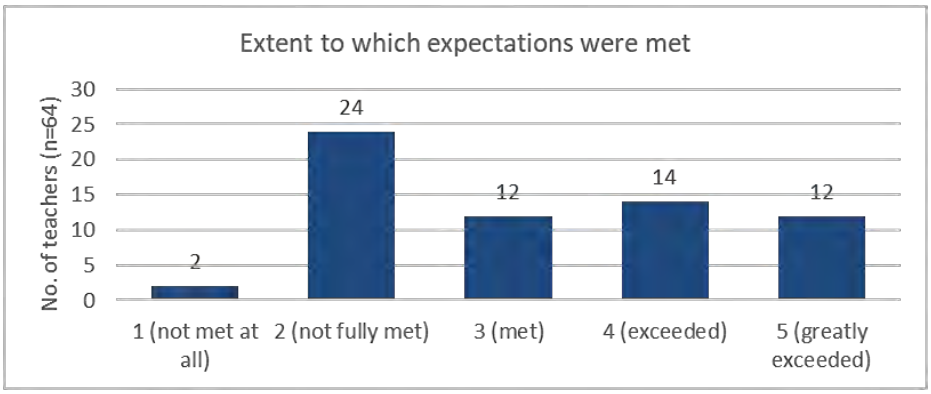


Figure 21 Fulfilment of expectations of according to post survey

To better understand the **fulfilment of expectations**, teachers were asked to explain their respective rating in one sentence. The categories resulting from the inductive coding process (cf. methodology section) are "Overall pilot experience", "technology skills and knowledge", "app functionalities & usability", "Pedagogy and educational value", and "collaboration".

In the following, the responses are presented following the participants' rating in the previous item, differentiating between participants whose expectations were not fulfilled and participants whose expectations were fulfilled.

Reasons why expectations were not fulfilled

26 participants who ticked "1 – expectations not met at all" or "2 – expectations not fully met" explained their rating by the following aspects:

1) Overall pilot experience (11):

Some teachers explained that guidance, support, and materials outside the app were missing or not extensive and helpful enough (10). 1 person acknowledged that he or she still enjoyed the app.

2) Technology skills and knowledge (11):

11 teachers explained their rating by being unsuccessful in the creation of AR learning experiences or AR-enhanced content, or by not being satisfied with its result.

3) App functionalities & usability (30):

Most comments in this group of participants referred to the app functionalities and usability. This includes criticism towards the functionalities of the app with things not working as intended, functions missing and similar issues (11); problems with the compatibility of the app and with devices (8), perceptions about the user-friendliness and ease of use (7), and a lack of clarity of instructions, guidance, and support within the app (4).

4) Pedagogy and educational value (4):

In 3 statements, the educational value and usefulness of the app was questioned. 1 person described that he or she had expected to learn more about educational content creation in AR.

Reasons why expectations were fulfilled

38 Teachers who ticked "3 – expectations fulfilled", "4 – expectations exceeded", or "5 – expectations greatly exceeded" gave the following explanations for their ratings. Reasons included satisfaction and confirmation, as well as criticism and recommendations:

1) Overall pilot experience (14):

6 comments in this category refer to guidance, support, and materials outside the app. 5 out of these 6 would have liked e.g., more materials or training. The remaining person described the materials provided as "very clear". With regard to learning and the acquisition of new or enhanced knowledge in general, 4 responses confirmed their satisfaction. 4 more teachers explained their rating with the fun, interesting and new experience.

2) Technology skills and knowledge (13):

Teachers appreciated that they had the opportunity to try out a new tool (6) and that they learned to create AR learning experiences, sometimes for the first time (4), even though it was hard (1). 1 person described failing to produce an adequate product. 1 response explained his or her rating by the improvement of AR-related knowledge.

3) App functionalities and usability (18):

With regard to the functionalities of the app, 4 teachers appreciated the capabilities of the app, whereas 2 teachers criticized that certain functions did not work. 5 comments mentioned an unsatisfying user-friendliness or a low ease of use, while 2 comments praised the user-friendliness and ease of use. 4 other comments focussed on problems with compatibility and devices. 1 response criticized the limited number of instructions.

4) Pedagogy and educational value (7):

Comments in this category confirmed the usefulness of the application (3). 2 persons added that it could be used to engage students, and 2 more comments appreciated the chance to improve one's own teaching methods.

5) Collaboration (1):

One teacher focused on social aspects, mentioning that he or she enjoyed the experience and will share it with students.

In order to assess the perceived usability of the toolkit, participants were asked for their ratings for items from the HARUS scale from 1 (strongly disagree) to 7 (strongly agree). The items marked with an Asterix are reverse and have been re-coded for the presentation and analysis. The average rating is 4.47 (SD .81).

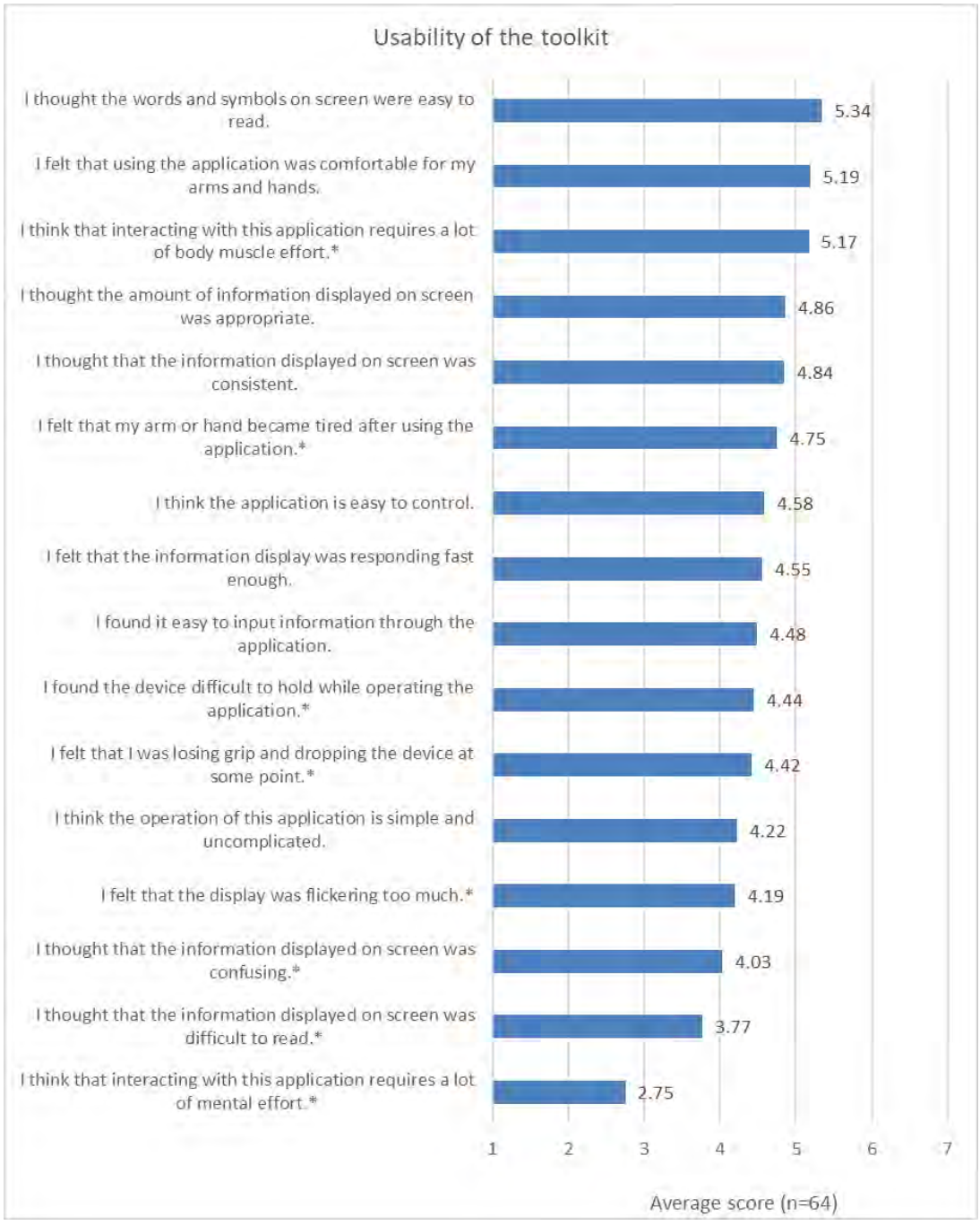


Figure 22 Usability of the toolkit according to post survey

In a final multiple choice-item, teachers could tick all **problems and drawbacks** they experienced when using the MirageXR toolkit to design an AR learning activity. The responses are summarized in Figure 23.

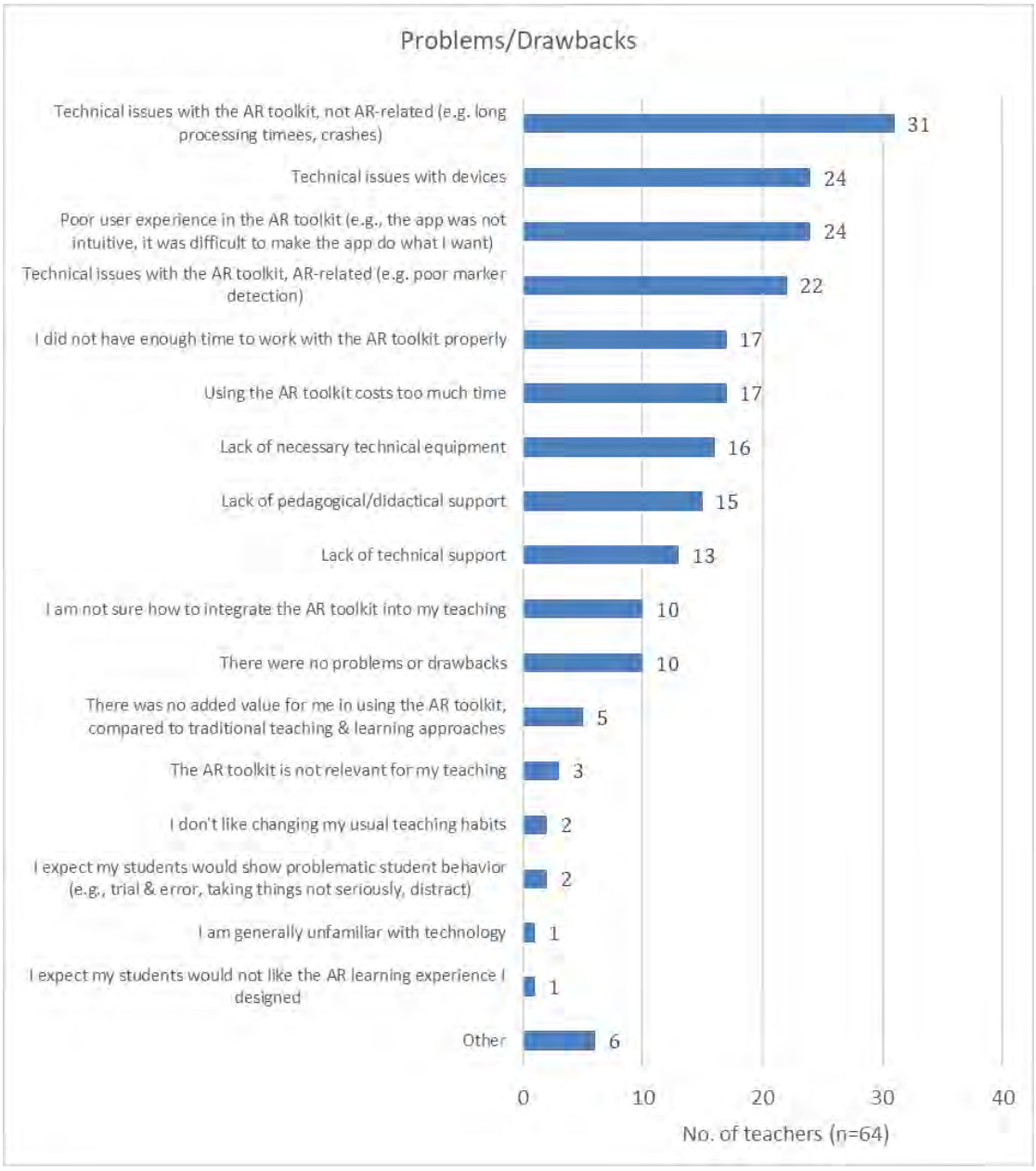


Figure 23 Problems/Drawbacks when using the MirageXR toolkit reported by teachers according to post survey

Other problems/drawbacks reported by teachers (n=6) after designing an AR learning activity with the MirageXR toolkit in the open field for "other" emphasized:

- the need to improve video tutorials and other user guidelines for teachers (n=2)
- difficulties to keep the app running smoothly (n=2)
- the lack of hardware compatibility with the app (n=1)
- that the app was not easy to use for secondary school students (n=1)

4.2.3 Conclusions on the survey findings

The results introduced above have to be contextualized against the background of certain limitations. Centrally, the sample composition and recruitment need to be considered: the teachers were recruited from a network of professional science teachers as a self-selecting convenience sample. As the demographic data reveal, approx. 84 % of teachers have more than 10 years of experience, which means they possess routine teaching strategies. The recruitment background from the professional network has a distinct focus on technology-enhanced teaching and learning approaches. It further suggests a high intrinsic motivation of teachers and a higher familiarity and experience with educational technology in general and particularly AR than an average teacher would be expected to show.

Regarding the methodology, it should be noted that the measurement was based on self-assessments, which brings a risk of bias because personal factors such as social desirability or different response styles can influence the choices participants make. Yet, the measurement by subjective self-assessments is an established approach for the research in question and was considered most appropriate to capture participants' perspectives by a low-threshold, convenient and efficient method.

Finally, a third limitation refers to the comparably high drop-out rate of approximately 45 % of teachers from pre-survey (116 complete responses) to post survey (64 complete responses). There are multiple explanations for this observation. One explanation refers to device compatibility: while the requirements for devices were communicated right from the beginning of the study, several teachers reported technical issues with their devices and could not work with the AR tool kit as intended, causing them to drop out. Also, it was reported that some teachers struggled to operate the app and to realise their intended learning experiences, which might have decreased the motivation of single participants. Based on this observation, it will be helpful for further work with AR authoring tool kit to focus on the teachers' support to provide more support material and guidance to ensure that all teachers can fully benefit from the tool kit. Furthermore, the timing of the study, during the summer break, may have led to decreased motivation. The study was organised flexibly, without obligations to contribute or to try out the tool kit in class, which made it easily accessible for teachers but also allowed for dropping out easily. Due to the recruitment strategy, teachers registered mainly on their own and not together with a colleague (see, e.g., Tiede et al., 2022); hence, there may have been less feeling of obligation and peer pressure despite the growing and active community of teachers exchanging on the Moodle platform which study participants used for sharing their activities. Also, the incentives provided for participation, i.e., a certificate and small gift for randomly selected teachers, might have been less appealing than, as in the case of the other ARETE pilot studies, the access to an app that would otherwise be liable to costs (Tiede et al., 2022).

