



HAL
open science

Exploring the Acceptability of HELP-XR among Instructors: A Tool for XR Pedagogical Content Creation

Alex Gabriel, Josselin Deborde, Alaa Hassan

► To cite this version:

Alex Gabriel, Josselin Deborde, Alaa Hassan. Exploring the Acceptability of HELP-XR among Instructors: A Tool for XR Pedagogical Content Creation. AVI 2024: International Conference on Advanced Visual Interfaces 2024, Jun 2024, Arenzano, Italy. pp.1-9, 10.1145/3656650.3656681 . hal-04605825

HAL Id: hal-04605825

<https://hal.science/hal-04605825v1>

Submitted on 10 Jun 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Exploring the Acceptability of HELP-XR among Instructors: A Tool for XR Pedagogical Content Creation

Alex Gabriel¹, Josselin Deborde¹ and Alaa Hassan¹

¹Université de Lorraine, ERPI, F-54000 Nancy, France

Abstract

Virtual and Augmented Reality (VR and AR) are recognized for their potential in education, yet their widespread adoption remains limited, primarily due to challenges in content creation, especially in Extended Reality (XR). This paper presents an acceptability study of HELP XR, an authoring tool aimed at simplifying XR content creation. Following the Design Science Research Paradigm, we assessed educators' attitudes towards technology using the Greek Computer Attitudes Scale (GCAS), followed by an evaluation of HELP XR's acceptability using the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) framework. Our study with 14 participants revealed positive attitudes towards computers, with high ratings in effort expectancy and facilitating conditions for HELP XR. These findings indicate its potential to ease XR content creation barriers in educational settings.

Keywords

Extended Reality, Authoring Tools, Training, Education, User Experience, Technological Acceptance

1. Introduction

Extended Reality (XR) technologies have become a potent resource for training within the manufacturing sector [1]. Immersive XR training demonstrates its potential in enhancing worker performance and boosting engagement [1]. XR comprises two distinct subcategories: Augmented Reality (AR) and Virtual Reality (VR), each with its own continuum [2]. These technologies have generated significant interest, particularly in training and education. AR has reached a maturity level that enables meta-analyses of its impact on learning outcomes [3, 4]. Conversely, VR has been extensively studied, resulting in numerous literature reviews on its educational applications [5, 6, 7]. Notably, these technologies, especially AR, are believed to support experiential and active learning [8]. Nevertheless, their widespread adoption faces challenges, notably the technical complexities associated with customizing VR experiences for students [9]. To surmount this hurdle, the development of suitable authoring toolkits is essential to optimize XR utilization in education. This paper outlines research aimed at addressing the need for improved authoring tools, serving as the motivation behind this study.

While XR technologies hold promise for education, the creation of XR experiences remains challenging for various reasons [10]. The facilitation of XR content creation in education is

AVI 2024: International Conference on Advanced Visual Interfaces 2024, June 3–7, 2024, Arenzano, Genoa, Italy.

✉ alex.gabriel@univ-lorraine.fr (A. Gabriel); josselin.deborde.recherche@gmail.com (J. Deborde);

alaa.hassan@univ-lorraine.fr (A. Hassan)

ORCID 0000-0002-3676-6417 (A. Gabriel); 0009-0002-5867-9717 (J. Deborde); 0000-0002-3676-6417 (A. Hassan)



© 2024 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

an emerging area that builds upon efforts to validate XR's value and feasibility in education domain. Designing interactive AR/VR experiences necessitate a balance between the necessary skills and resources and the desired level of fidelity [11]. Authoring tools seek to empower users without specific design or development skills to create AR experiences [11]. Like other software tools, AR/VR authoring tools must meet two crucial criteria regarding the user interface: the "threshold" and the "ceiling" [12]. The "threshold" signifies the ease of use for new users, while the "ceiling" defines the extent of what users can accomplish and the limitations they may face. The aim is to maintain a low threshold for ease of use while offering a high ceiling of capabilities [12]. This aligns with the first requirement proposed by [8] for educational AR authoring toolkits, emphasizing easy accessibility.

XR tools in instructional context implies two main profiles: learner and instructor. Admitting XR tools has a positive impact on science academic success, as well as increase the satisfaction and motivation of learners [4], benefits for instructors is a key aspect for adoption in training. Creating XR instructional content is a challenge for these actors as they don't have neither time nor expertise to develop it from scratch. XR authoring tool is an evident solution to answer the technical feasibility issues and eases the content creation process. However, the existence of facilitating tool is not enough to guarantee adoption, some instructor might be reluctant to adopt technology. Further, involving future users to the design process and making acceptability evaluation help to anticipate difficulties and improve acceptance and adoption during the usage phase [13]. Acceptability might depend on personality traits and psychological characteristics [14, 15], or their gender [16]. This article aims to study the instructor perspective of the open source XR authoring tool – HELP XR. The research objective is to evaluate if the authoring tool is acceptable and accessible to people with low appetite to technology. The next section will discuss related work about XR in education context, authoring tools, personality and acceptability evaluation. Then the third section presents the features and design of the HELP XR authoring tool. The fourth section deals with methodology and protocol. The results are detailed in the fifth section. The sixth section discuss the results before concludes in section seven.

2. Background

2.1. XR usage in education

In opposition to the Reality-Virtuality Continuum [17] that put augmented reality and virtual reality on the same continuum, eXtended Reality refers to two distinct sub streams with their own continuum [2]: AR and VR. These continua depends on the sophistication of the experience [2]. The interest of using extended reality technology, either AR or VR, is manifold. Both of these technologies increase satisfaction and motivation [18, 4]. XR notably contribute to active learning practices in pedagogical activities [19, 20]. From the perspective of VR, it also allows simulations to practice procedures in risk-free environment [21]. Immersive laboratory simulation could also be justified by distance education [22]. VR teaching and learning goals can be classified into four categories [20]: knowledge transmission, practicing, feedback, and evaluation. Independently from the goals, VR experience can be structured into three types [20]: serious game, simulation, collaboration VR. On the other hand, the most significant

affordance of augmented reality is the unique ability to create an immersive hybrid learning environments that combine digital and physical objects [23]. It is used in particular for training in manufacturing activities such as assembly operations [24]. AR demonstrated some interest to cognitively support operators notably contributes to better quality operations, lower stress levels, higher degree of independence and a lower perceived complexity [24]. Despite benefits, the usage of XR in education and training remains limited and sometimes conflicting [25]. Cognitive load while XR usage is notably one of these conflicting aspects. For instance, some science lab simulation in virtual reality has shown higher cognitive load than desktop display based EEG measure [26]. Furthermore, in the specific case of AR, it is still a training medium, as the benefits of AR seem to disappear as training continues and the operator begins to master the task [24].

