



# Exploring the influence of the use of augmented reality for analyzing the safety of sport equipment in motivational climate, behaviors, and intention to use in a higher education context: a structural equation modelling approach

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## Abstract

The main objectives of this research were to analyze the impact of the use of augmented reality (AR) for analyzing the safety of sport equipment, on the motivational climate, behavior, and intention to use, and to validate a theoretical model for predicting continuance intention to use AR among students. The sample consisted of 254 university sport science degree students, who analyzed the safety of sports equipment using AR, after which they proceeded to complete the usability scale, the usage behavior scale, the behavioral intention factor of the System Usability Scale, and the motivational climate dimensions of mastery and performance of the Motivational Climate in Education Scale. The results showed that both usefulness and behavioral intention were found to play a positive role in intention to use. In addition, usefulness, perceived mastery motivational climate, and perceived performance motivational climate, influenced behavioral intention. In addition, perceived mastery motivational climate perception and gender positively and negatively influenced usefulness, respectively. Finally, gender had a significant influence on mastery motivational climate. In conclusion, a model was found according to which the motivational climate of mastery could predict students' usefulness and behavioral intention, with the latter two affecting user behavior.

**Keywords** Technology-enhanced learning · Technology acceptance model · Behavioral · Motivation · University · Usefulness

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## 1 Introduction

Research on Technology-Enhanced Learning (TEL) has increasingly focused on emerging technologies such as augmented reality (AR), which has become one of the technologies that has received the most attention and interest in the last decade (Bowers & Sabin, 2024; Garzón & Acevedo, 2019; Tolba et al., 2022). AR technology provides significant tools to enhance the experience of interacting with reality (Garzón & Acevedo, 2019). It enables the integration or enhancement of real-world objects with virtual ones, in either 2D or 3D. As a result, virtual and physical objects appear to coexist within the same spatial environment, thereby creating a mixed reality that facilitates simultaneous interaction with both domains (Chen & Lin, 2019).

### 1.1 AR in education

In education, AR has become an innovative and effective resource to enrich learning, thanks to its ability to combine the physical and digital worlds in an interactive and visual way. In fact, studies related to the integration of AR in the area of education have continued growing in recent decades (Garzón & Acevedo, 2019; Garzón et al., 2019; Koutromanos et al., 2023; Liono et al., 2021; Ozdemir et al., 2018; Quintero et al., 2019; Regnier et al., 2024). Regarding the positive impacts of AR integration in the educational setting, as compared to traditional methods, most previous research mainly highlighted improved student performance and learning gains (Amores-Valencia et al., 2022; Elmira et al., 2022; Garzón & Acevedo, 2019; Mokmin & Rassy, 2024; Ozdemir et al., 2018; Tolba et al., 2022), followed by increasing students' motivation towards learning (Amores-Valencia et al. 2022; Khan et al., 2019; Saadon et al., 2020). However, some limitations of AR also exist. The most relevant of these are usability (Garzón et al., 2019; Marín Rodríguez et al., 2023; Salar et al., 2020), with AR devices requiring continued development to ensure they are both user-friendly and easily portable (Liono et al., 2021), financial challenges (Marín Rodríguez et al., 2023), and lack of training and expertise (Barroso-Osuna et al., 2019; Marín Rodríguez et al., 2023).

### 1.2 AR as a tool for sports equipment safety education

AR is emerging as a powerful tool in the area of sports, both for coaching and teaching sport skills (Soltani & Morice, 2020). In particular, the use of AR to learn sport skills provides additional information, offers additional feedback, and simulates practice, among others (Soltani & Morice, 2020; Tolba et al., 2022). In the educational context, AR has the potential to enrich sports learning by providing interactive experiences, hands-on simulations, and real-time performance analysis (Soltani & Morice, 2020). In fact, previous research studies have analyzed the application of AR in this sector, as well as its benefits and future trends (Cabero-Almenara et al., 2019; da Silva et al., 2021; Marín Rodríguez et al., 2023; Soltani & Morice, 2020).

One of the fields that could benefit from the inclusion of AR technology is the analysis of the safety of sports spaces and equipment. In order to teach this type of content, students enrolled in Sports Science or Sports Management studies, or other undertaking non-formal training, such as the training of sports technicians of municipalities, county councils, or federations, have traditionally been required to travel to different sports facilities in order to carry out live observations of different items related to the safety of sports facilities and equipment (Diacin, 2018). However, this type of activity has some casuistic limitations, such as the fact of having to spend a lot of time travelling, or the lack of a sufficient amount of equipment within the same sport space to achieve significant learning (Diacin, 2018).