All in all, the teachers' feedback and evaluation was heterogeneous. From the pedagogical perspective, it is significant to summarize that various ideas were developed in this pilot

study to include the MirageXR toolkit into classroom practice. The teachers, who were quite experienced in teaching on average and shared a generally open and positive attitude towards Augmented Reality, described that they designed different AR-enhanced teaching and learning scenarios which cover a range of topics (with a focus on STEM-related contents) and are applicable in various contexts, mainly in primary and secondary schools. According to the teachers' hypotheses, these scenarios could potentially stimulate different cognitive processes from remembering to creating (cf. Bloom, 1956; Anderson & Krathwohl, 2001) and fulfil a range of objectives within teaching and learning processes at school.

The teachers' overall evaluations show that the pilot experience was perceived heterogeneously (mean 3.58, SD 1.14 on a scale from 1 (poor) to 5 (excellent)). Half of the respondents felt that their expectations were not fully met (24 persons) or not met at all (2 persons), while the other half considered their expectations either met (12 persons), exceeded (14 persons) or greatly exceeded (12 persons). The explanations why expectations were not fulfilled focus on missing or inadequate support and materials, an unsuccessful or unsatisfying result of the design process with the toolkit, shortcomings in app functionalities and usability, and a questionable educational value of the toolkit. On the other hand, explanations why expectations were fulfilled praise the overall pilot experience, the chance to try out something new and to learn how to create AR-enhanced learning scenarios, the app functionalities, and the usefulness of the application. These findings are also mirrored in a final multiple choice-item about problems and drawbacks, where technology-related issues are a clear focus.

Summary

Based on responses of the pre- and post-intervention surveys, the teachers' experience for MirageXR application can be summarised as follows:

- The Pilot Study 4 pre-survey helped us understand the teachers' attitude towards Augmented reality and also if they were acquainted in using digital technology for learning and teaching. The teachers were very motivated to include Mirage XR application into teaching and learning.

- The teachers' engagement with the toolkit was analysed with the responses to the post survey, the attitude of the teachers towards the Mirage XR toolkit was found to be mostly positive. The application faced some minor setbacks in terms of interface, functionality, and lack of technical support.

- In summary, the teachers involved in Pilot Study 4 had mixed responses towards MirageXR, and their attitude and motivation of applying it were mostly positive. The MirageXR application satisfied most of the teachers' learning and teaching requirements, but the user experience can still be further improved by containing its complexity and other hardware-based issues such as overheating.

Nonetheless, the overall positive observation is that once teachers understand the toolkit, they are able to develop their AR activity for teaching and learning.

While comparing the pre- and post-intervention experience of the teachers in ARETE Pilot Study 4 regarding the use of the MirageXR toolkit, the most salient observation is that despite the post-intervention attitudes, the teachers faced difficulty in using the AR toolkit. Some teachers reported a lack of resources to use the application, or the application would not run due to the compatibility issues with the other gadgets. These issues regarding long processing times and crashes of the application can be addressed in the future to further improve the experience for teaching and learning. The lack of technical support and guidance could be addressed in the current study, enabling the teachers and students to benefit from the application.

For the ongoing advancement of the uptake of XR technologies in teaching and learning processes, it will be relevant to address the problems pointed out and to find a way to also include less technology-savvy teachers effectively.

Generally, the outcomes are not surprising and in line with where others see the technology on the Gartner hype cycle, moving from hype through the trough of disillusionment onto the emerging plateau of stability (Gartner, 2023): Expectations for AR in education are high, while practice still stays behind these expectations, shaped by, e.g., the gaming market. Moreover, while many are familiar with the concept of AR, they struggle with the changed user interaction paradigms, device problems, novel functionalities.

Compared to earlier studies (Ravagnolo et al., 2019), advances in usability are visible, and with version 2 benefiting from the pilot 4 study, further advances beyond what has been assessed in pilot 4 can be expected. For example, MirageXR includes now in version 2 built in tutorials and a dynamic context help, which addresses some comments above. Moreover, the user interface concept for version 2 has been completely redesigned from the ground up.

For the ongoing advancement of the uptake of XR technologies in teaching and learning processes, it will be relevant to address the problems pointed out and to find a way to also include less technology-savvy teachers effectively.

5 Teacher Interviews

5.1 Methodology

In addition to the surveys described above, teacher interviews were conducted as a second main research activity within the mixed methods approach applied in pilot 4. By the interviews, the input collected in the surveys from numerous participants in a mainly quantitative way was amended by additional qualitative in-depth insights with regard to the research questions from pedagogical and HCI perspective outlined above.

For the interviews, a convenience sample was recruited from the overall sample of survey respondents. The last page of the survey included an invitation to participate in the interviews voluntarily and a link to register. There were no additional incentives provided for this contribution.

The interview guideline was developed in accordance with related literature (Krueger & Casey, 2015; Bogner, Littig, & Menz, 2009). It combines questions about usability and pedagogical perspectives. The slides used in the interviews can be found in annex 6[7].

As the user experience (UX) research suggested (Roto et al., 2011), users can anticipate their experience by simply viewing the artefact under evaluation or somehow getting to know it (e.g. reading or word-by-mouth) without interacting with it directly. This is so-called anticipated UX. Nonetheless, UX evolves with actual experience; users can confirm (or disconfirm) what they have anticipated. After interacting with the artefact, they can reflect on the whole interaction episode and revise (or reconfirm) the experience gained during the actual interaction. Grounded in this conceptual framework on the UX temporality, a three-phrase approach was applied by asking the teachers about their experience "before", "during/while" and "after" interacting with the MirageXR toolkit.

Specifically, teachers were asked to recall their experience of utilizing the training material, which was meant to prepare them to use the MirageXR toolkit. Presumably, based on what they have learnt from the material, teachers might revise what they had expected from the toolkit (i.e. Pre Survey) and form newly anticipated UX. The second phase was to ask them to recall the actual interaction experience, which was essentially the core part of feedback teachers provided. To guide teachers to focus on central usability aspects, 4 items from the questionnaire HARUS (see above) were selected – two for the construct *Comprehensibility* and two regarding *Manipulability*. Nevertheless, teachers were basically free to express their opinions and comments on other aspects. The third phase (i.e. "after") was to summarise the overall experience. In this phase, teachers were asked to provide improvement suggestions for making the toolkit more usable and useful for them in real-life applications. The questions for the section "after using the app" also aim to summarise outstanding characteristics in terms of most and least liked features. They also address the pedagogical implications by asking for advantages and benefits for teaching and learning, but also for problems and barriers.

In accordance with related literature, student motivation, student engagement and knowledge acquisition can be named as three central affordances of AR in classroom practice (Yakuba et al., 2021; Lham, Jurmey & Tshering, 2020; Delello, 2015). With regard to student motivation, Keller's well-established ARCS model (1987) states that instructional materials can have a motivational effect because they address students' attention, their feelings of relevance, their confidence, and their satisfaction.

[7] The slides used in the interviews are available in annex 6 at: ARETE_Pilot_4_interview.pdf

As a second relevant construct, classroom engagement was analyzed. According to Lee and Reeve (2013), classroom engagement can have different forms: it can either be agentic, i.e., students are very active and ask a lot of questions, it can be cognitive, which means that students apply advanced learning strategies, it can be emotional, which means that they express or display positive emotions, and it can be behavioural, meaning that students are focused and concentrated and show high persistence also with challenging tasks.

The interviews were concluded by a final question on the likelihood of future uses of an AR toolkit such as MirageXR. This question refers back to the concept of technology acceptance (TAM) and thus addresses an important potential outcome of the ARETE Pilot 4 study.

The interviews were conducted by one educational researcher and one HCI researcher in accordance with the research objectives defined. They were realized as online interviews with a duration of approximately 1 hour each via an online web-conferencing tool. They were recorded and transcribed for analysis in an anonymized format.

The data collected this way were analyzed both by the HCI and the pedagogical team applying a qualitative content analysis (Mayring, 2014). The coding system was developed deductively based on related literature (e.g., Keller, 1987; Lee & Reeve, 2012; Shneiderman, B. (2000).and amended by inductively derived categories to fully capture the participants' inputs.

Against the background of the overall research objectives for pilot 4, the pedagogical analysis of interviews focused on the following three research questions:

1. Which pedagogical scenarios do teachers design or envision for the integration of MirageXR into classroom practice?
2. Which advantages for teaching and learning processes do teachers expect from using AR / MirageXR in classroom practice?
3. What are the problems and barriers, for teaching and learning processes, do teachers expect from using AR / MirageXR in classroom practice?

The ARETE MirageXR toolkit was analysed from the HCI perspective on its usability and user experience, the interviews enabled us to gain qualitative, in-depth feedback about the application and its compatibility for teaching and learning. The analysis of the interviews focused on the following three research questions:

1) What did you like most about the MirageXR toolkit?

2) What did you like the least about the MirageXR toolkit?

3) Which issue would you want to see improved in the MirageXR application?

The interview helped in understanding the user experience from the pedagogical as well as HCI perspective, which will further help in understanding the teacher's requirements for

research and teaching. The Mirage XR toolkit interview was designed in three stages as before, while, and after.

The convenience sample included n=12 teachers, interviewed in 11 interviews because 2 colleagues who collaborated in the pilot preferred to be interviewed together in one interview. One additional interview was completed but excluded from analysis due to a significant language barrier that impeded the conversation and prevented meaningful results.

5.2 Pedagogical Analysis

All references to app functionalities and usability, whilst relevant, especially in the context of problems and barriers for teaching and learning processes, are covered in the context of the HCI analysis of usability in section 5.3. In the following, the three sections of use scenarios, advantages, and problems and barriers as focused on the qualitative content analysis from the pedagogical perspective are summarized.

It should be noted that the teachers, who tested the application during their summer breaks, did not use it in actual classroom practice. Hence, the statements analysed in the following reflect expectations based on their professional experience, not on actual experiences with using MirageXR in class.

Pedagogical use scenarios designed or envisioned by the teachers

Teachers either designed, planned or imagined a variety of use scenarios for the MirageXR toolkit. These scenarios the teachers described covered different subjects such as mathematics, chemistry, biology, geography, or physics. In accordance with the sample recruited from a network of STEM teachers, the scenarios described show a focus on STEM subjects. However, it was also mentioned that the toolkit could be useful in language learning or history and that the applicability of AR in general is subject-independent.

With regard to the structure of the use scenarios, it is noteworthy that several teachers described that they would like their students to become authors of their own learning experiences, instead of reducing the students' involvement to the role of a consumer only. The basic concept of teachers designing learning experiences for their students was enhanced by more student-centered and interactive approaches.

Advantages for teaching and learning processes

Against the structural analysis of motivation suggested by Keller (1987), most references were made to the app's potential stimulation of students' satisfaction: this is due to the fact that many teachers were convinced that their students would have fun with the app, enjoy using it, and overall show positive emotions. Numerous teachers pointed out that it would motivate by attracting students' attention, mainly due to the novelty effect and visually appealing effects. Fewer statements also confirmed the perceived potential to increase students' confidence, especially if the app is integrated carefully into the teaching and

learning processes so that students are able to handle the technology successfully and do not get frustrated or overstrained. Finally, very few remarks referred to the enhancement of students' feelings of relevance, which is closely related to their familiarity with and fascination for technology in general.

With regard to classroom engagement (Lee & Reeve, 2013), teachers made several references to emotional and behavioral engagement. In terms of emotional engagement, they expected that their students would express feelings such as joy, pleasure, and excitement. With regard to behavioral engagement, it was mentioned that students would work on app-related tasks in a concentrated and constructive manner and show high persistence in doing so. Fewer statements referred to students with high agentic engagement (ibid), meaning that, e.g., they will ask a lot of questions and express their preferences. Finally, two comments pointed towards a potential cognitive engagement of students thinking critically and being efficient in learning.

Almost all teachers were confident that the app would support their students' learning processes and knowledge acquisition. Concerning things students could learn by using the app, the following dimensions were mentioned:

- Content knowledge, esp. from STEM subjects
- Disciplinary skills
- Digital skills
- Learning of complex concepts
- Critical thinking
- Soft skills
- Creativity

With regard to the learning process, the following potential advantages were listed:

- Better / easier understanding
- Faster learning
- Higher retention
- Interactive learning / active learning / experimental learning
- Learning by different channels
- Learning with fun and passion

One advantage that was mentioned several times is visualization and 3D, and this is closely related to the affordances for teaching and learning processes summarized above. Teachers appreciated the potential of the toolkit to display content in 3D and thus to visualize things that could not or only insufficiently be shown, e.g., on a screen or a piece of paper. As the

teachers described, this is one of the central unique advantages of Augmented Reality technology in educational settings, especially with regard to STEM contents.

Among further advantages the teachers mentioned, flexibility and adaptivity were also important factors. The teachers described the applicability of the app for heterogeneous learning groups and for individuals with different learning requirements, and they valued the usefulness in flexible and heterogeneous settings.

Further, advantages mentioned were:

- The applicability for and enhancement of collaborative learning scenarios
- The modern and innovative teaching approach
- A high familiarity of students with the approach or technology in general
- The fact that the app is free of costs
- The fact that the app can save the teacher's time

Expected problems and barriers for teaching and learning processes

During the interviews, the teachers mentioned a number of problems they expect or consider likely when imagining using the MirageXR toolkit or a comparable AR app in classroom practice. While a majority of respective comments relates to the usability of the app and software issues (see section 5.3), a number of statements also took into account other potential issues from the pedagogical perspective, which can be grouped into the following two main categories:

1) Students, Teachers & Parents

2) Teaching and Learning Processes

With regard to students, teachers and parents, most comments were concerned with the target group of teachers. The study participants, while being tech-savvy and open for innovations themselves, said that some of their colleagues could be put off because of the following arguments:

- Negative attitudes, reluctance towards change, conservative teaching methods, no interest in technology-enhanced teaching
- The concept of AR is unfamiliar
- Inadequate digital pedagogical competencies / digital skills
- Designing learning activities takes too much time and effort

Two potential solutions were brought up in this context to address these challenges and to enhance the accessibility of the toolkit for teachers and, consequently, its acceptance. The first idea was to provide more materials for an easier initial access, such as additional video

tutorials, live demonstrations, and more documentation, guidance and examples. Centrally, it was suggested to provide a set of learning scenarios which are ready to be used or to be adapted, so that teachers do not have to develop everything on their own but can rely on valid and professional ready-to-use materials. The second solution suggested was to create and support more collaboration between teachers so that peer feedback and peer support mechanisms and mentoring systems can facilitate a helpful exchange and decrease reservations.