2.2. XR Authoring Tools

Admitting the relative benefits of XR for training, these technologies require technical skills to be implemented in the pedagogical context. As illustrated by a qualitative study done with Saudi educators, educators may have awareness of education XR experience but no technical hands-on experience [27]. This study also supports the interest from instructors for using minimal coding solutions to create the XR experience [27]. However, the entry point is freely available XR apps and contents in order to experiment although it might be less educationally valuable [27]. All the authoring tools are not equivalent, instructors selection will depends on the properties of the tools. One of the first criteria is the type of experience the can be created by the authoring tool: augmented reality, virtual reality or both. Another criteria that was also raised by a previous research [28] is the immersive content creation. A classification into 5 groups has been proposed by [11] according to the level of fidelity and the skill and resources required to create the application. Although the principle is interesting, this classification integrates 3D modeling software such as Maya or Autodesk's 3ds Max (named class 4) with dedicated XR authoring tools (class 3) or even generic game engine such as Unreal engine or Unity (class 5). This classification lack of criteria and put altogether authoring tools indiscriminately. Conversely, a literature review of XR adoption studies proposed a model of determinants, antecedents and reactions to XR technology [29]. Although this article proposes an adoption model involving individual and organizational factors, at no point is content creation discussed. This literary review doesn't appear to differentiate between content consumption and content creation. However, there is already a wealth of literature review on AR [8, 30], VR [31, 9] and XR [10] authoring tools. These reviews highlighted necessity to reuse/import assets in the authoring tool [31, 9], explore the evaluation of authoring tools [31] and support different interaction methods [31], notably multi user experience [9, 11]. It also raised specific features for education such as integrated assessment such as quiz [9] or skill validation, student account management [9] and collaboration between authors [9]. As the key point for engaging immersive experience is the interactivity, this requires some form of programming although this is a barrier to adoption [10, 27]. Scripted behavior [10] or GUI programming is a desirable feature [8] to ease the interactive content creation. Concerning the content creation modality, the interest was also highlighted to provide both immersive and non-immersive interface for authoring tasks [32]. All of the above are features of the authoring tool design guideline produced from a literature review

[33]. Among the 14 guidelines, it also highlights requirements that summarize end-user needs. The first one is the adaptation and commonality, however, no authoring tool was identified in the literature to allow both AR and VR content creation. Furthermore, despite a large body of literature on authoring tools, few have been evaluated through user studies to assess their relevance [8].

2.3. Technological Acceptance Evaluation

There are numerous approaches to evaluate acceptability in the literature that have evolved over the years. As highlighted by a review of the major technology acceptance illustrated by Figure 1 [34], these models also admitted some merge and factors combination. Technology acceptance model originally started with a general model, not designed for a specific behavior or technology: Theory of Reasoned Action (TRA) [34]. It analyzes the determinants of conscious behavior determined by behavioral intention which is itself determined by personal attitude and subjective norms [34]. TRA was adapted for modeling user acceptance of information systems. This new model is the Technology Acceptance Model (TAM). The original difference is the removal of the subjective norms and the introduction of perceived utilities and perceived ease of use. According to model evolution, intermediate factors such as attitude were removed but numerous antecedents were added to explain the perceived usefulness and the perceived ease of use. With the emergence of various derivatives of TRA, TAM, motivational models and many others, the need for a unified model of user acceptance has been identified [35]. Based on eight different models, the Unified Theory of Acceptance and Use of Technology (UTAUT) has distilled the critical factors and contingencies related to the prediction of behavioral intention to use a technology and technology use [35]. While UTAUT is first to explain employee technology acceptance and use, UTAUT2 focuses on consumer technologies acceptance and use [35]. The difference between UTAUT and UTAUT2 is the context of the application, the former is a workplace while the latter is the consumer context. This context difference implies the addition of new relationship in the model such as hedonic motivation, cost of the technology, and habit, and drop voluntariness [35].

In the context of extended reality, a literature review of studies on augmented and virtual reality adoption has highlighted various usages of the above-mentioned models [29]. On the 45 studies reviewed, 11 based their approach on TAM, while 3 used UTAUT and only one used TRA. However, according to the explicability analysis of models on usage and intention-to-use, UTAUT 2 performs better (26% better than TAM) [34]. Thus, an exploratory study was conducted using UTAUT2 to evaluate the acceptance of different VR authoring tools [28]. In addition to acceptance and adoption models, the same literature review [29] also includes one study which made the use of Big Five model to consider human personality to predict the adoption of smart glass [36]. The Big Five personality model is certainly the most widely applied one, also when the influential role of personality traits on team functioning and performance are investigated [14]. This smart glass adoption study [36] points to an underrepresented avenue in the context of XR technology according to this state of the art [34], which is to consider the personality of the person dealing with the technology. As teachers' personal characteristics, computer self-efficacy, motivation, and attitudes are also key to the introduction of modern technologies in education [37], it could be interesting to characterize the instructor profile to better interpret

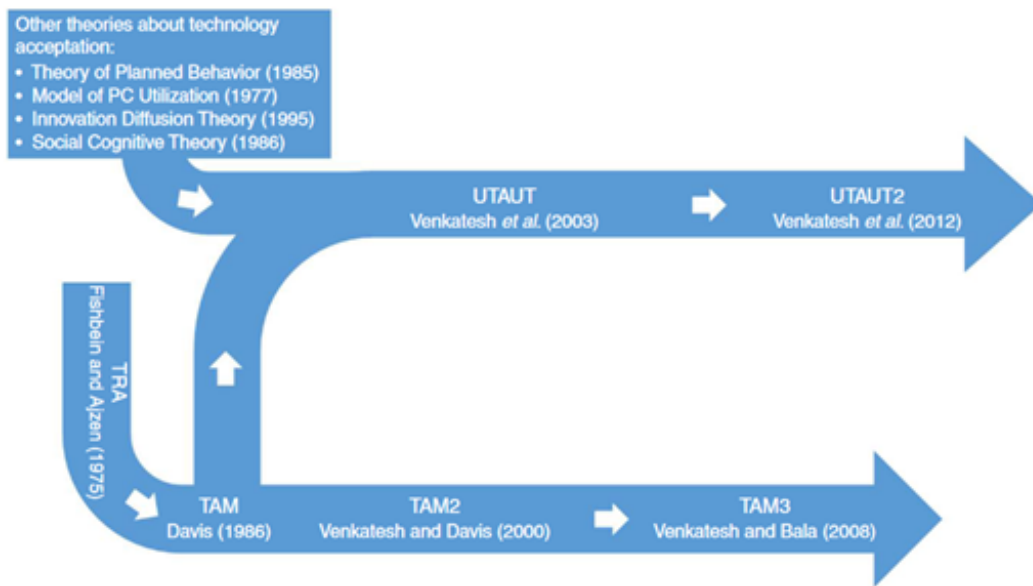


Figure 1: Evolution of theories about technology acceptance [34]

feedback and adoption evaluation. Ideally, considering personality and psychological traits could be accommodated to promote and ease the adaptation of ICT in educational practice [14] and more specifically adaptation of XR. Like acceptance models, there are various models to evaluate personality traits. In the specific context of training and technology, a study relating psychological characteristics and ICT use in teaching context [14, 15] illustrated the usage of questionnaires such as:

- Big five questionnaire: Five Factor personality model (Extraversion, Agreeableness or Friendliness, Conscientiousness, Emotional Stability or Neuroticism, and Intellect or Openness to Experience) divided into 10 sub-dimensions (12 question each) coupled with the Lie scale (14 questions) and evaluated through 134 questions [38].
- TPQue: Five Factor personality model composed of 180 items distributed in 30 personality facets [39].
- TPQue5: a short form of TPQue with 75 statements measuring the Big Five dimensions and 26 items evaluating social desirability responses [40].
- The Greek Computer Attitudes Scale (GCAS): 30 items decomposed into measuring confidence, affection and cognitive [41].
- Greek Computer use Self-efficacy Scale (GCSES): a 2-subscale and 29 items to evaluate the overall degree of competency of computer (basic knowledge and concepts related to operating systems, text processing software and simple computer use) [42].
- Questionnaire on Intention for Future ICT Integration in Teaching Practice: intention to use ICT in teaching practice evaluated in 11 items.