The second group of users mentioned are students. As the teachers described, there may be a small group of students who do not like to use technology, or who are not familiar with it and intimidated by it. Some students might also lack the necessary technological skills to use the AR toolkit effectively and would need special training to compensate for these shortcomings. It was also hypothetized that problematic student behaviour, such as distraction, could increase over time once the novelty effect wears off. While many references were made to the potential motivational effects of the toolkit, it was also mentioned that this motivation might not reach all students, e.g., because these are used to games that require a low cognitive effort.

In the context of appealing to students by the toolkit, one relevant concern was also raised with respect to student diversity and heterogeneous learning requirements: some teachers expected that the toolkit might not be applicable in all learning settings and for all learners. As examples, primary school children might struggle with the technology according to the teachers and students with special needs (e.g., visual impairments, disabilities, neurodiversity) might be excluded if not addressed and supported in a special way.

Another potential problem was raised with regard to student health. Two teachers mentioned that it might not be healthy for students' eyes to look at a screen for longer periods of time.

As the third group of persons concerned, very few references were made to parents as a potentially problematic target group. While most teachers agreed that parents in their classes are usually very supportive and fond of technology-enhanced teaching and learning approaches, it was mentioned in single cases that some parents might either not like the idea or not have the equipment and skills needed to support their children appropriately.

The category of teaching and learning processes summarizes different aspects in relation to methodology and classroom practices. Some teachers would find it challenging to integrate the toolkit into their pedagogical approaches because this is perceived as cognitively demanding. Also, the lack of examples and ready-to-use suitable contents mentioned above added to this perceived mental load.

Practical reasons might have inhibited the inclusion, such as the following arguments:

- There are too many students in a class to work with it efficiently,
- Lessons are too short in time,

- There are too few lessons in the timetable to allow for the inclusion of the toolkit,
- Classroom environments and spaces are sometimes inadequate (too narrow, fixed furniture, no free walls for calibration markers).

Beyond classroom practices, the challenges with regard to teaching and learning processes also have an institutional, legal or systemic dimension. In this context, it was pointed out that governmental decisions and legislation can and do have a severe impact on technology-enhanced teaching in some cases, as there are countries where it is forbidden to use phones at school. In other places, such decisions are up to the directors or schools and restrict teachers' flexibility and pedagogical autonomy.

Conclusions from the pedagogical perspective

Overall, the interviews revealed a variety of relevant ideas and shed light on shared hopes and expectations, but also on challenges and restrictions in the context of using the MirageXR toolkit and AR in teaching and learning.

With regard to pedagogical use scenarios, the variety of ideas showed that teachers can well imagine including the toolkit into their individual contexts, even though there was a predominance of STEM teachers and related concepts. It is interesting to see that a reappearing motif was the reversal of roles and the constructivist empowerment of students as self-dependent and active designers of their own learning experiences, as opposed to classic recipients of teacher-designed learning scenarios. In order to enhance the application's compatibility with the teachers' pedagogical requirements, it might be worth to elaborate on this concept and to include students as content creators and designers of learning experiences as well, instead of an exclusive focus on teachers as learning experience designers.

In the context of advantages for teaching and learning processes, motivation, classroom engagement and knowledge acquisition were prioritized by the teachers. It appears that the participants appreciated the potential of the application to have a positive impact on the students and on their learning, if applied successfully and efficiently.

Several aspects were noted which, according to the teachers, might have an impeding effect on this successful and efficient integration. It appears that central concerns with regard to teachers, especially referring to negative attitudes, acceptance, competencies and skills, can be addressed by fostering peer exchange and by providing very detailed and comprehensive guidance. This might include,

- Rich and easily accessible materials: e.g., detailed and beginner-friendly tutorials, videos, guidelines.
- Support: synchronous (e.g., live demo sessions, Q&A sessions, live support) and asynchronous (e.g., via email, in a forum)

- Good practice examples and a database of ready-to-use learning scenarios that are relevant for different subjects, age groups and school forms.

Problems noted in respect to students are to be addressed primarily by the teachers; certain issues, like a hesitance to engage with digital media in learning contexts, only apply to a smaller and very individual target group and are to be considered by the teachers in their daily practices also in other related contexts. Other concerns, such as in relation to student health and special learning requirements, will need further investigation and, potentially, a respective preparation of teachers to ensure that all students can take benefit from AR-enhanced learning while maintaining their health.

Finally, the investigation of potentially impeding factors for teaching and learning processes revealed that there are also influential stakeholders and circumstances that go beyond the level of classroom practices. While teachers are central stakeholders in the design of teaching and learning processes in their classes, the facilitation of technology-enhanced learning has also a political and institutional dimension, as there are contexts in which teachers are restricted in their application of innovative teaching and learning concepts.

In this regard, it is an ongoing desideratum on a global level to further increase the visibility of good AR-enhanced educational practice and to communicate supportive research findings transparently to ensure that barriers are reduced on a systemic level. This way, frame conditions need to be redesigned to support teachers and students in taking advantage from the potential Augmented Reality can offer for educational purposes.

5.3 HCI Analysis

The HCI specialists performed the analysis of the interviews regarding the MirageXR toolkit to understand the issues encountered during the teaching and learning process. The teachers' feedback about the MirageXR application had some positive, neutral, and negative responses. When the teachers were asked "What did they like the most about the Mirage XR application", the question received mixed responses, most of the teachers found it very interesting, and they liked the "avatars" available in the application.

Teachers' experience with ARETE MirageXR application:

The user experience about the MirageXR application was accounted for by (n=11) teachers, who used the application for teaching and learning purposes. The teachers shared their after-use experience of the application and the challenges they faced while using the MirageXR application as follows.

Positive responses:

· "It's something new and something that engaged my students more, I am sure they would like to play with this app".

- “3D vision is to interact is the best and the best quality of 3D model”
- “I found it very interesting to use “
- “The app is easy to handle”
- “I think the application is easy to control”

***Negative responses*:**

- “Lot of problem”
- “The system prevented me to log on this app, because of battery consumption”
- “I had some issues, well, how to place my phone and to create my space”
- “Tablet is really better option to use”
- “I think interacting with this application requires a lot of body muscle effort”
- “my phone was boiling”

Neutral responses:

- “I feel after knowing how to use, it is simple to use”
- “neutral”
- “It is okay to use”

It can be concluded that the teachers’ user experience was both positive and negative, the teachers were mostly concerned with the user interface navigation of the application. We have further categorised the teachers’ comments expressed through the interviews.

From the HCI perspective, the application has some negative feedback from the teachers due to its limited functionality, in its current stage. The most reported issues about the Mirage XR application are the time consumption, limited guidance and compatibility cases that are reported during the interaction with the toolkit. The problems are as follows:

- “All my devices were not compatible with this AR toolkit”
- “Not easy to use for a secondary school student”
- “Using the app causes overheating. The app needs to be shut down several times.”

· "The system is not yet straightforward enough. At the moment, I feel there is not enough support available to make a smooth-running app."

· "More instructions and tutorials were missing on how to connect the AR elements".

· "I spent a lot of time trying to complete my experience, but without success. The Mirage XR was crashing or running very slowly, and I had a problem of overheating my device. Unfortunately, I was not able to explore in a more effective way because of the technical issues that I already described."

The feedback about the MirageXR application received a mixed response, where; half of the teachers were satisfied with the performance and functionality of the toolkit, while the others reported some technical issues. From the HCI perspective, the application faced some significant drawbacks due to adaptability issues, the teachers were not used to the interface and reported problems with the navigation of the application. The post-survey consisted of the question related to problems and drawbacks "What problem did you encounter when working with AR Toolkit App?", some teachers(n=24) responded with "Technical Issues with AR toolkit, AR related", while other teachers (n=33) reported "Technical Issues with AR toolkit, not AR related".

Overall, from the HCI perspective, the teachers were not satisfied with the usability of the application, the teachers' feedback also took the expected/estimated/projected student experience into account. Some teachers faced difficulty in providing instructions to set up the application to their students, as they approximately took four to five hours to navigate the application. The teachers reported too much use of body muscle while using the Mirage XR toolkit, which might not be feasible for students. These issues can be addressed in a future study to guarantee proper performance of the MirageXR toolkit.

Table 3 Teachers usability comments

Category	Interview Response
User Interface	"I have to practice and explore more the Mirage XR." "I had some issue with the app and I did my best to accomplish this voluntary task but, regrettably, I couldn't."
Time Consumption	"The continuous process of calibration can be troublesome, finding a compatible device is not easy. The whole process can be time-consuming, even though it worths it: I just expected it to be more user-friendly"
Compatibility	"Because the app didn't work appropriately" "The app it do not work on my android phone" "Unfortunately, my devices were not compatible with this AR app"
Guidance	"I would have needed subtitles and precise guidance of the actions to be taken. The Mirage XR app is quite heavy, but mostly it is not clear how to build the activity. I struggled a lot with implementing the storyboard and after numerous" "The promise is great but I experienced too many hiccups in the implementation of an activity, so I think the system, support, and tutorials are not on the required level."

Expected Barriers due to Usability Issues:

The MirageXR toolkit interviews from teachers addressed some significant concerns regarding the application; the most common issue reported was that teachers did not understand the application's user interface or did not have enough guidance to use it. One

of the teachers reported that they could not use the application due to compatibility issues and didn't have other resources to install it.

The application can be a barrier to the students due to the limited availability of resources; some schools restrict the use of phones in the classroom. The teachers reported that the application crashed and had compatibility issues on iOS devices, and the Android users reported that their phones were boiling while using the application. From the HCI point of view, the Mirage XR application faced some significant barriers to usability. Most of the teachers expressed their need for training and application support during the interviews "I need someone to hold my hand and help me navigate the application", and "it should be more accessible and compatible."

The teachers' feedback reflects their motivation to use the Mirage XR application, their willingness to overcome the usability barriers, and the need for additional support and guidance to improve the performance of the MirageXR application. We can conclude that the usability of the MirageXR application needs to be improved to ensure acceptance and adoption by students and teachers.

Conclusion from the HCI perspective:

Overall, the interviews revealed a variety of experience, needs, and issues from the teachers. It can be argued that the toolkit has some minor drawbacks due to the application compatibility issues. In terms of advantages for teaching and learning processes, the application's usability should be improved to increase student-teacher engagement with the MirageXR application. The teachers can utilise the potential of the application for supporting student learning if the time consumption as well as the compatibility issues are resolved.

6 Workshop Data

Very recently the Indian School Education Department, in collaboration with augmented and virtual reality (AR/VR) startup Meynikara, has launched a series of immersive learning courses at five regional government-backed schools. "Meta Kalvi", an immersive learning lab is associated with this initiative and enables Metaverse-based science, technology, engineering, and math (STEM) education. Meta Kalvi provides affiliated schools with real-time 3D environments where teachers and students can collaborate and learn. The labs also aim to improve the way students participate in learning theoretical concepts by allowing them to interact with immersive *visualizations. Furthermore,* MeitY Startup Hub and Meta will shortlist 80 innovators and select 16 for further support contributing to the advancement of the XR technology ecosystem. Since 2022 India is accelerating development in Extended Reality Technologies and the project coordinator (Prof. Eleni Mangina) through the activities for UCD Global Engagement and visits at Schools, delivered visiting lectures to secondary school students on how AI can be utilised for our everyday life and the XR developments in

the area of education. During the lecture, the teachers were participating, and the stakeholders welcomed with enthusiasm the new realism of XR applications. The data were collected face to face by pen and paper anonymously after the students and teachers downloaded the ARETE MirageXR application on their devices. This data collection was associated with the research question: "How did students from India perceive the motivational effects of the ARETE toolkit".

6.1 Methodology & Sample

The data introduced in the following were collected from a convenience sample of n=138 students[8]. As in the case of ARETE pilots 1 and 2, the Intrinsic Motivation Inventory [IMI] (CSDT, n.d.) was applied to capture the students' perceptions about the perceived motivational impact of the application used on a scale from 1 (not at all true) to 7 (very true).

The IMI defines motivation as an interplay of different subscales (ibid.). For the current context, the three items for each of the following subscales were included: interest/ enjoyment, perceived competence, effort, value/ usefulness, felt pressure and tension, and perceived choice (ibid.).

The scale shows a very good internal consistency with Cronbach's α .82.

The following average ratings were recorded:

[8] It was intended to amend the students' evaluation of motivation by surveys with the teachers involved in the workshops, applying the same online surveys used for the other pilot 4 teachers. However, the response rate was very low: 10 teachers (6 from India, 2 from South Africa, 1 from Singapore, 1 from Spain) filled in the pre-survey and only 1 teacher from Ireland filled in the post survey.

The pre-survey responses show a high share of educators in higher education and some previous familiarity with AR. These teachers' expectations for their work with the toolkit within the workshop context resemble the expectations mentioned by the other pilot 4 teachers, e.g., with regard to learning how to use AR in teaching and learning. The one post survey feedback collected was very positive, always indicating the highest ratings and best options.

Due to the very low response rate and the limited informative value, the results are not included in this report in greater detail.

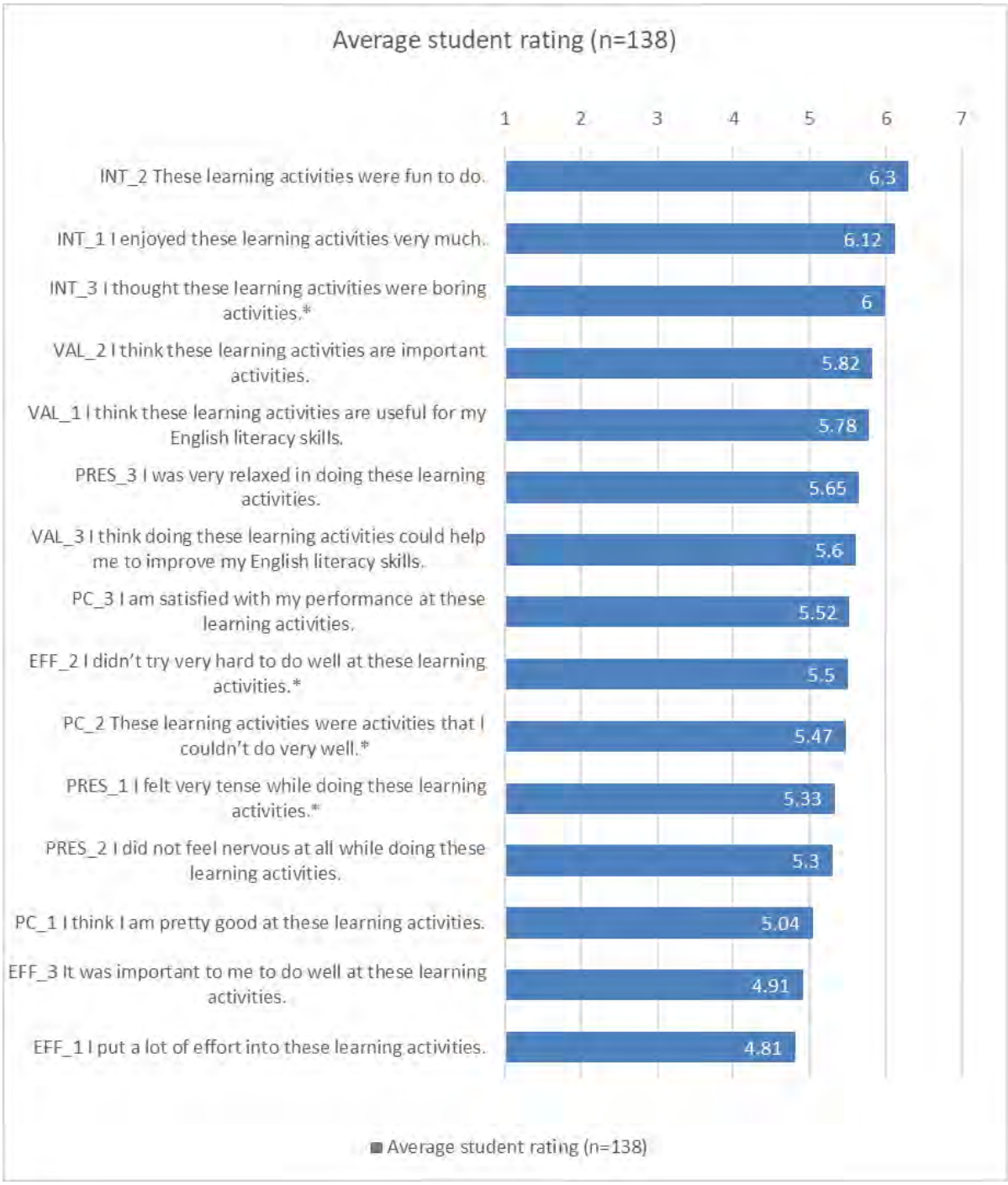


Figure 24 Self-assessed student motivation according to workshop data

For the interpretation of these IMI data, it is important to note that items marked with an asterisk are reverse items: in these cases, the scale works inverted, meaning that a lower

value would mark a better result. For the consistency of data presentation, these data were recoded so that a higher value now means a better evaluation as in case of all other items.

On the scale from 1 (not at all true) to 7 (very true), the average student rating across all items is 5.54 (SD .80). Based on this finding, it can be concluded that the students overall confirmed a motivational effect of the application. Only 5 out of 138 students gave an average rating of below the medium value of 4.

With regard to the different constructs or sub-dimensions of motivation inherent in the IMI model of motivation, it is noteworthy that items relating to interest/enjoyment received the highest confirmation (mean 6.15, SD 1.12), followed by value/usefulness (mean 5.74, SD 1.08). Apparently, the limited experience with the toolkit the participants had during the workshop was perceived as fun and successfully conveyed the usefulness of the tool. On the other hand, it is understandable that the subscales for Perceived Competence (mean 5.34, SD 1.20) and especially for effort (mean 5.08, SD 1.10) received lower average ratings, given the limited opportunity to actively work and learn with the toolkit in the context of the workshop.

These observations on the level of sub-dimensions lead to the conclusion that overall, a motivational effect of the MirageXR toolkit was confirmed by the student participants in the workshops, with a strong confirmation especially for its stimulation of interest and enjoyment and for its value and usefulness.

However, this conclusion needs to be interpreted in the context of the limited exposure to the toolkit in the context of the workshop, which potentially results in a superficial assessment. Also, social desirability needs to be considered as a potential influence, especially with regard to the face to face-setting and the pen and paper-versions of the scale used in the workshops.

6.2 ARLEM - learning activities files and design artefacts

Learning experience: The learning experience files and the designed artefacts – were stored in ARLEM format (augmented reality learning experience models) and in compliance with IEEEP1589-2020 Standard. As previously stated, not all trial participants chose to upload their whole learning experiences designs (LXD) and not all participants followed the preparatory design artefact process, which was designed to assist and inspire teachers to create an innovative LXD. However, the participants who did follow the training and instructions and selected to upload artefacts and the LXD files produced interesting and engaging short learning experiences.

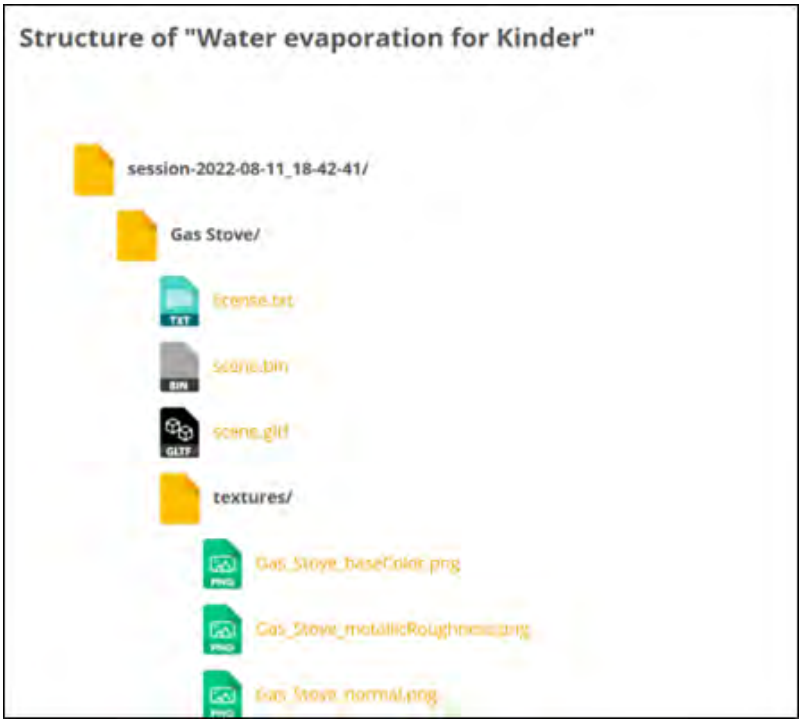


Figure 25 An example of the learning activities data as shown in archive

It was interesting to note that the diversity of the learning experiences that were created by the trial participants, diverse in content and technical use of multimedia. Many of the teachers selected characters and added in audio (wav.) files with succinct learning points of interest. Some participants decided to upload a full and complete learning experience which could be downloaded and used immediately, whereby others only partly uploaded audio files and visual images.

6.3 Design artefacts

Pilot 4 trial participants were invited to share their training materials, augmentation plans, design artefacts with their fellow trial participants within a forum.

The resources and materials used within the learning experience design consisted of the following elements:

· *Problem statement—Teachers* were asked to select an appropriate teaching problem that could become part of the trial, e.g., explaining the water cycle, how students could t work independently, or as simple as how learners could set up their desk at the start of the day.

· *Empathy canvas* – teachers were offered an empathy canvas as a stimulus, a document that would act as catalysts to allow them to define, control and actuate the

kind of experiences their students would have whilst using the learning experience application.

· *Activity map* – To facilitate the teachers with a comprehensive activity plan, they were given five-step activity maps and asked to log a step-by-step approach to events and happenings within their learning experience.

· *Augmentation plan* – Mirage XR supports 14 different types of augmentation e.g., image, videos, labels, and models. All augmentations were designed to assist the teachers to draw their student's attention to a specific and meaningful part of the learning activity. Teachers were requested to select an appropriate range of augmentations and to add it to the augmentation plan.

Samples of completed problem statement, empathy map, activity map and augmentation plan

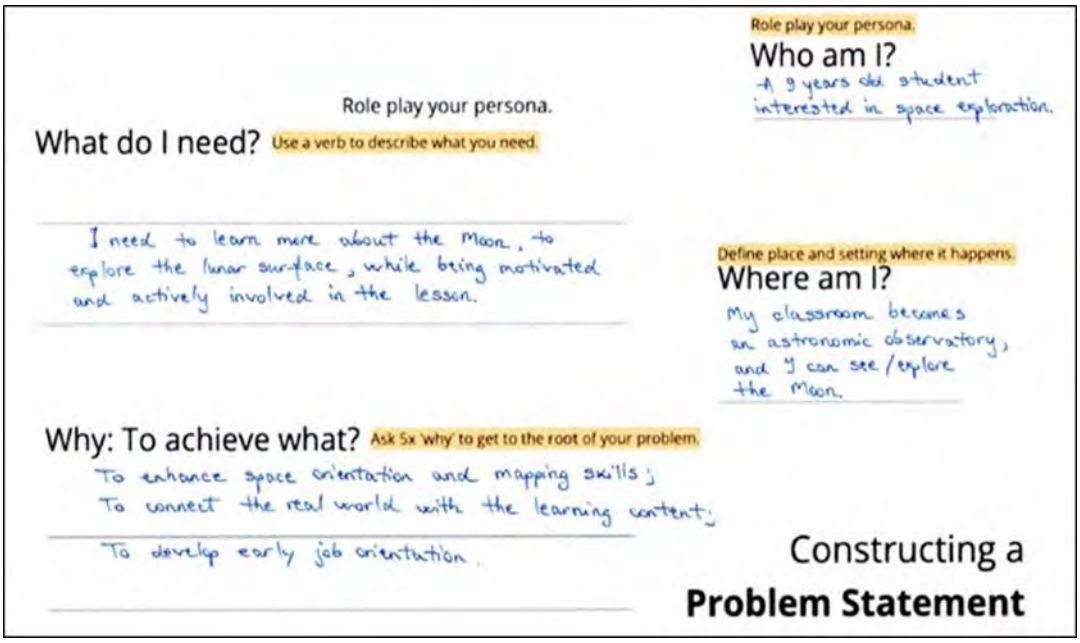


Figure 26 Problem statement example

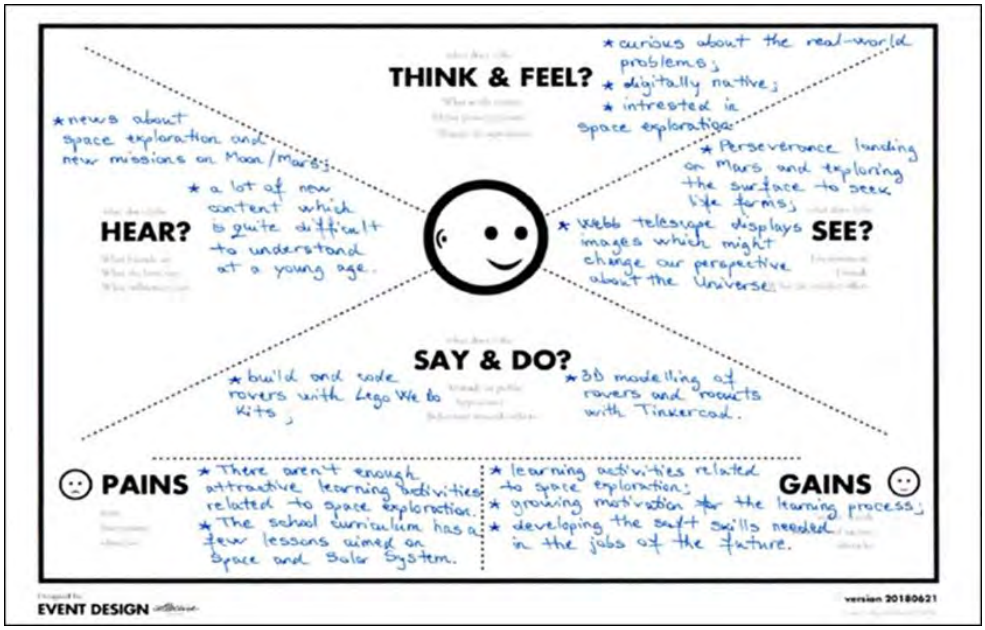


Figure 27 An example of an empathy canvas

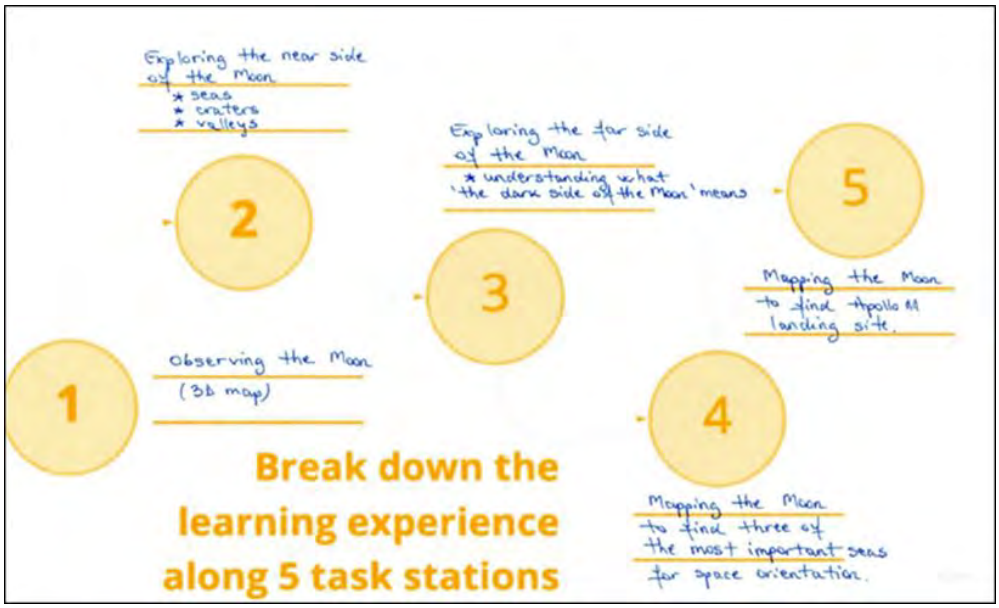
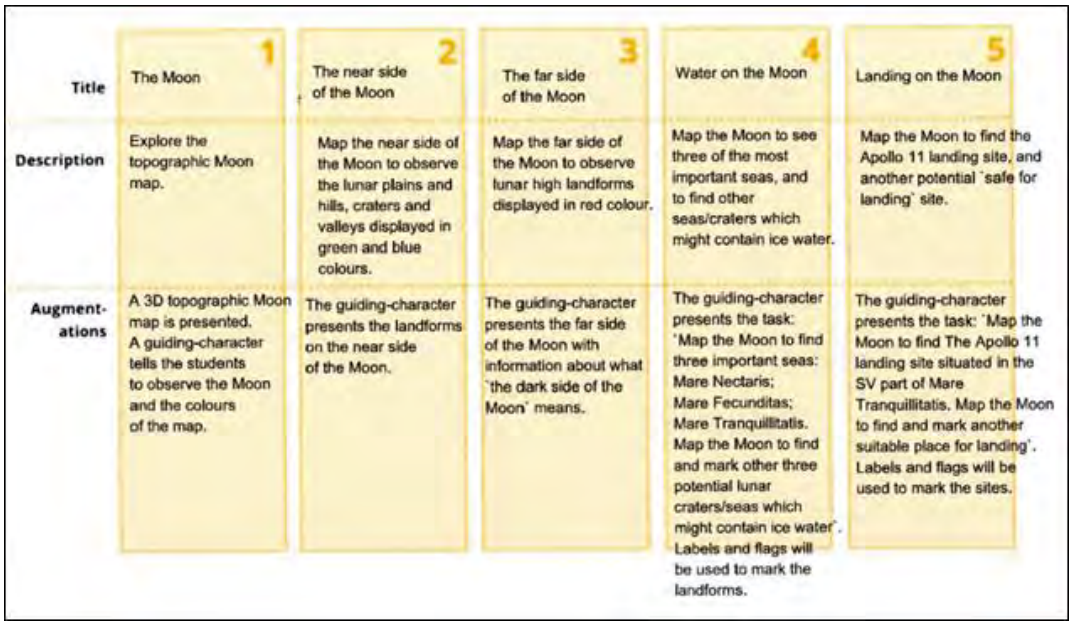