In the same context of ICT usage in education, GCAS and GCSES were used to relate computer self-efficacy with computer attitudes, notably its subclass of its subscales of confidence and

affection [43]. It showed a significant and highly positive correlation between computer use self-efficiency and computer attitudes [43]. The raise a special interest to integrate computer attitudes as a variable in the adoption evaluation, notably for XR authoring tool. According to author's knowledge, this combination was not done.

3. HELP-XR design

3.1. Authoring Tool Requirements

Before initiating the HELP-XR development, various AR and VR authoring tools were reviewed from the literature in the perspective to use it in a teaching context. As shown in the introduction, none was able to provide both AR and VR content creation. Based on existing experience and recommendations, a list of design requirements has been defined for an XR content creation tool in an educational context. More specifically, the pedagogical context was to train students in the use of workshop machines such as laser cutters. The training to be provided was relatively sequential. De facto, the specifications were derived from these needs, personal experience and conversations with colleagues teaching machinery handling. The following list describes the main features:

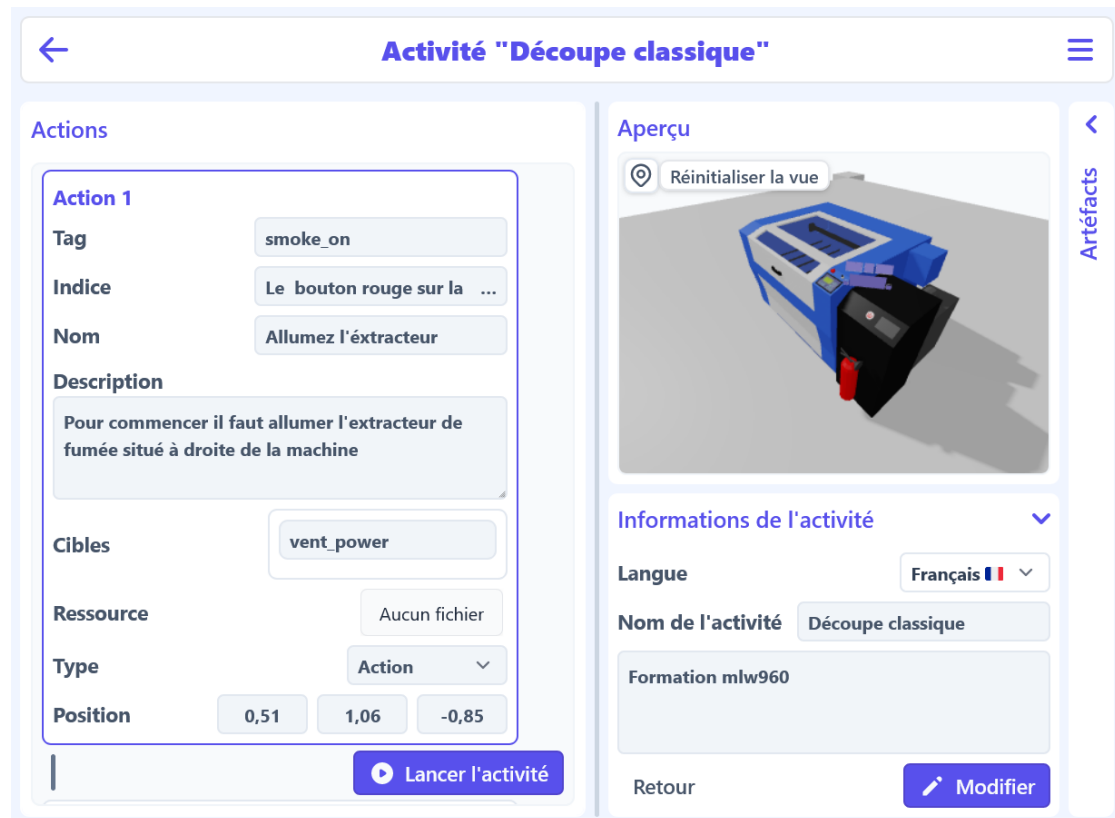


Figure 2: Screenshot of HELP XR interface for the activity description and 3D preview



Figure 3: Screenshot of HELP XR interface for the artefact configuration and visualization

- Reduce the technical skills needed to create XR content and asset behaviors - the XR activity is presented as a diagram inspired by activity diagrams where each node represents a step in the XR training. The information for each step consists of a step name, a description, a step ID (tag), a type of action, and parts of the 3D model concerned (Figure 2). The description is converted into a voice-over for learners using text-to-speech functions. Similarly, the behavior of the assets can be defined through a block programming interface inspired from Blockly (Figure 3).
- Provide a unique design process through a web interface to create AR and VR content simultaneously - one XR activity diagram includes all the information for both AR and VR experiences.
- Customize the experience by importing 3D models and adding multimedia elements - is based on the import of GLB-format 3D models and additional content such as images, videos and sounds for each step.

3.2. Technical Design

As illustrated by Figure 4, HELP XR is composed of various elements: an API, the authoring tool web app, a web XR client and various clients for each XR devices. The core of the system is the web authoring tool and the API that ease the creation of content and accessibility on XR devices. The authoring tool web app provides the unique interface to create training through aforementioned diagram, upload 3D models and multimedia files, and define artefact behavior. The authoring web app is also the portal for learners to sync an XR device with a user account