Figure 28 An Example of the five-step learning experience plan



	1	2	3	4	5
Title	The Moon	The near side of the Moon	The far side of the Moon	Water on the Moon	Landing on the Moon
Description	Explore the topographic Moon map.	Map the near side of the Moon to observe the lunar plains and hills, craters and valleys displayed in green and blue colours.	Map the far side of the Moon to observe lunar high landforms displayed in red colour.	Map the Moon to see three of the most important seas, and to find other seas/craters which might contain ice water.	Map the Moon to find the Apollo 11 landing site, and another potential `safe for landing` site.
Augment-ations	A 3D topographic Moon map is presented. A guiding-character tells the students to observe the Moon and the colours of the map.	The guiding-character presents the landforms on the near side of the Moon.	The guiding-character presents the far side of the Moon with information about what `the dark side of the Moon` means.	The guiding-character presents the task: `Map the Moon to find three important seas: Mare Nectaris; Mare Fecunditas; Mare Tranquillitatis. Map the Moon to find and mark other three potential lunar craters/seas which might contain ice water`. Labels and flags will be used to mark the landforms.	The guiding-character presents the task: `Map the Moon to find The Apollo 11 landing site situated in the SV part of Mare Tranquillitatis. Map the Moon to find and mark another suitable place for landing`. Labels and flags will be used to mark the sites.

Figure 29 An example of the augmentation plan

7 Conclusions

This report offers evaluations for Pilot 4, (WP6) (ARETE, The Interactive Authoring Toolkit integration with MirageX) within the ARETE project plan. Pilot 4 was designed to evaluate the usability and acceptance of AR technology by teachers to facilitate them to design innovative and engaging learning experiences. This report has provided full details of the authoring tool, which were trialled by experienced in-service teachers. Within the report we show user demographics, detailed methodology as well as a full evaluation of the findings at each phase of the pilot 4 pre & post intervention, the report closes with results from a sample group (n=12) interview.

7.1 Recommendations and outlook

Since the beginning of Pilot 4 trial participants have engaged pragmatically with the forum using it as a platform to feedback useful and practical suggestions as well as open discussions. Within the forum threads, participants recommended usability issues and technical changes to MirageXR, for example, some participants found the authoring app challenging, whilst others enjoyed the quality and function of the application and augmented characters, some noted they learned a great deal about using the application, whilst others felt frustrated at first, but with time managed to achieve a useful learning experience. However, it is

noteworthy that more participants fed back that they found the app more acceptable - under the category of ease of use, than unacceptable (40 vs 24).

All technical and usability participant feedback was used to strengthen the next iteration of MirageXR version 2 (v2), which was released end of January 2023, to the Google Play Android and iOS Apple App stores. There are high expectations at the partners for future work with MirageXR, i.e., work that goes beyond the remit of ARETE project. For example, the Open University is now building new openXR studios for production of XR content for the benefit of all teaching programmes and for all 205,000+ students, which includes, as a centrepiece version 2 of MirageXR as a key delivery channel.

Overall, authoring toolkits for use by non-experts are still relatively limited. Nevertheless, this study has offered evidence that authoring tools such as MirageXR app have been proved to be useful to support teachers in their creation of learning experiences. The ARETE development and research team are encouraged by the outcome evaluations for pilot 4, and we are looking forward to the potential of MirageXR (version 2) and its use within future work.

In response to participant feedback, the ARETE research team developed a new version 2 (V2) of the MirageXR application. The following are screenshots showing the new layout and adaptations for MirageXR (V2).

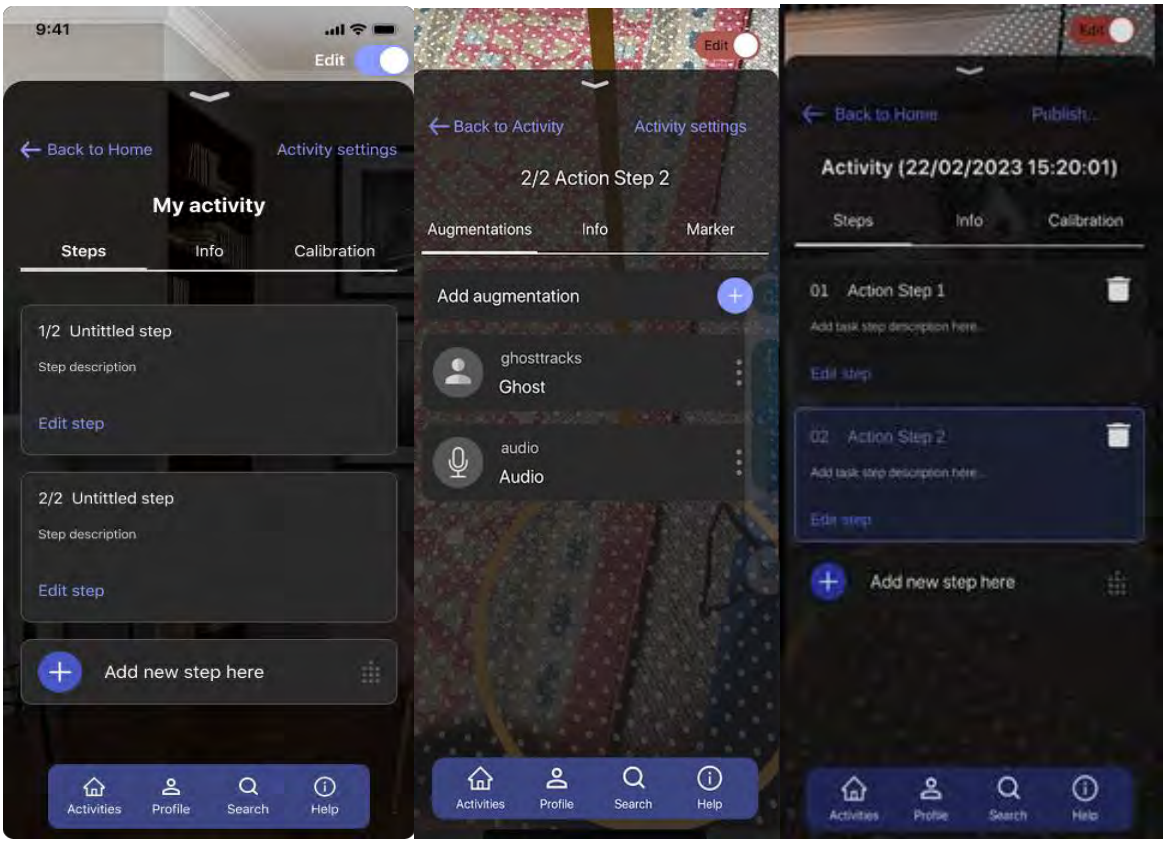


Figure 30 Screen shots from Mirage XR (V2)

In response to user feedback - presented in this report, the following points highlights a sample of a much larger gamut of changes made to Mirage XR (v1.9). For the full changelog, please refer to annex 7 – that shows the full release changelog for the changes since version V1.9 to V2.0.

Sample of new features and additional features:

- **New and improved mobile user interface.** We completely redesigned the concept of user interaction and dialogues on the mobile platforms. The app now has a significantly improved usability and user experience, and many new features.
- **Context help.** We introduced a new dynamic context help system, with a comprehensive set of help dialogues.
- **Interactive tutorial.** We added a facility for step-by-step interactive tutorials and added a tutorial introducing the user to the editing functionality.
- **Onboarding:** We added onboarding swipe-through slides on first app launch, explaining the key concepts of MirageXR with text and animations.
- **Bottom bar:** We added a new bottom tab bar with icons for quickly switching between activity stream, profile, search, and the new dynamic context help.

- **Quick edit toggle:** We introduced a new edit toggle button in the top right corner of the mobile user interface for quickly switching from viewing to editing.

The focus for the changes has been to strengthen usability redesign of the interface, interactive tutorial, adding contextual help, and swipe gestures through features for ease of use.

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9 List of annexes

9.1 ***ARETE Pilot 4 Information Leaflet & Consent form.pdf***

9.2 ***ARETE Pilot 4 Data Flow Diagram.pdf***

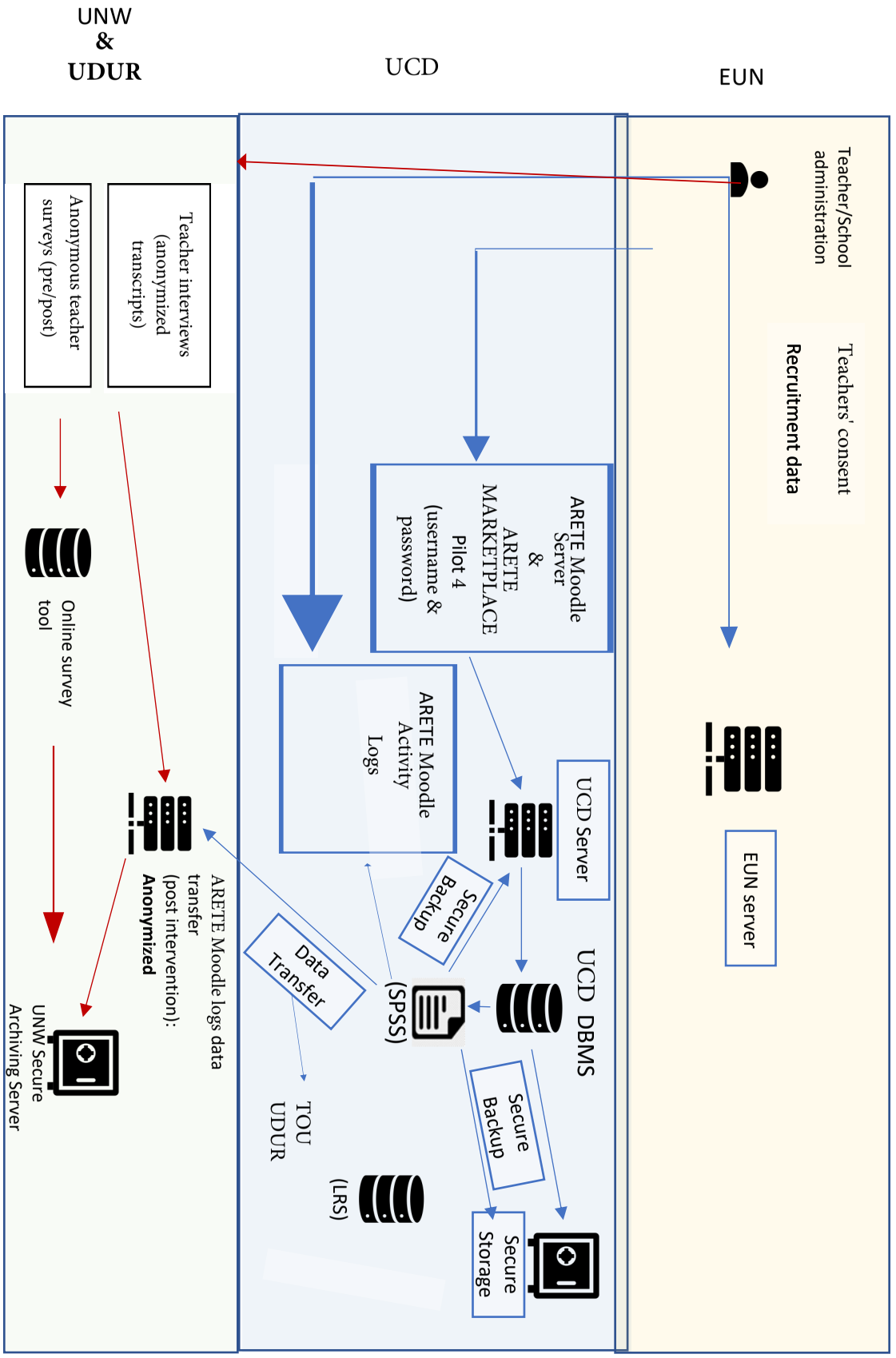
9.3 ***ARETE Pilot 4 Record of Processing Activities.pdf***

9.4 ***ARETE Pilot 4 Teachers Pre Survey.pdf***

9.5 ***ARETE Pilot 4 Teachers Post Survey.pdf***

9.6 ***ARETE Pilot 4 Interview.pdf***

9.7 ***ARETE Pilot 4 Changelog***



(Pilot 4 Data flow diagram (UCD, EUN School, UDUR, UNW)

TEACHER INFORMATION FOR THE ARETE PILOT 4 PROJECT

Main information

WHAT IS THIS RESEARCH ABOUT?

WHO IS DOING THIS RESEARCH? This pilot (Pilot 4) is one of four pilot studies of the Horizon 2020 funded ARETE project which is coordinated by Prof. Eleni Mangina from the University College Dublin in partnership with European Schoolnet (Belgium), Vrije Universiteit Amsterdam (The Netherlands), National Research Council (Italy), WordsWorth Learning (Ireland), CleverBooks (Ireland), University of Durham (UK), University of Würzburg (Germany), Vicomtech (Spain), and The Open University (UK).

WHY WOULD YOU CONSIDER PARTICIPATING IN THIS RESEARCH? By taking part in this pilot, you will contribute to evaluating novel AR interactive technologies for teaching. The data we gather from this project would help design and develop more effective and efficient digital education solutions and contribute to improving XR Open Educational Resources.

WHAT ARE THE SELECTION CRITERIA TO TAKE PART? To help us in this research project, we are looking for teachers who:

- have a good level of English language (B2 in Reading and B1 in Writing + Speaking)
- are pre-service or in-service teachers
- are willing to participate
- have an AR-compatible iOS[1] or Android[2] phone or tablet

To test if your mobile device is compatible, simply search the Google Play Store / Apple App Store for the "MirageXR" (one word) and install/run the app. If the store allows you to install, your device is compatible.

WHEN WILL THE RESEARCH START? We aim to start in May 2022 after the recruitment stage is completed.

WHAT DO WE EXPECT FROM YOU? Before starting to use the AR authoring kit, we will ask you to sign consent forms. Then, you will be invited to create an account on our ARETE online platform, which we will use to train you and manage data collection for the pilot study. Following training and a pre-questionnaire, you will then design your own AR experience, guided and supported by our project team. Finally, you will fill in a post-questionnaire. Some of you will be invited to an interview by our research team.
We will ask you to provide us with feedback on the content design experience and the app use. The focus of our study is on teacher authoring, so we will NOT ask you to try out the designed learning experiences with your students (but you can do that if you want to). The AR content you design will later be contributed to an Open Content pool (on the ARETE Marketplace), once the research is finished.
We expect the process to start in May and end in June, and it would take you a total of 10 hours max to participate in the training, fill in the feedback forms, and test out the XR platform. We will keep the study open over the summer, to allow for a second wave of participant recruitment.

HOW WILL YOUR DATA BE USED?
The data collected during the Pilot 4, include personal data during registration, pseudonymised data collected from interviews, focus groups, audio recordings, questionnaires, and surveys. Furthermore, through data logging personal data will also be collected in the form of email-ID and password for registration process to ARETE authoring toolkit and ARETE data repository. For the analysis purposes of the activities within the Learning Management System, will be anonymised for publications' purposes utilising the AMNESIA[3] software provided from Horizon 2020. The methods of data collection for Pilot 4 include:

[1] Any iOS device with an A9 chip and above (released Sep 2015): iPhone 6S and higher, iPhone SE, all iPad Pro, iPad 2017/5th Gen or higher; no ipad mini!
[2] Most Android phones and tablets younger than August 2016, full list see here: https://developers.google.com/ar/devices
[3] https://amnesia.openaire.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 856533. Content provided and information within this document is the sole responsibility of the ARETE Consortium and does not necessarily represent the views expressed by the European Commission or its services.

1. **Recruitment:** The recruitment of all teachers will take place via EUN. All personal identifiable data collected during recruitment will remain and will be in the possession of EUN and **will not** be shared with any other members of the ARETE project team.
2. **Questionnaires/Surveys:** Questionnaires refer to forms filled in by respondents and will take place online. Respondents need to fill out the forms themselves. Two online surveys (before and after the content creation experience) will be administered to all teachers involved in the study. Interview and focus groups will involve only selected participants.
3. **Direct observations**

3.1 Data logging: The ARETE project will collect information about the teachers, while experimenting and using the ARETE authoring toolkit based on confidentiality and data protection. All identifiable data collected through Moodle Learning Management System and the project Marketplace will be removed after the pilot data collection.

3.2 Data exchange between the Pilot applications and the ARETE digital repository: The data collected will be sent to the Open University, the University of Würzburg, and the University of Durham for analysis to evaluate the authoring toolkit from a teacher perspective. Data will be exchanged via secure cloud storage to guarantee privacy and integrity of the exchanged data. Pilot 4 does not (seek to) collect any sensitive data. All anonymised research data will be deposited to ZENODO[4] open source ARETE community digital research data repository by UCD.

WHAT WILL HAPPEN IF YOU DECIDE TO TAKE PART IN THIS RESEARCH STUDY? With this pilot study (ARETE Pilot 4), we seek to evaluate quantitatively and qualitatively, in which ways and how well our authoring toolkit supports teachers in designing XR learning experiences. The consortium confirms that Teachers will have been provided with information on all recipients of their data in advance of any processing of their personal data.

HOW WILL YOUR PRIVACY BE PROTECTED? Teacher consent forms will be collected and stored by EUN. The ARETE consortium will follow the GDPR rules and inform the participants how their data will be used.

All research data within the ARETE project will be anonymised/pseudonymised.
The ARETE consortium will ensure that data gathered for research are not collected in such a way that allows the results to be reasonably traced back to individual participants.

- Research data (i.e., survey responses, interview responses) gathered will always be anonymized.
- Personal information gathered (e.g., informed consent forms) will be processed in accordance with the privacy notice.

WHAT ARE THE RISKS OF TAKING PART IN THIS RESEARCH STUDY? There is minimal risk to participants in taking part in this research project. The ARETE project follows the high ethical guidelines and standards required for EU Horizon 2020 Projects.

CAN YOU CHANGE YOUR MIND AT ANY STAGE AND WITHDRAW FROM THE STUDY? Yes, if you decide that you do not wish to participate, you may withdraw at any time, and you do not need to provide a reason and with no disadvantage. Just please inform EUN of your decision. All data linked to your participation will then be immediately destroyed.

HOW WILL YOU FIND OUT ABOUT THE OUTCOMES OF THIS PROJECT? Once the project is completed and the results have been published, the information will be uploaded onto the ARETE website.

CONTACT DETAILS FOR FURTHER INFORMATION: For more information on this project please visit http://www.areteproject.eu/ or email arete@ucd.ie. If you feel that your private data or your rights were infringed under the GDPR, you have the right to make an official complaint to the data protection authorities in your country or the data protection authority where the infringement occurred https://edpb.europa.eu/about-edpb/about-edpb/members_en.

[4] https://zenodo.org/communities/augmented/

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TEACHER CONSENT FORM

ARETE Pilot 4: Teaching with eXtended Reality – Evaluating the MirageXR Authoring Tool.

Note: All personal identifiable data collected in this form will be collected by and remain in the possession of EUN and **will not** be shared with any other members of the ARETE project team. Please refer to the privacy section in the Information handout for further details.

- I have read and understood the teacher information leaflet for the ARETE Pilot 4 study.
- I understand what the study is about and what my results will be used for.
- I have had time to consider whether to take part in the study.
- I understand that my personal information will not appear on any research data from this pilot study and any audio/video recordings will be deleted permanently once information for the project is collected and will not be shared[5].
- I am aware of the procedures involving my participation and of possible risks and benefits associated with the study.
- I understand that my **participation is voluntary** (choice under free will) and that I am free to withdraw from the research study at any time without disadvantage and without giving any reason.

Therefore, **I agree to take part in this research** (please tick the box): ☐

I hereby give my permission for the use of **pseudonymised** data collected from me and through the use of the ARETE Authoring toolkit for the following purposes:

1. **Publications and conference presentations.**
2. **Future research (subject to ethical review).**
3. **Sharing of pseudonymised data with third parties for research purposes only.**

If in agreement, please tick the box ☐

Name of Teacher (in block letters): _____

School: _____ Class: _____

Signature: _____ Date:_____

Please return this form to: maria.delmiche@eun.org

CONTACT DETAILS FOR FURTHER INFORMATION:

For more information on this project please visit http://www.areteproject.eu/ or email arete@ucd.ie.
If you have any questions about the protection of your personal data or if you wish to exercise your rights under the GDPR to access, rectify or, as the case may be, to erase any personal data relating to you or restrict the processing of your personal data, you may contact us at arete@ucd.ie.
Further information can be found at: https://www.areteproject.eu/gdprpolicy/
If you feel that your private data or your rights were infringed under the GDPR, you have the right to make an official complaint to the data protection authorities in your country or the data protection authority where the infringement occurred:

[5] Except for public workshop and conference events, where consent will be required prior to the event.

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ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Introduction

Thank you for participating in the ARETE project. ARETE (https://www.areteproject.eu) is an EU-funded project, aiming to develop and evaluate the effectiveness of an interactive Augmented Reality (AR) content toolkit. This will give students and teachers access to innovative AR content to enhance their learning and teaching.

The following survey is part of an ARETE pilot study which will be evaluated to assess the usability and pedagogical usefulness of the AR toolkit in education. It will take you about 15 minutes to complete.

Your answers in the following questionnaire are a central resource for this evaluation and of great value for this project. There are no right or wrong answers. **Please fill in all questions honestly and completely** to ensure a comprehensive and significant evaluation. Please note that your participation is voluntary.

The questionnaire is entirely anonymous. We assure you that your data will be treated in the strictest confidence and in accordance with General Data Protection Regulation (GDPR) <https://www.ucd.ie/gdpr/about/>. The data will only be viewed by personnel working on this project, will not be forwarded to third parties and will be used solely for research purposes.

If you have questions regarding this survey or the evaluation process, please contact a member of the evaluation team: Jennifer.tiede@uni-wuerzburg.de

1. Please confirm that you have read the information above and that you give us your consent to use your anonymous responses for our research work by checking the box:

☐ I agree

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Demographic Data

2. What is your gender? (select one answer)

- ◯ Female
- ◯ Male
- ◯ Other / prefer not to say

3. What is your age?

4. What is your country of residence?

5. How many years of teaching experience do you have? (select one answer)

- ◯ None yet / preservice teacher
- ◯ < 5 years
- ◯ 5 - 10 years
- ◯ > 10 years

6. At what kind of school are you teaching / going to teach? (select all that apply)

- ☐ Pre-School / Kindergarden
- ☐ Primary School
- ☐ Secondary School
- ☐ Higher Education
- ☐ Other context (please specify)

7. Which subjects are you teaching / going to teach? (select all that apply)

- [ ] Languages
- [ ] STEM (Science, Technology, Engineering, Mathematics etc.)
- [ ] Arts & music
- [ ] History, social & cultural studies
- [ ] Physical education
- [ ] Other (please specify)

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Digital Pedagogical Expertise and Previous Experience with AR

8. How do you rate your level of expertise in using digital media for teaching and learning? (select one answer)

- ◯ Very good
- ◯ Good
- ◯ Acceptable
- ◯ Poor
- ◯ Very poor

9. Have you heard or read about Augmented Reality before this project? (select one answer)

- ◯ Yes, a lot
- ◯ Yes, a little
- ◯ No
- ◯ I don't know

10. Have you ever used an Augmented Reality app in your leisure time? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

11. Have you ever used an Augmented Reality app for teaching and learning outside of this project? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Teachers' Digital Pedagogical Competence and Previous Experience with AR II

12. Have you ever created own content with AR for teaching and learning outside of this project? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Teachers' Attitudes

13. Apps which include Augmented Reality may have different qualities for teaching and learning. To what extent do you agree with the following statements: (select one answer per row)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
They are fun for the students.	◯	◯	◯	◯	◯
They are hands-on for the students.	◯	◯	◯	◯	◯
They are motivating for the students.	◯	◯	◯	◯	◯
They increase the students' classroom engagement.	◯	◯	◯	◯	◯
They promote cognitive learning.	◯	◯	◯	◯	◯
They promote collaborative learning.	◯	◯	◯	◯	◯
They help increase content knowledge acquisition.	◯	◯	◯	◯	◯
They can be used as rewards when students do well in class.	◯	◯	◯	◯	◯
They can be used to promote learning objectives that meet curriculum requirements.	◯	◯	◯	◯	◯
They can be used as supplemental learning materials.	◯	◯	◯	◯	◯
They bridge the gap between what students do at home and at school.	◯	◯	◯	◯	◯
They improve student attitudes toward the content.	◯	◯	◯	◯	◯
They promote personalized learning.	◯	◯	◯	◯	◯
They can promote learning in STEM (science, technology, engineering, mathematics).	◯	◯	◯	◯	◯
They can promote literacy skills.	◯	◯	◯	◯	◯
They are easy to set up to facilitate classroom teaching and learning.	◯	◯	◯	◯	◯
They bring me into a better position among classroom teachers who are interested in using digital technologies for teaching.	◯	◯	◯	◯	◯
They provide me with another platform to engage my students in learning.	◯	◯	◯	◯	◯
Using them helps me relate to my students.	◯	◯	◯	◯	◯
I enjoy incorporating them into teaching.	◯	◯	◯	◯	◯
Nowadays students are attuned to learning with Augmented Reality.	◯	◯	◯	◯	◯

Teachers' Attitudes

14. To what extent do you agree with the following statements: (select one answer per row)

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I look forward to those aspects of my job that require me to use Augmented Reality (AR).	◯	◯	◯	◯	◯	◯	◯
My interaction with AR is clear and understandable.	◯	◯	◯	◯	◯	◯	◯
I have the resources necessary to use AR.	◯	◯	◯	◯	◯	◯	◯
I like working with AR.	◯	◯	◯	◯	◯	◯	◯
I am addicted to using AR.	◯	◯	◯	◯	◯	◯	◯
People in my school who use AR have more prestige than those who do not.	◯	◯	◯	◯	◯	◯	◯
AR needs to work together with existing software I use.	◯	◯	◯	◯	◯	◯	◯
The support provided allowed me to use AR to a higher standard than without.	◯	◯	◯	◯	◯	◯	◯
I worry that I could become too dependent on a single AR tool and supplier.	◯	◯	◯	◯	◯	◯	◯
I could complete the pilot task if I had used similar technologies before in my job.	◯	◯	◯	◯	◯	◯	◯
With AR, I immediately know when a learning activity is finished.	◯	◯	◯	◯	◯	◯	◯
Using AR increases my productivity.	◯	◯	◯	◯	◯	◯	◯
The AR learning activity was well supported by the system.	◯	◯	◯	◯	◯	◯	◯
AR increases precision of learning activities.	◯	◯	◯	◯	◯	◯	◯
People who are important to me think that I should use AR.	◯	◯	◯	◯	◯	◯	◯
I will always try to use AR in my daily work.	◯	◯	◯	◯	◯	◯	◯
In the future, I would feel comfortable sharing the personal data captured with my school.	◯	◯	◯	◯	◯	◯	◯
The information provided by the application was appropriate for my level of expertise.	◯	◯	◯	◯	◯	◯	◯
The right amount of information was	◯	◯	◯	◯	◯	◯	◯

presented in each step of the activity.

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Engagement with the Toolkit

For the following questions, please refer to your experiences with the ARETE MirageXR Authoring toolkit over the past weeks.

15. How many hours did you spend designing your AR learning activity?

16. What is the target level for your AR learning activity? (select all that apply)

- [ ] Pre-School / Kindergarden
- [ ] Primary School
- [ ] Secondary School
- [ ] Higher Education
- [ ] Other context
- [ ] No specific target level

17. What is the target subject for your AR learning activity? (select all that apply)

- [ ] Languages
- [ ] STEM (Science, Technology, Engineering, Mathematics etc.)
- [ ] Arts & music
- [ ] History, social & cultural studies
- [ ] Physical education
- [ ] Other (please specify)

18. Please summarize in one sentence what your AR learning activity is about.

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Application in Classroom Practice

Imagine applying your AR learning experience in your classroom practice.