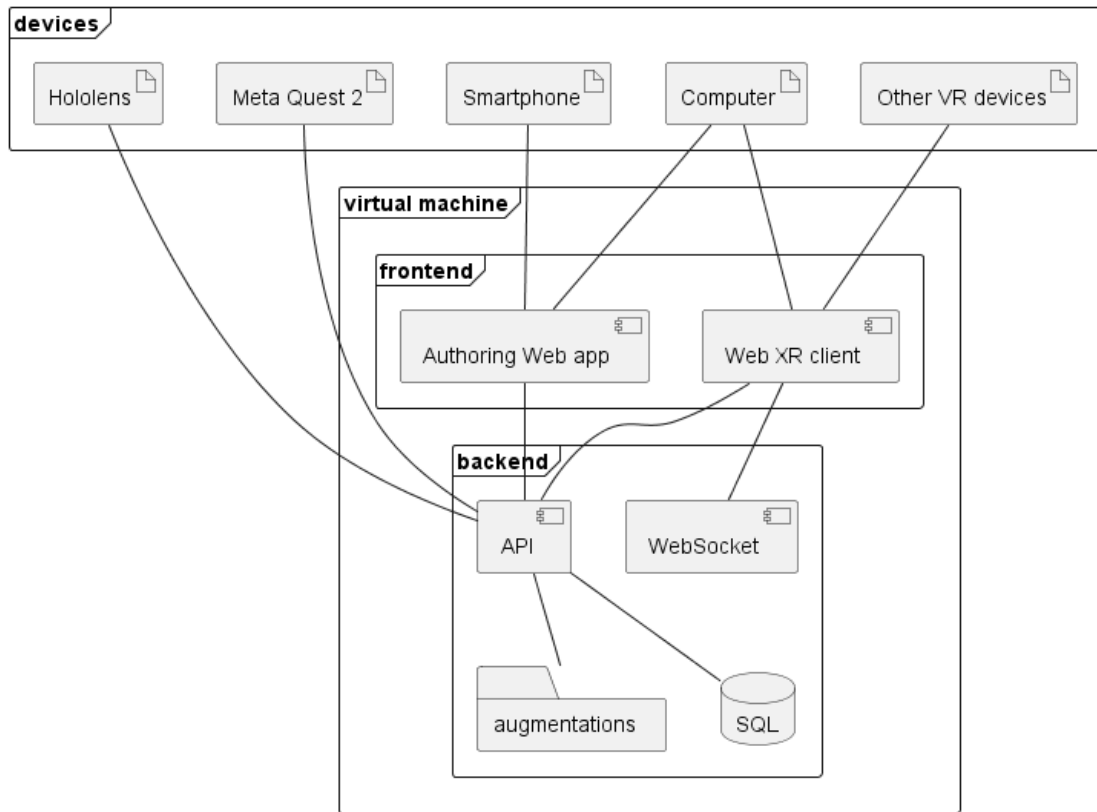


Figure 4: Architecture of the authoring tool HELP XR

and access to training activities. This web app was developed with VueJS for dynamic front-end. The back-end consists of an API and a database to store data collect the training data from the front-end. This API, developed in Python using FastAPI library, process data about the training scenarios, the augmentation (3D model, images, videos ...), the artefact behavior. It is the core element that allow the import/reuse feature for 3D models and multimedia files. It is also through the API that XR devices can have access to training information, 3D models and multimedia files. Concerning XR devices, two types were used: Microsoft Hololens 2 and Meta Quest 2. Each device had their own client app developed with Unity to allow access to training respectively in AR or VR . Finally, a third client is the WebXR app which address accessibility issue to people who don't have aforementioned devices. WebXR allow access to content like a video game on computer as well as immersive content if it is accessed with VR devices.

4. Methodology

4.1. Research question

The ambition of this research is to confront XR authoring tool to potential instructor in order to evaluate its acceptability by non expert. The particularity is that the tool presents the activity design as a diagram, which doesn't require any programming skills. Beyond the fact that no programming or immersive experience is required, instructors are not equal when it comes to digital technology. Individual differences such as consumer personality traits perform well in predicting various media and technology use [29]. In this way, individual differences such as personality traits and demographic data can be taken into account to design user experiences that are more adapted and therefore more acceptable. In other words, the research work can be structured around this research questions:

- RQ To what extent do demographic and personality differences among teachers influence their levels of acceptability of an authoring tool for XR content?

This research question give rise to several hypotheses that this study aims to investigate, including:

- H1: The level of acceptability varies based on the personality profile of the instructors.
- H2: Acceptability differs depending on demographic characteristics, such as gender, age, and technical familiarity.

4.2. Participants

In conducting the acceptability study for the HELP XR authoring tool, individuals were primarily recruited based on their involvement in teaching activities, encompassing roles such as professor, assistant professor, lecturer, or part-time lecturer, irrespective of their expertise in XR application design. The only thing that the people recruited had in common was that they had an engineering background, whatever their speciality, or were teaching at an engineering school.

4.3. Procedure

In order to validate the hypotheses and answer question, it was a necessity to confront instructors to the authoring tool and collect data through observation, exchange and surveys. This experimentation was structured into 6 steps as illustrated by Figure 5. All questionnaires and instructions were given in French.

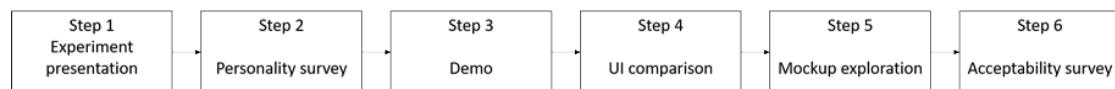


Figure 5: Steps of the experimental protocol

- Step 1: Before starting any data collection the first step was the presentation of the experiment, its objective and also the signing of the consent form.
- Step 2: The participant was invited to fulfill a former questionnaire that contained 7 demographic questions and then the psychometric questions. As the ambition is to design an authoring tool that may help users with a relatively low attitude toward computers, the dedicated questionnaire was used for this: the Greek Computer Attitudes Scale [41]. LimeSurvey was used to implement this survey and collect data among participants.
- Step 3: In order to provide an overall idea about what is the finality of the authoring tool, this step consists in letting participants watch a video showing what a learner will see with an AR headset. This video was captured from the Hololens while doing some training for a laser-cutting machine.
- Step 4: Collecting user needs and requirements can be difficult as they are facing a new tool. To ease the needs elicitation, a static A/B test was used as a pretext to start a dialogue on user experience and interface needs. Five different interfaces were used. First, participants were exposed to two versions of the same page and chose the preferred version. Then the discussion started about positive and negative aspects of what they saw.
- Step 5: Prototype exploration consisted to achieve three missions on the authoring tool while the experimenter observed its user path in the prototype. The three tasks were: add an intermediary step in the laser cutting training, find training statistics of a given student for the laser cutting training, and modify the laser cutter artefact.
- Step 6: Finally, participants were asked to answer the 27 questions of the UTAUT 2 questionnaire implemented on LimeSurvey, on their own and unsupervised. The UTAUT2 questionnaire used was based on a version translated and validated in Canadian French [44].

5. Results

All subsequent analyses were conducted using a Python notebook, which has been provided along with the raw data [45].

5.1. Demographic data

Following the protocol mentioned earlier, 14 individuals participated in the experiment. Among them, 5 were women (35.74%) and 9 were men (64.29%). In this cohort, the average age was 34 years (SD = 10.76). Eligibility for the experiment was determined by individuals' ability to instruct or train students, with an average of 9.07 years of training experience (SD = 8.76). Participants self-assessed their technical expertise, averaging a rating of 3 out of 5 (SD = 0.96).

5.2. Greek Computer Attitudes Scale

The summary of GCAS results for three demographic variables is provided in Table 1. Gender analysis reveals a lower mean score for women compared to men. A Mann-Whitney U test confirms this difference as statistically significant ($p = 0.030$, $\text{cohen's } d = 1.25$) for overall

Table 1

GCAS results broken down by gender, age and technical experience

Variable	Value	Individuals	Overall		Confidence		Affection		Cognitive	
			Mean	Std	Mean	Std	Mean	Std	Mean	Std
Gender	All participants	14	119.79	11.36	52.43	6.38	45.50	5.29	26.50	1.74
	Women	5	111.80	12.93	48.20	6.83	42.20	5.76	26.00	2.34
	Men	9	124.22	7.80	54.78	5.04	47.33	4.27	26.78	1.39
Age group	<25 y.o.	4	124.50	7.19	56.50	3.70	45.00	3.65	27.50	1.73
	>= 25<= 40 y.o.	6	124.00	7.04	54.50	3.94	48.00	4.33	26.50	0.84
	> 40 y.o.	4	108.75	14.03	45.25	6.13	42.25	52.25	25.50	2.52
Technical experience level	1	1	119.00	-	51.00	-	46.00	-	27.00	-
	2	3	106.33	14.57	46.00	8.54	39.67	5.86	24.67	2.31
	3	5	122.0	5.83	54.20	4.09	45.40	3.36	27.20	1.48
	4	5	125.80	9.58	54.80	6.06	49.00	4.64	26.80	1.30
	5	0	-	-	-	-	-	-	-	-

Table 2

Demographic data according to the level of attitude towards computers

Attitude	Indiv.	Age		Tech. exp. level		Gender	
		Mean	Std	Mean	Std	Mean	Std
Negative	4	43.25	13.96	2.75	0.96	2	2
Neutral	6	32.16	7.70	2.67	1.03	3	3
Positive	4	27.50	5.57	3.75	0.50	4	0

GCAS scores and men's confidence scores ($p = 0.041$, cohen's $d=1.15$). However, no significant differences were found in affective and cognitive scores.