19. Which cognitive processes could be addressed with learners by the AR learning activity you designed? (tick all that apply)

- [ ] Remembering (recalling knowledge from memory)
- [ ] Understanding (constructing meaning; e.g., summarizing, comparing, explaining)
- [ ] Applying (using a procedure learned, through executing or implementing)
- [ ] Analyzing (breaking materials or concepts into parts, determining how the parts relate to one another or how they relate to an overall structure or purpose)
- [ ] Evaluating (making judgments based on criteria and standards through checking and critiquing)
- [ ] Creating (putting parts together in a new way, or synthesizing parts into something new and different)

20. What could be the main objectives of using the AR learning activity in your class? (tick all that apply)

- [ ] To provide new information/content
- [ ] To practice contents already learned
- [ ] To trigger and support learning processes
- [ ] To provide a tool for knowledge acquisition
- [ ] To provide a tool for communication
- [ ] To provide a tool for collaboration
- [ ] To give students a break activity
- [ ] To conduct assessments

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Evaluation of Experiences with the App

21. How would you rate your overall experience with the AR toolkit on a scale from 1 (poor) to 5 (excellent)? (select one answer)

poor excellent

☆ ☆ ☆ ☆ ☆

22. How easy was it for you to use the AR toolkit to create your own AR content? (select one answer)

- ◯ Very easy
- ◯ Easy
- ◯ Neither easy nor difficult
- ◯ Difficult
- ◯ Very difficult

23. Please recall your expectations before the pilot.
To what extent were your expectations for the pilot study met?

- ◯ Expectations greatly exceeded
- ◯ Expectations exceeded
- ◯ Expectations met
- ◯ Expectations not fully met
- ◯ Expectations not met at all

24. Please explain in one sentence why your expectations were or were not met.

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Post Test

Evaluation of Experiences with the App II

25. To what extent do you agree with the following statements about the AR toolkit? (select one answer per row)

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
I think that interacting with this application requires a lot of mental effort.	◯	◯	◯	◯	◯	◯	◯
I thought the amount of information displayed on screen was appropriate.	◯	◯	◯	◯	◯	◯	◯
I thought that the information displayed on screen was difficult to read.	◯	◯	◯	◯	◯	◯	◯
I felt that the information display was responding fast enough.	◯	◯	◯	◯	◯	◯	◯
I thought that the information displayed on screen was confusing.	◯	◯	◯	◯	◯	◯	◯
I thought the words and symbols on screen were easy to read.	◯	◯	◯	◯	◯	◯	◯
I felt that the display was flickering too much.	◯	◯	◯	◯	◯	◯	◯
I thought that the information displayed on screen was consistent.	◯	◯	◯	◯	◯	◯	◯
I think that interacting with this application requires a lot of body muscle effort.	◯	◯	◯	◯	◯	◯	◯
I felt that using the application was comfortable for my arms and hands.	◯	◯	◯	◯	◯	◯	◯
I found the device difficult to hold while operating the application.	◯	◯	◯	◯	◯	◯	◯
I found it easy to input information through the application.	◯	◯	◯	◯	◯	◯	◯
I felt that my arm or hand became tired after using the application.	◯	◯	◯	◯	◯	◯	◯
I think the application is easy to control.	◯	◯	◯	◯	◯	◯	◯
I felt that I was losing grip and dropping the device at some point.	◯	◯	◯	◯	◯	◯	◯
I think the operation of this application is simple and uncomplicated.	◯	◯	◯	◯	◯	◯	◯

26. Which problems or drawbacks did you encounter when working with the AR toolkit? (tick all that apply)

- [ ] There were no problems or drawbacks
- [ ] The AR toolkit is not relevant for my teaching
- [ ] There was no added value for me in using the AR toolkit, compared to traditional teaching & learning approaches
- [ ] I am not sure how to integrate the AR toolkit into my teaching
- [ ] Lack of pedagogical/didactical support
- [ ] I am generally unfamiliar with technology
- [ ] I don't like changing my usual teaching habits
- [ ] I did not have enough time to work with the AR toolkit properly
- [ ] Using the AR toolkit cost too much time
- [ ] I expect my students would not like the AR learning experience I designed
- [ ] I expect my students would show problematic student behavior (e.g., trial & error, taking things not seriously, distraction, etc.)
- [ ] Poor user experience in the AR toolkit (e.g., the app was not intuitive, it was difficult to make the app do what I wanted, etc.)
- [ ] Technical issues with the AR toolkit, AR-related (e.g., poor marker detection)
- [ ] Technical issues with the AR toolkit, not AR-related (e.g., long processing times, crashes)
- [ ] Technical issues with devices
- [ ] Lack of necessary technical equipment
- [ ] Lack of technical support
- [ ] Other, please specify:

Invitation to ARETE Interview Study

Thank you very much for your responses.

We would like to hear even more from you and chat with you about your experiences, if possible. Your additional input will be an invaluable contribution to our research and help us better understand teachers' requirements for and expectations towards Augmented Reality.

If you agree to share your experiences with us in an online interview (approx. 1 hour), the ARETE research team will be in touch to arrange for an online meeting on a date that suits your preferences around August 2022.

(Please note that the interview language will be English and it will be recorded for research purposes. All data collected will be strictly anonymized. By agreeing to participate, you give your consent to the recording.)

If you would like to participate, please click on the following link to enter your email address.

LINK TO INTERVIEW STUDY INVITATION

This research has been supported by the European Union's Horizon 2020 research and innovation program under grant agreement No 856533, project ARETE.

ARETE

ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test

Introduction

Thank you for participating in the ARETE project. ARETE (https://www.areteproject.eu) is an EU-funded project, aiming to develop and evaluate the effectiveness of an interactive Augmented Reality (AR) content toolkit. This will give students and teachers access to innovative AR content to enhance their learning and teaching.

The following survey is part of an ARETE pilot study which will be evaluated to assess the usability and pedagogical usefulness of the AR toolkit in education. It will take you about 5 minutes to complete.

Your answers in the following questionnaire are a central resource for this evaluation and of great value for this project. There are no right or wrong answers. **Please fill in all questions honestly and completely** to ensure a comprehensive and significant evaluation. Please note that your participation is voluntary.

The questionnaire is entirely anonymous. We assure you that your data will be treated in the strictest confidence and in accordance with General Data Protection Regulation (GDPR) <https://www.ucd.ie/gdpr/about/>. The data will only be viewed by personnel working on this project, will not be forwarded to third parties and will be used solely for research purposes.

If you have questions regarding this survey or the evaluation process, please contact a member of the evaluation team: Jennifer.tiede@uni-wuerzburg.de

1. Please confirm that you have read the information above and that you give us your consent to use your anonymous responses for our research work by checking the box:

☐ I agree

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ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test

Demographic Data

2. What is your gender? (select one answer)

- ◯ Female
- ◯ Male
- ◯ Other / prefer not to say

3. What is your age?

4. What is your country of residence?

5. How many years of teaching experience do you have? (select one answer)

- ◯ None yet / preservice teacher
- ◯ < 5 years
- ◯ 5 - 10 years
- ◯ > 10 years

6. At what kind of school are you teaching / going to teach? (select all that apply)

- ☐ Pre-School / Kindergarden
- ☐ Primary School
- ☐ Secondary School
- ☐ Higher Education
- ☐ Other context (please specify)

7. Which subjects are you teaching / going to teach? (select all that apply)

- [ ] Languages
- [ ] STEM (Science, Technology, Engineering, Mathematics etc.)
- [ ] Arts & music
- [ ] History, social & cultural studies
- [ ] Physical education
- [ ] Other (please specify)

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Digital Pedagogical Expertise and Previous Experience with AR

8. How do you rate your level of expertise in using digital media for teaching and learning? (select one answer)

- ◯ Very good
- ◯ Good
- ◯ Acceptable
- ◯ Poor
- ◯ Very poor

9. Have you heard or read about Augmented Reality? (select one answer)

- ◯ Yes, a lot
- ◯ Yes, a little
- ◯ No
- ◯ I don't know

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ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test
Previous Experience II

10. Please summarize in one sentence what Augmented Reality means to you.

11. Have you ever used an Augmented Reality app in your leisure time? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

12. Have you ever used an Augmented Reality app for teaching and learning? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

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ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test
Previous Experience III

13. Have you ever created own content with AR for teaching and learning? (select one answer)

- ◯ Yes, 5 or more times in the last 3 months
- ◯ Yes, 1 - 4 times in the last 3 months
- ◯ No
- ◯ I don't know

ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test
Previous Experience IV

14. Please describe your experience with creating own content with AR for teaching and learning in one sentence.

ARETE Evaluation Survey for Teachers • Pilot 4 • Pre Test
Teachers' Attitudes

15. Please summarize in one sentence your expectations for the ARETE pilot study.

16. How easy do you think it will be to use the AR toolkit to create your own AR content? (select one answer)

- ◯ Very easy
- ◯ Easy
- ◯ Neither easy nor difficult
- ◯ Difficult
- ◯ Very difficult

17. Apps which include Augmented Reality may have different qualities for teaching and learning. To what extent do you agree with the following statements: (select one answer per row)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
They are fun for the students.	◯	◯	◯	◯	◯
They are hands-on for the students.	◯	◯	◯	◯	◯
They are motivating for the students.	◯	◯	◯	◯	◯
They increase the students' classroom engagement.	◯	◯	◯	◯	◯
They promote cognitive learning.	◯	◯	◯	◯	◯
They promote collaborative learning.	◯	◯	◯	◯	◯
They help increase content knowledge acquisition.	◯	◯	◯	◯	◯
They can be used as rewards when students do well in class.	◯	◯	◯	◯	◯
They can be used to promote learning objectives that meet curriculum requirements.	◯	◯	◯	◯	◯
They can be used as supplemental learning materials.	◯	◯	◯	◯	◯
They bridge the gap between what students do at home and at school.	◯	◯	◯	◯	◯
They improve student attitudes toward the content.	◯	◯	◯	◯	◯
They promote personalized learning.	◯	◯	◯	◯	◯
They can promote learning in STEM (science, technology, engineering, mathematics).	◯	◯	◯	◯	◯
They can promote literacy skills.	◯	◯	◯	◯	◯
They are easy to set up to facilitate classroom teaching and learning.	◯	◯	◯	◯	◯
They bring me into a better position among classroom teachers who are interested in using digital technologies for teaching.	◯	◯	◯	◯	◯
They provide me with another platform to engage my students in learning.	◯	◯	◯	◯	◯
Using them helps me relate to my students.	◯	◯	◯	◯	◯
I enjoy incorporating them into teaching.	◯	◯	◯	◯	◯
Nowadays students are attuned to learning with Augmented Reality.	◯	◯	◯	◯	◯

Thank you very much for your responses.

This research has been supported by the European Union’s Horizon 2020 research and innovation program under grant agreement No 856533, project ARETE.

Partner Name/Participant schools	Pilot No	Name of Record	Data Subjects	Categories of Personal data	Special Category data	Purpose of processing	Source of data	General Description Of Technical And Org. Security Measures	Retention Period	Categories Of Recipients	Basis For Transfer	Role Of Partner In Data Sharing	Third Countries/ Internat. Orgs That Personal Data Are Transferred To	Safeguards For Exceptional Transfers Of Personal Data To Third Countries Or International Organisations	
EUN	4	Call for pilot teachers (selected)	Pilot teachers	Name, surname, email address, city, country, establishment of teaching, teaching status, address of the establishment of teaching, subjects taught	N/A	Call for project teachers data will be collected by EUN via email (Scientix network) and application form (using third party processor SurveyMonkey)	Data subject	EUN secure server. The Data Processing Agreement with SurveyMonkey for the transfer of data as approved by the European Commission under standard contractual clauses is in place.	6 years post project completion	Respective Ministry of Education	N/A	Data controller	A pontential third party data export.	The Data Processing Agreement with SurveyMonkey for the transfer of data as approved by the European Commission under standard contractual clauses is in place. EUN constantly reviews, audits and updates its technologies, processes, and practices designed to protect networks, computers, programs, and data from unauthorized access or damage. It does regular staff training, regarding the best practices and procedures related to cyber-security.	
EUN	4	Call for pilot teachers (not selected)	Pilot teachers (that do not meet eligibility requirements)	Name, surname, email address, city, country, establishment of teaching, teaching status, address of the establishment of teaching, subjects taught	N/A	Call for project teachers data will be collected by EUN via email (Scientix network) and application form (using third party processor SurveyMonkey)	Data subject	EUN secure server. The Data Processing Agreement with SurveyMonkey for the transfer of data as approved by the European Commission under standard contractual clauses is in place.	1 year after the end of the selection process	Respective Ministry of Education	N/A	Data controller	A pontential third party data export.	The Data Processing Agreement with SurveyMonkey for the transfer of data as approved by the European Commission under standard contractual clauses is in place. EUN constantly reviews, audits and updates its technologies, processes, and practices designed to protect networks, computers, programs, and data from unauthorized access or damage. It does regular	
EUN	4	General coordination of teachers	Pilot teachers	Name, surname, email address	N/A	General coordination	Data subject	EUN secure server	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	
EUN	4	Consent form	Pilot teachers	Name, school, address, signature	N/A	Teachers' consent to participate in ARETE research activities	Data subject	EUN secure server	6 years post completion	N/A	N/A	Data controller	N/A	N/A	
UNW, UDUR, TOU	4	pre/post teacher surveys	pilot teachers	gender, age, country of residence, years of teaching experience, experience with AR, Attitudes towards AR, Technology acceptance, Experiences with MirageXR toolkit, expectations, estimations of role of MirageXR toolkit in teaching & learning processes (anonymized)	N/A	ARETE research	online form	Data collection via SurveyMonkey. Storage at UNW secure server, post-project secure archive server at UNW	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	
UNW, UDUR, TOU	4	Teacher coordinator interviews	pilot teachers	Perceptions of working with the mirageXR toolkit before using it, while using it and after using it. Perceptions of pedagogical aspects of the MirageXR Toolkit such as estimated impact on student motivation, classroom interaction, knowledge gain, future perspectives on AR etc.. Usability aspects.	N/A	ARETE research	Data subject	Interviews conducted jointly by UNW & UDUR. Interviews recorded by EUN, transcribed & anonymized by UNW & UDUR. Analysis by UNW & UDUR. UNW secure server, post-project secure archive server at UNW	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	
UCD	4	ARETE Moodle registrations	Pilot teachers	Username and email addressed from self registration process	N/A	ARETE research	Moodle database	UCD Secure server	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	
UCD	4	ARETE Web services MARKETPLACE	Pilot teachers	Username and email addressed from self registration process	N/A	ARETE research	UCD server database	UCD Secure server	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	
UCD	4	ARETE Moodle activity logs	Pilot teachers	Username and time series of activity logs	N/A	ARETE research	Moodle database	UCD Secure server	6 years post project completion	N/A	N/A	Data controller	N/A	N/A	

ARETE

ARETE MirageXR Interview

UCD DUBLIN

Introduction

- Joint efforts in the ARETE project
- Feedback for improving the Mirage XR application
- The interview will be recorded
- All data will be anonymised – no identifiable personal information in our report or publication
- Feel free to ask question or stop at any time