Regarding age groups, there were no significant differences in GCAS scores across different age brackets ($p > 0.05$). This pattern persisted across confidence, affective, and cognitive subscales.

Analysis of technical experience levels also found no statistically significant differences in GCAS scores ($p = 0.091$), including across the subscales ($p = 0.370$, $p = 0.167$, $p = 0.210$, respectively).

Based on the original GCAS method [41], attitudes toward computers (negative, neutral, positive) are defined using the 25th and 75th percentiles. Demographic data can be categorized accordingly, as shown in Table 2.

5.3. Acceptability

After using the tool, the final step in the protocol was the acceptability assessment. Overall participant scoring is depicted in Figure 6, with generally high scores. Notably, "effort expectancy" and "facilitating condition" factors stand out above others. Figure 7 shows a relatively similar distribution of scores among GCAS categories, with no statistically significant differences found

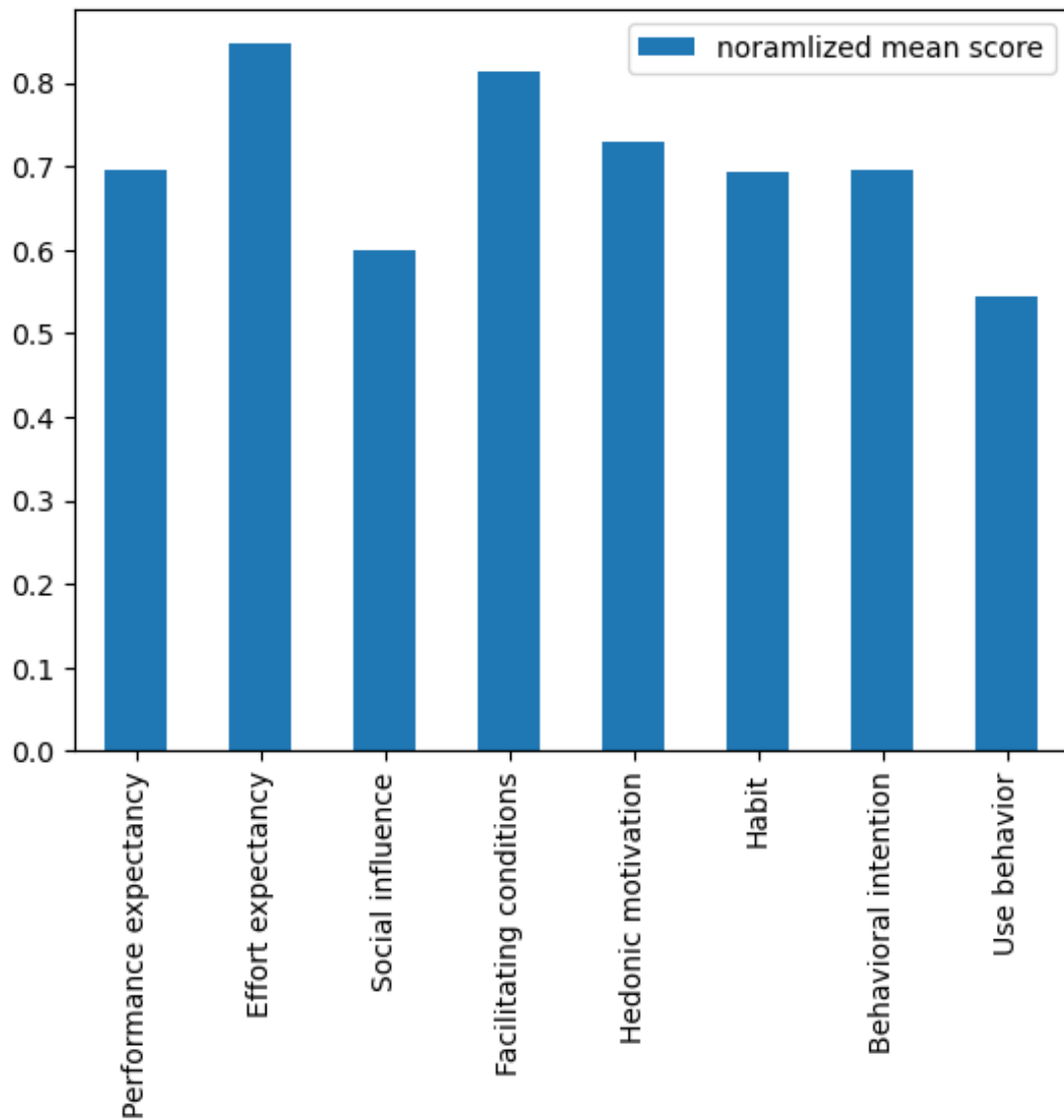


Figure 6: Overall normalized mean score for each UTAUT2 factors

via the Kruskal-Wallis test. However, a one-sided Mann-Whitney U test revealed significantly higher "usage behavior" among instructors with positive attitudes compared to those with neutral attitudes ($p = 0.033$, Cohen's $d = 1.90$). In terms of gender, the sole significant distinction was found in the "hedonic motivation" factor, wherein women scored higher than men ($p = 0.041$, Cohen's $d = 1.30$). Moreover, no notable differences were detected among UTAUT2 factors concerning technical experience and age, as indicated by the Kruskal-Wallis test.

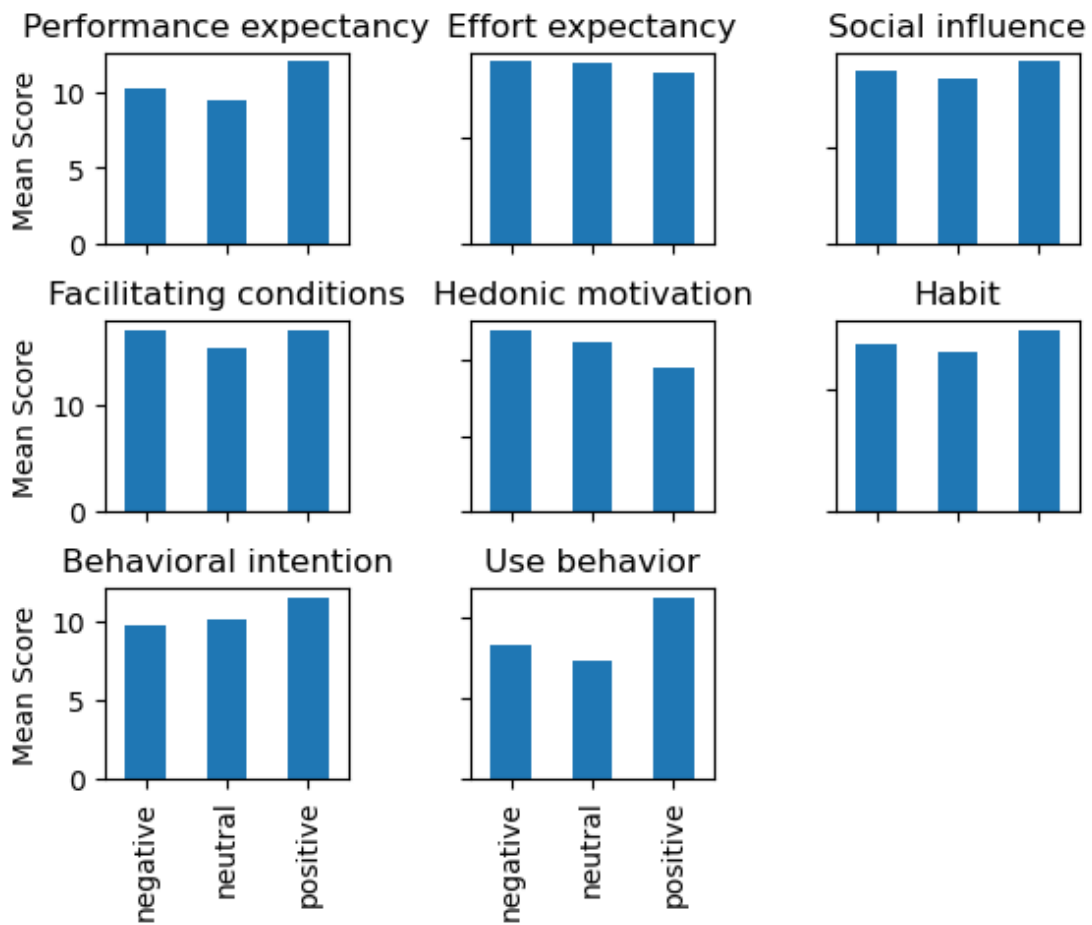


Figure 7: UTAUT2 factors according to GCAS level

6. Discussion

The aim of this study was to investigate the influence of demographic and personality differences among teachers on their levels of acceptability of an authoring tool for XR content.

Overall, our results reject the H1 hypothesis that the level of acceptability varies according to the personality profile of the instructors. The only exception concerns the "use behavior" factor from UTAUT2 was higher for person with positive attitudes towards computer than person with neutral attitude. However, we observed high levels of "effort expectancy" and "facilitating condition" among participants, suggesting that the tool was perceived as user-friendly and conducive to their teaching practices. This implies that although the tool received high scores in other acceptability factors, it may not be as attractive for creating XR content in educational settings for individuals who are less digitally inclined. One possible explanation could be the challenges educators encounter in visualizing the integration of XR into their teaching approaches.

With regard to H2, our results suggest that, in general, acceptability does not differ according to demographic characteristics such as gender, age and technical familiarity. There were no statistically significant differences in overall acceptability scores between demographic groups, except for the gender factor of hedonic motivation. In fact, women clearly and significantly rated this factor more favorably than men.

Another gender disparity was observed in the results of the Greek Computer Attitudes Scale (GCAS), women scoring lower on average and showing less confidence compared to men. We have no explanation for these results, but there could be links between these hedonic motivation and confidence scores.

It is important to acknowledge some limitations of the study. Firstly, the restricted number of participants in the acceptability assessment limit the generalizability of our findings, especially when breaking down data into subgroups based on GCAS categories. Additionally, the study targets a relatively small and less available segment of the population, and the face-to-face nature of the test with its 50-minute duration may have influenced the scope and diversity of the participant pool. These limitations highlight the need for further research with larger and more diverse participant samples to validate and extend these findings.

7. Conclusion and Future Work

This research aimed to assess whether the design concept behind HELP XR—an authoring tool for XR instructional content based on a unified design process depicted through activity-diagram-inspired diagrams—is acceptable to instructors, irrespective of their computer attitudes. Our study, utilizing the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) framework and the Greek Computer Attitude Scale, reveals that instructors' attitudes towards computers do not significantly impact most acceptability factors. However, an exception was noted in the 'use behavior' dimension, where instructors with a positive attitude towards computers were more inclined to use HELP XR compared to those with a negative attitude.

This finding indicates a potential design limitation in the user experience of the authoring tool, potentially hindering instructors from envisioning its practical use. Another possible explanation is the lack of concrete use case scenarios in the training of these instructors. Despite these considerations, the overall evaluation of acceptability factors was positively uniform, suggesting that the diagram-based content creation approach of HELP XR holds promise.

HELP XR represents a unique contribution to the field of authoring tools. To our knowledge, it is the only tool that simultaneously facilitates the creation of both AR and VR content in a diagrammatic format. The primary limitation of this study is the participant number in the acceptability assessment. Future work will involve a more extensive study following the refinement of the tool to address identified user frustrations. However, this preliminary acceptability study has shown relatively high score on the different UTAUT2 dimensions, indicating that HELP XR is positively perceived, supporting its potential for broader adoption in educational settings.

Additionally, this research opens several avenues for further exploration. One potential direction is to investigate a hybrid design approach, combining the current diagrammatic method with immersive techniques for fine-tuning information placement. This could include purely

immersive methods or collaborative approaches involving simultaneous use by individuals with a headset and those at a computer. Future studies should establish comparable protocols for these methods to facilitate effective evaluation as in [28]. Another intriguing research pathway involves enhancing support for content creators in aligning their designs with educational objectives [46]. While some research exists on structuring information within AR or VR authoring tool [47, 48, 49], further exploration in this area is warranted to fully harness systems capabilities such as HELP XR that use various client and WebXR technologies.

Acknowledgments

The development of the tool that initiated this work was funded by the Grand Est region of France. The authors would like to express their gratitude to Paul Loisl and Antonin Rousseau for their contribution to software development. The authors also extend their appreciation to the Lorraine Fab Living Lab for hosting the experimentation and to Benjamin Ennesser-Serville for providing technical assistance.

References

- [1] S. Doolani, C. Wessels, V. Kanal, C. Sevastopoulos, A. Jaiswal, H. Nambiappan, F. Make-don, A Review of Extended Reality (XR) Technologies for Manufacturing Training, *Technologies* 8 (2020) 77. URL: <https://www.mdpi.com/2227-7080/8/4/77>. doi:10.3390/technologies8040077, number: 4 Publisher: Multidisciplinary Digital Publishing Institute.
- [2] P. A. Rauschnabel, R. Felix, C. Hinsch, H. Shahab, F. Alt, What is XR? Towards a Framework for Augmented and Virtual Reality, *Computers in Human Behavior* 133 (2022) 107289. URL: <https://linkinghub.elsevier.com/retrieve/pii/S074756322200111X>. doi:10.1016/j.chb.2022.107289.
- [3] J. Garzón, J. Acevedo, Meta-analysis of the impact of Augmented Reality on students' learning gains, *Educational Research Review* 27 (2019) 244–260. URL: <https://linkinghub.elsevier.com/retrieve/pii/S1747938X18301805>. doi:10.1016/j.edurev.2019.04.001.
- [4] Z. A. Yilmaz, V. Batdi, Meta-Analysis of the Use of Augmented Reality Applications in Science Teaching, *Journal of Science Learning* 4 (2021) 267–274. URL: <https://ejournal.upi.edu/index.php/jslearning/article/view/92>. doi:10.17509/jsl.v4i3.30570.
- [5] L. Freina, M. Ott, A Literature Review on Immersive Virtual Reality in Education: State Of The Art and Perspectives., *The international scientific conference elearning and software for education* 1 (2015) 10–1007.
- [6] S. Kavanagh, A. Luxton-Reilly, B. Wuensche, B. Plimmer, A systematic review of Virtual Reality in education, *Themes in Science & Technology Education* 2 (2017) 85–119.
- [7] M. A. Rojas-Sánchez, P. R. Palos-Sánchez, J. A. Folgado-Fernández, Systematic literature review and bibliometric analysis on virtual reality and education, *Education and Information Technologies* 28 (2023) 155–192. URL: <https://link.springer.com/10.1007/s10639-022-11167-5>. doi:10.1007/s10639-022-11167-5.