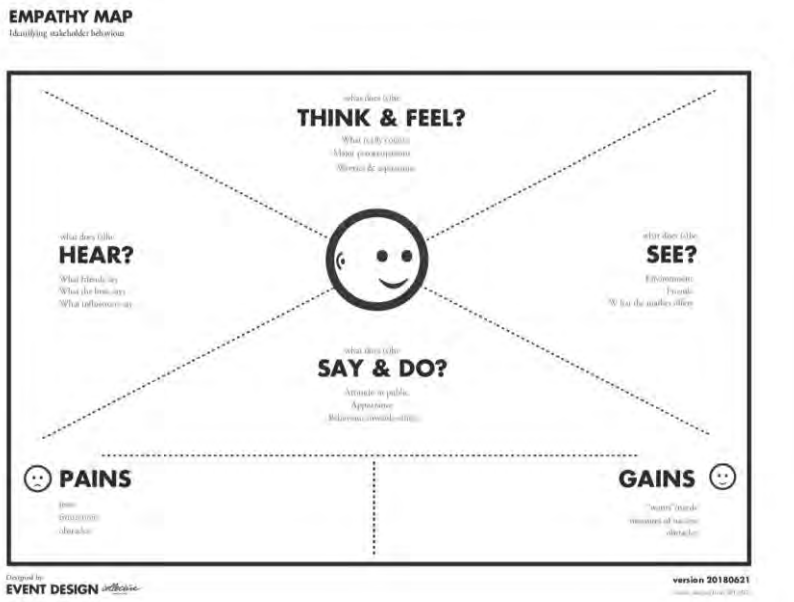
ARETE Mirage XR Interview

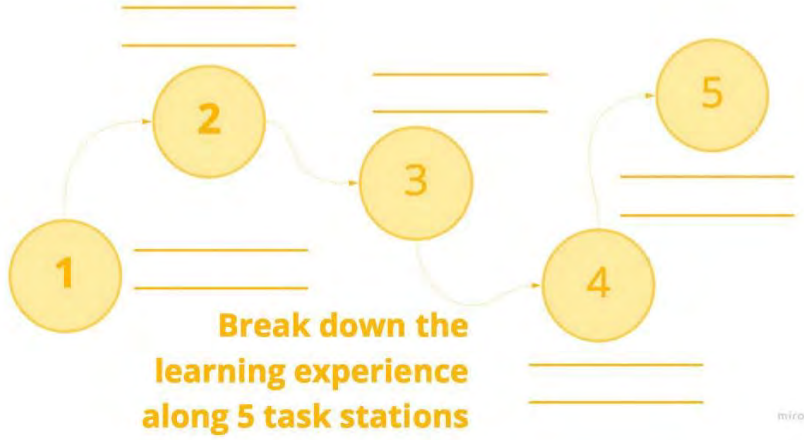
Today, we would like to ask for your feedback on the Mirage XR application at three stages of use:

- Before you used the application
- While you used the application
- After you used the application

ARETE Mirage XR Interview

Before using the app, was the training material adequate to prepare you to use it?





Before using the app

After using the app

While using the app

To what extent do you agree with the following statement?

1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

I think that interacting with this application requires a lot of mental effort.

To what extent do you agree with the following statement?

1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

I thought that the information displayed on screen was confusing.

To what extent do you agree with the following statement?

1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

I think that interacting with this application requires a lot of body muscle effort.

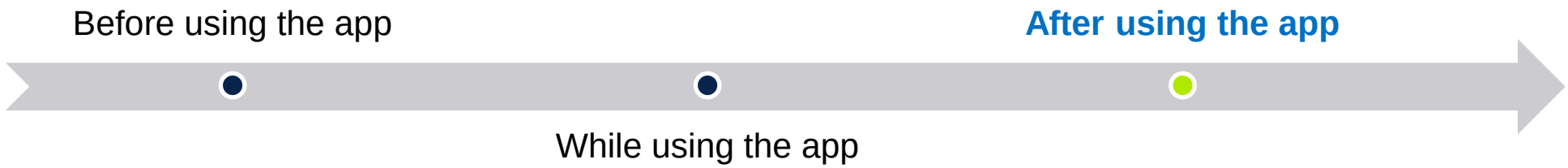
To what extent do you agree with the following statement?

1: Strongly Disagree 2: Disagree 3: Neutral 4: Agree 5: Strongly Agree

I think the application is easy to control.

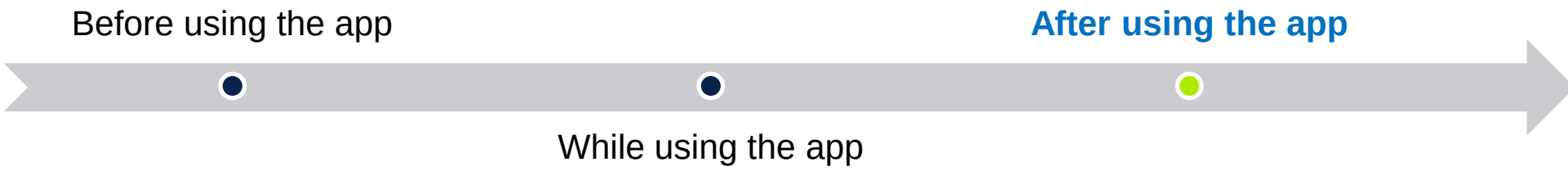
ARETE Mirage XR Interview

What did you like **most** about the MirageXR toolkit?



ARETE Mirage XR Interview

Which **advantages and benefits** for teaching and learning can you imagine when using the MirageXR toolkit?

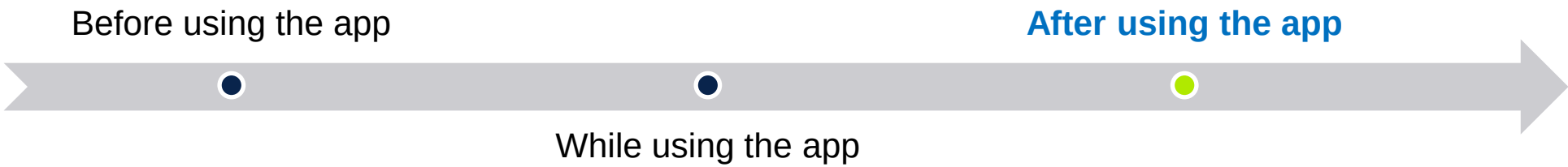


ARETE Mirage XR Interview

What did you like **least** about the MirageXR toolkit?

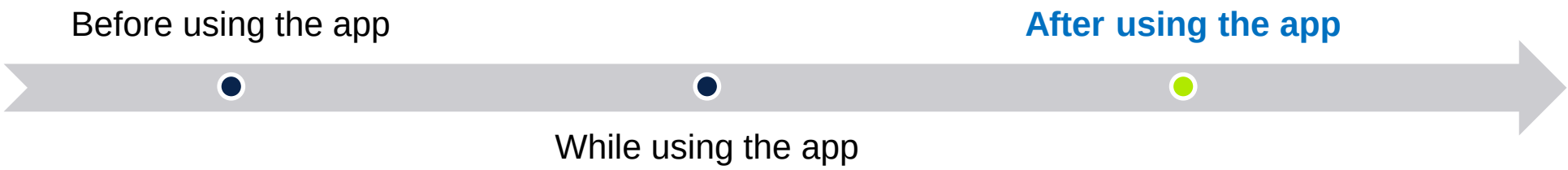
ARETE Mirage XR Interview

Which **problems and barriers** do you expect when using the MirageXR toolkit in your daily classroom practice?



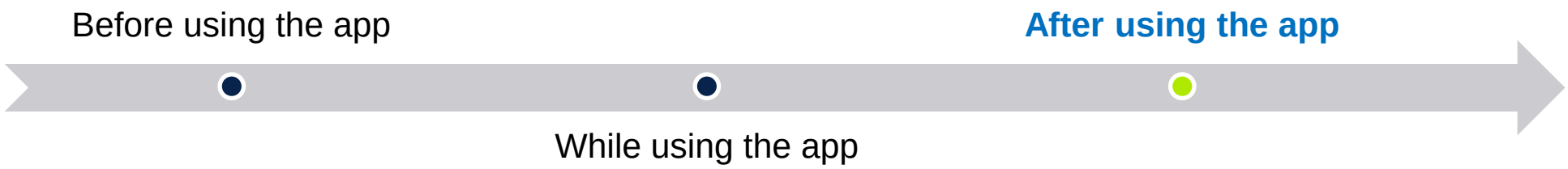
ARETE Mirage XR Interview

Which issue would you want to see **improved** the most?



ARETE Mirage XR Interview

How likely is it that you will use an Augmented Reality toolkit such as MirageXR for teaching and learning in the future?



ARETE Mirage XR Interview

Thank you!
Questions?

MirageXR release notes Changelog.md

This document is for collaborative writing and review of the release notes.

MirageXR release notes 2.0

Change Log 2.0

Featured:

- **New and improved mobile user interface.** We completely redesigned the concept of user interaction and dialogues on the mobile platforms. The app now has a significantly improved usability and user experience, and many new features.
- **Context help.** We introduced a new dynamic context help system, with a comprehensive set of help dialogues for anything we could think of.
- **Interactive tutorial.** We added a facility for step-by-step interactive tutorials and added a tutorial introducing the user to the editing functionality.

Added:

- Onboarding**:** We added onboarding swipe-thru slides on first app launch, explaining the key concepts of mirageXR with text and animations.
- Bottom bar**:** We added a new bottom tab bar with icons for quickly switching between activity stream, profile, search, and the new dynamic context help.
- Quick edit toggle**:** We introduced a new edit toggle button in the top right corner of the mobile user interface for quickly switching from viewing to editing.
- Collapsable main panel: Users can now minimize the main menu, providing 'prev'/'next' quick navigation buttons in the collapsed view for moving forwards and backwards between action steps. Especially on smaller screen phones, this frees valuable screen real estate up for a less cluttered view of the activity.
- Model augmentation: We added boundary box handles for the model augmentation as alternative to the direct manipulation with pinch and rotate.
- Pick & place augmentation: We added trigger functionality to allow jumping to the specified step if the pick object is placed in the correct target location, and we added reset options for placement.
- Pick & place augmentation: We added sound effects for the pick & place augmentation (for correct and incorrect placement).
- Character models: We added trigger functionality to character models, moving on to the next action step, when audio or animation are finished playing (whichever takes longer).
- Character models: The AI mode of character models now supports the use of "%%trigger%%" control commands in the text string of their dialogue responses, triggering to move on to the next action step.
- Audio augmentation: We added a 'jump to' option for audio triggers (not just 'next step').
- Action augmentation: We added gaze trigger functionality for action augmentations.

- Preview: We added a preview button from the publish settings to remind content authors to test their activities before uploading to the cloud.
- Marker augmentation: We improved the marker augmentation to display the target image with a 'find this' instruction and we worked on the anchor stability of the task station during tracking.
- Locate: We reintroduced the locate functionality to activate a red arrow viewfinder pointing to the augmentation it is activated for.
- Acknowledgements: We added logos of new collaborators to the acknowledgements.

Changed:

- Login at the start: The app starts now with the login, also adding buttons for registering (opens browser for web registration) and anonymous guest login.
- Activity stream: We upgraded the activity list to a swipeable activity stream on mobiles and improved the sorting and search functionality.
- Publish dialogue: We created a new 'Publish...' dialogue to simplify data handling for content authors, with quick access for saving locally and saving to the cloud in public (or private).
- Image and video augmentations: We added boundary box handles for easier manipulation to the image and video augmentations.
- Step order: We improved the process of adding action steps during editing.
- Best augmentations first: We reordered the list of augmentations in the editor by popularity.
- Content selection: We improved support for content selection, adding a short description and additional context help to the augmentation list on mobiles.
- Calibration dialogue: We created a new calibration guide and dialogue, which now starts automatically when a user opens an activity to view.
- Highlight current step: We are now visually highlighting the current step in the step list also on mobiles.
- Keep alive: We created a new dialogue with from/to dials on mobiles for the 'keep alive' functionality of augmentations, simplifying setting from which action step to which action step an augmentation shall remain visible.
- Updated views: We implemented new views for activity settings, steps, list of step contents, content selection, step settings, and profile.
- Activity: We improved the process of deleting activities.
- Screen layout: We improved the basic screen layout for tablets and large screen phones (e.g. Motorola Edge Pro). We increased icon resolutions.

Fixed:

- We updated the reference resolution for the new mobile user interface, which was causing crashes on some devices.
- We extended the audio trigger functionality to work also with the GhostTrack augmentation.
- Fixed portrait mode for video augmentation player.

- We fixed bugs with the AI mode for character models.
- We fixed bugs causing the image augmentation to crash (iOS), reset (Android), or not display (all).
- We suppressed the calibration video instructions from displaying during the editing tutorial, so that the optional dialogue does not occlude the tutorial.
- We fixed issues with the appearance of character models ('zombie mode') and improved the appearance for some.
- We fixed issues with calibration.
- We fixed a bug causing label augmentations to crash when using the trigger.
- We fixed a bug with pick & place objects forgetting their orientation.

Enterprise:

- We updated the base URI for xAPI statements, retiring 'wekit-community.org'.
- We removed the Android advertising SDK package from project (it was never used).
- We added a new profile setting for selecting repository servers from a dropdown list of preconfigured endpoints.
- We added new profile settings for selecting the learning record store from a dropdown list, automatically configuring their xAPI endpoint URL, replacing the free text entry.
- We fixed issues with the Sketchfab API direct login and authentication.
- We reinstated the broken deep link launch from QR codes in Moodle (allowing MirageXR to launch from any QR-code enabled mobile camera app).
- We added new app icons.

Developer:

- We migrated to Unity 2021 LTS and updated the CI pipelines to use the corresponding images.
- We updated the ARfoundation versions.
- We created a new UI kit to unify the presentation layer.
- We introduced a new dialogue manager for presenting interactive dialogues.
- We implemented a new drag & drop controller for ordering of UI elements.
- We added CONTRIBUTING.md instructions, replacing the agile development wiki page.
- We updated the CI pipeline badges in the README.md.
- We excluded workspace layout settings from git index and added to gitignore.
- We removed the UserSettings folder from git index and added it to gitignore.
- We removed some ghost meta files that were still tracked by git.
- We updated the cache action on the Android build pipeline.
- We fixed the Android CI pipeline signing error and left a note in the CONTRIBUTING.md about not ticking the developer key option in the build settings.
- We fixed the problem of the Android build pipeline running out of space before concluding the build.

- We added missing standard Windows fonts on the Android build pipeline, which were causing many dialogues to not display type in automated preview builds.
- We added StyleCop support and adjusted the rules to our needs, also reformatting large parts of the code to fix some of the warnings.