- [8] A. Dengel, M. Z. Iqbal, S. Grafe, E. Mangina, A Review on Augmented Reality Authoring Toolkits for Education, *Frontiers in Virtual Reality* 3 (2022) 798032. URL: <https://www.frontiersin.org/articles/10.3389/frvir.2022.798032/full>. doi:10.3389/frvir.2022.798032.
- [9] S. Vert, D. Andone, Virtual Reality Authoring Tools for Educators, *ITM Web of Conferences* 29 (2019) 03008. URL: <https://www.itm-conferences.org/10.1051/itmconf/20192903008>. doi:10.1051/itmconf/20192903008.
- [10] M. Nebeling, XR tools and where they are taking us: characterizing the evolving research on augmented, virtual, and mixed reality prototyping and development tools, *XRDS: Crossroads, The ACM Magazine for Students* 29 (2022) 32–38. URL: <https://dl.acm.org/doi/10.1145/3558192>. doi:10.1145/3558192.
- [11] M. Nebeling, M. Speicher, The Trouble with Augmented Reality/Virtual Reality Authoring Tools, in: *2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, IEEE, Munich, Germany, 2018, pp. 333–337. URL: <https://ieeexplore.ieee.org/document/8699236/>. doi:10.1109/ISMAR-Adjunct.2018.00098.
- [12] B. Myers, S. E. Hudson, R. Pausch, Past, present, and future of user interface software tools, *ACM Transactions on Computer-Human Interaction* 7 (2000).
- [13] L. Acosta Salgado, E. Bonjour, A. Rakotondranaivo, Towards an improved acceptability assessment model of innovative solutions in the design phase, *International Journal of Business Information Systems* 1 (2020) 1. URL: <http://www.inderscience.com/link.php?id=10029802>. doi:10.1504/IJBIS.2020.10029802.
- [14] K. Kounenou, P. Roussos, V. Yotsidi, Teacher Training in Technology Based on their Psychological Characteristics: Methods of Group Formation and Assessment, *Procedia - Social and Behavioral Sciences* 116 (2014) 3536–3541. URL: <https://www.sciencedirect.com/science/article/pii/S1877042814008155>. doi:10.1016/j.sbspro.2014.01.798.
- [15] K. Kounenou, P. Roussos, V. Yotsidi, M. Tountopoulou, Trainee Teachers' Intention to Incorporating ICT Use into Teaching Practice in Relation to their Psychological Characteristics: The Case of Group-based Intervention, *Procedia - Social and Behavioral Sciences* 190 (2015) 120–128. URL: <https://www.sciencedirect.com/science/article/pii/S1877042815032188>. doi:10.1016/j.sbspro.2015.04.925.
- [16] R. Scherer, F. Siddiq, Revisiting teachers' computer self-efficacy: A differentiated view on gender differences, *Computers in Human Behavior* 53 (2015) 48–57. URL: <https://www.sciencedirect.com/science/article/pii/S0747563215004781>. doi:10.1016/j.chb.2015.06.038.
- [17] P. Milgram, H. Takemura, A. Utsumi, F. Kishino, Augmented reality: A class of displays on the reality-virtuality continuum, *Telemanipulator and Telepresence Technologies* 2351 (1994). doi:10.1117/12.197321.
- [18] V. S. Pantelidis, Reasons to Use Virtual Reality in Education and Training Courses and a Model to Determine When to Use Virtual Reality, *Themes in Science and Technology Education* 2 (2010) 59–70. URL: <http://earthlab.uoi.gr/theste/index.php/theste/article/view/22>, number: 1-2.
- [19] I. F. Adi Badiozaman, A. R. Segar, J. Hii, A pilot evaluation of technology –Enabled active learning through a Hybrid Augmented and Virtual Reality app, *Innovations in Education and Teaching International* 59 (2022) 586–596. URL: <https://doi.org/10.1080/>

- 14703297.2021.1899034. doi:10.1080/14703297.2021.1899034, publisher: Routledge
_eprint: <https://doi.org/10.1080/14703297.2021.1899034>.
- [20] S. Philippe, A. D. Souchet, P. Lameris, P. Petridis, J. Caporal, G. Coldeboeuf, H. Duzan, Multimodal teaching, learning and training in virtual reality: a review and case study, *Virtual Reality & Intelligent Hardware* 2 (2020) 421–442. URL: <https://www.sciencedirect.com/science/article/pii/S2096579620300711>. doi:10.1016/j.vrih.2020.07.008.
- [21] A. Ayala García, I. Galván Bobadilla, G. Arroyo Figueroa, M. Pérez Ramírez, J. Muñoz Román, Virtual reality training system for maintenance and operation of high-voltage overhead power lines, *Virtual Reality* 20 (2016) 27–40. URL: <https://doi.org/10.1007/s10055-015-0280-6>. doi:10.1007/s10055-015-0280-6.
- [22] D. Galvez, L. Delgado, C. Caceres, L. Villarroel, Virtual Laboratory, a Learning Resource for Distance Education, in: 2022 IEEE 28th International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 31st International Association For Management of Technology (IAMOT) Joint Conference, 2022, pp. 1–6. URL: <https://ieeexplore.ieee.org/document/10033177>. doi:10.1109/ICE/ITMC-IAMOT55089.2022.10033177.
- [23] M. Dunleavy, C. Dede, R. Mitchell, Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning, *Journal of Science Education and Technology* 18 (2009) 7–22. URL: <https://doi.org/10.1007/s10956-008-9119-1>. doi:10.1007/s10956-008-9119-1.
- [24] P. Vanneste, Y. Huang, J. Y. Park, F. Cornillie, B. Decloedt, W. Van den Noortgate, Cognitive support for assembly operations by means of augmented reality: an exploratory study, *International Journal of Human-Computer Studies* 143 (2020) 102480. URL: <https://www.sciencedirect.com/science/article/pii/S1071581920300823>. doi:10.1016/j.ijhcs.2020.102480.
- [25] M. Akçayır, G. Akçayır, Advantages and challenges associated with augmented reality for education: A systematic review of the literature, *Educational Research Review* 20 (2017) 1–11. URL: <https://www.sciencedirect.com/science/article/pii/S1747938X16300616>. doi:10.1016/j.edurev.2016.11.002.
- [26] G. Makransky, T. S. Terkildsen, R. E. Mayer, Adding immersive virtual reality to a science lab simulation causes more presence but less learning, *Learning and Instruction* 60 (2019) 225–236. URL: <https://www.sciencedirect.com/science/article/pii/S0959475217303274>. doi:10.1016/j.learninstruc.2017.12.007.
- [27] M. Meccawy, Teachers’ prospective attitudes towards the adoption of extended reality technologies in the classroom: interests and concerns, *Smart Learning Environments* 10 (2023) 36. URL: <https://doi.org/10.1186/s40561-023-00256-8>. doi:10.1186/s40561-023-00256-8.
- [28] V. Pires De Oliveira, R. De Jesus Macedo, F. Vinicius De Freitas, A. Machado, T. Murari, I. Winkler, Virtual reality authoring tools acceptance and use: An exploratory study with the UTAUT2 model, in: *Symposium on Virtual and Augmented Reality*, ACM, Rio Grande Brazil, 2023, pp. 299–303. URL: <https://dl.acm.org/doi/10.1145/3625008.3625053>. doi:10.1145/3625008.3625053.
- [29] S. H.-W. Chuah, Why and Who Will Adopt Extended Reality Technology? Literature Review, Synthesis, and Future Research Agenda, 2018. URL: <https://papers.ssrn.com/abstract=3300469>. doi:10.2139/ssrn.3300469.

- [30] M. Ez-zaouia, I. Marfisi-Schottman, M. Oueslati, C. Mercier, A. Karoui, S. George, A Design Space of Educational Authoring Tools for Augmented Reality, in: K. Kiili, K. Antti, F. De Rosa, M. Dindar, M. Kickmeier-Rust, F. Bellotti (Eds.), *Games and Learning Alliance*, volume 13647, Springer International Publishing, Cham, 2022, pp. 258–268. URL: https://link.springer.com/10.1007/978-3-031-22124-8_25. doi:10.1007/978-3-031-22124-8_25, series Title: *Lecture Notes in Computer Science*.
- [31] H. Coelho, P. Monteiro, G. Gonçalves, M. Melo, M. Bessa, Authoring tools for virtual reality experiences: a systematic review, *Multimedia Tools and Applications* 81 (2022) 28037–28060. URL: <https://link.springer.com/10.1007/s11042-022-12829-9>. doi:10.1007/s11042-022-12829-9.
- [32] R. Horst, R. Naraghi-Taghi-Off, L. Rau, R. Doerner, Authoring With Virtual Reality Nuggets—Lessons Learned, *Frontiers in Virtual Reality* 3 (2022). URL: <https://www.frontiersin.org/articles/10.3389/frvir.2022.840729>.
- [33] I. L. Chamusca, C. V. Ferreira, T. B. Murari, A. L. Apolinario, I. Winkler, Towards Sustainable Virtual Reality: Gathering Design Guidelines for Intuitive Authoring Tools, *Sustainability* 15 (2023) 2924. URL: <https://www.mdpi.com/2071-1050/15/4/2924>. doi:10.3390/su15042924, number: 4 Publisher: Multidisciplinary Digital Publishing Institute.
- [34] F. Rondan-Cataluña, J. Arenas-Gaitán, P. Ramírez-Correa, A comparison of the different versions of popular technology acceptance models: A non-linear perspective, *Kybernetes* 44 (2015). doi:10.1108/K-09-2014-0184.
- [35] V. Venkatesh, J. Y. L. Thong, X. Xu, Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology, *MIS Quarterly* 36 (2012) 157–178. URL: <https://www.jstor.org/stable/41410412>. doi:10.2307/41410412, publisher: Management Information Systems Research Center, University of Minnesota.
- [36] P. A. Rauschnabel, A. Brem, B. S. Ivens, Who will buy smart glasses? Empirical results of two pre-market-entry studies on the role of personality in individual awareness and intended adoption of Google Glass wearables, *Computers in Human Behavior* 49 (2015) 635–647. URL: <https://www.sciencedirect.com/science/article/pii/S0747563215001880>. doi:10.1016/j.chb.2015.03.003.
- [37] F. Paraskeva, H. Bouta, A. Papagianni, Individual characteristics and computer self-efficacy in secondary education teachers to integrate technology in educational practice, *Computers & Education* 50 (2008) 1084–1091. URL: <https://www.sciencedirect.com/science/article/pii/S0360131506001643>. doi:10.1016/j.compedu.2006.10.006.
- [38] G. V. Caprara, C. Barbaranelli, L. Borgogni, M. Perugini, The “big five questionnaire”: A new questionnaire to assess the five factor model, *Personality and Individual Differences* 15 (1993) 281–288. URL: <https://www.sciencedirect.com/science/article/pii/019188699390218R>. doi:10.1016/0191-8869(93)90218-R.
- [39] I. Tsaousis, The traits personality questionnaire (TPQue), in: *Big five assessment*, Hogrefe & Huber Publishers, Ashland, OH, US, 2002, pp. 238–256.
- [40] I. Tsaousis, P. Kerpelis, The Traits Personality Questionnaire 5 (TPQue5), *European Journal of Psychological Assessment* 20 (2004) 180–191. URL: <https://econtent.hogrefe.com/doi/10.1027/1015-5759.20.3.180>. doi:10.1027/1015-5759.20.3.180, publisher: Hogrefe Publishing.

- [41] P. Roussos, The Greek computer attitudes scale: construction and assessment of psychometric properties, *Computers in Human Behavior* 23 (2007) 578–590. doi:10.1016/j.chb.2004.10.027.
- [42] S. Kassotaki, P. Roussos, The Greek computer self-efficacy scale, in: *Proceedings of the 5th Panhellenic Conference ICT in Education*, 2006, pp. 726–733.
- [43] A. Proedrou, M. Stankova*, M. Malagkoniari, P. Mihova, Self-Efficacy and Attitudes Toward Computers of General and Special Education Teachers in Greece During the COVID-19 Period, *European Journal of Educational Research* 12 (2023) 1645–1656. URL: <https://eu-jer.com/self-efficacy-and-attitudes-toward-computers-of-general-and-special-education-teachers-in-greece-during-the-covid-19-period>. doi:10.12973/eu-jer.12.4.1645.
- [44] I. Pagé, M. Roos, O. Collin, S. D. Lynch, M.-E. Lamontagne, H. Massé-Alarie, A. K Blanchette, UTAUT2-based questionnaire: cross-cultural adaptation to Canadian French, *Disability and Rehabilitation* 45 (2023) 709–716. doi:10.1080/09638288.2022.2037746.
- [45] A. Gabriel, Help-xr instructor acceptability, 2024. URL: <https://archive.softwareheritage.org/swh:1:snp:bce7da486fe04f78882c514f7fa523469e5dd172;origin=https://github.com/ERPI-UL/helpxr-instructor-acceptability>.
- [46] ARETE, Interactive Authoring Toolkit integration with MirageXR (2022). URL: <https://zenodo.org/records/6579859>. doi:10.5281/zenodo.6579859.
- [47] F. Lécuyer, V. Gouranton, A. Reuzeau, R. Gaugne, B. Arnaldi, Action sequencing in VR, a no-code approach, *Transactions on Computational Science* (2020) 57. URL: <https://inria.hal.science/hal-02879073>. doi:10.1007/978-3-662-61983-4_4.
- [48] F. Wild, C. Perey, B. Hensen, R. Klamma, IEEE Standard for Augmented Reality Learning Experience Models, in: *2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, IEEE, Takamatsu, Japan, 2020, pp. 1–3. URL: <https://ieeexplore.ieee.org/document/9368405/>. doi:10.1109/TALE48869.2020.9368405.
- [49] K. Richard, V. Havard, J. His, D. Baudry, INTERVALES: INTERActive Virtual and Augmented framework for industrial Environment and Scenarios, *Advanced Engineering Informatics* 50 (2021) 101425. URL: <https://www.sciencedirect.com/science/article/pii/S1474034621001774>. doi:10.1016/j.aei.2021.101425, publisher: Elsevier.