In this context, AR could be an interesting tool to allow students to learn in an immersive manner about the analysis of the safety of sports spaces and equipment, avoiding the handicaps previously mentioned. However, there are no previous studies that implement AR technology with respect to the analysis of the safety of sports spaces and equipment. Previous studies warn about the shortcomings in the safety of sports spaces and equipment, which can lead to risks and accidents (Maciá Andreu et al., 2021; Maciá et al., 2020). Therefore, one of the fundamental aspects to be considered by professionals in the sports field is the safety of spaces and equipment because, although most accidents are fortuitous, many of them are caused by poor conditioning (Prieto-González et al., 2021). In this regard, most of these accidents could be avoided if adequate safety measures were taken (Magaz-González & García-Tascón, 2022) through preventive actions, considering the safety requirements established in the current regulations, both at the time of purchase of sports equipment and in routine inspections (Maciá et al., 2020).

Given that augmented reality (AR) can be specifically designed to simulate any academic environment (Tolba et al., 2022), educators are able to expand the organizational space to enhance both the setting and situational context, thereby providing knowledge-rich experiences (Sánchez Pato & Remillard, 2018). In this way, enabling students to visualize and analyze sports equipment for design and safety flaws through AR would allow them to benefit from the positive impact of AR technology, by improving their ability to detect, recognize, and process objects and situations (Brito et al., 2018), and increasing their learning in terms of spatial structures (Papakostas et al., 2022), as compared to traditional environments.

In addition, the use of AR could have an impact on the motivational climate of the students, by approaching this type of content in a more practical and novel way (Amores-Valencia et al., 2022; Khan et al., 2019), as well as the intention of university students to continue using resources such as AR for learning content, as they understand that learning is much more transferable to professional reality (Gómez-Galán et al., 2020).

### **1.3 Technology acceptance model in education and its relationship with motivation and use behavior**

The arrival of AR in the educational field in general, and more specifically in the teaching of contents related to the field of sports, has been welcomed with great

expectations by students and teachers alike, as reflected in the large number of publications on this subject published in recent years (Calabuig-Moreno et al., 2020; da Silva et al., 2021; Soltani & Morice, 2020). Numerous theories on expectations, intentions and preferences for new technologies have been proposed in the field of education. Univariate models and theories have not been able to provide answers, due to the large number of variables that interact with each other, influencing motivation and usage behavior. For this reason, structural equation models (SEM) are proposed, as it is a multivariate statistical analysis technique that allows for the analysis of complex patterns of relationships between variables, making comparisons between and within groups, and validating theoretical and empirical models.

Different models and theories have been identified that attempt to provide a better understanding of information technology user perception and information system user acceptance, including the Technology Acceptance Model (TAM) (Davis, 1989), the Theory of Planned Behavior (TPB) (Ajzen, 1991), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), and the Combined TAM-TPB (C-TAM-TPB) (Taylor & Todd, 1995). The TAM (Davis, 1989) indicates that technology acceptance will be influenced by the belief held about the consequences of its use. More specifically, TAM identifies two main factors that influence technological acceptance (Davis, 1989). One of the factors indicated as influencing behavioral intention is usefulness, which is one of the factors most frequently included in the different theories (TAM, TPB, C-TAM-TPB & UTAUT) (Venkatesh et al., 2003). The second factor is behavioral intention, which refers to the end of the deliberation about what one will do, and indicates how hard one is prepared to try, or how much effort one will exert, in order to achieve desired outcomes (Webb & Sheeran, 2005). Therefore, in order to know whether a technology will be used optimally, it will be necessary to identify different external variables that can influence these factors, such as usefulness or behavioral intention (Yong Varela et al., 2010).

On the other hand, motivation is a key factor in technological acceptance. It can be analyzed from the perspective of intrinsic motivation, or internal interest in using technology out of curiosity, enjoyment, or intellectual challenge; or extrinsic motivation, referring to external influences, such as rewards, grades, or academic demands (Granero-Gallegos & Carrasco-Poyatos, 2020; Hew & Cheung, 2014; Saadon et al., 2020). This motivational approach in education is largely connected to learning goals (Granero-Gallegos & Carrasco-Poyatos, 2020). More specifically, the achievement goal theory attempts to explain achievement motivation on the basis of the goals pursued by the learner. In this way, two types of goals are mainly distinguished: mastery motivational, characterized by the student's motivation due to his or her desire to know, curiosity, preference for a challenge, or interest in learning; or performance motivational, where the student seeks to achieve extrinsic goals, such as academic performance, rewards, positive judgements, approval from family or teachers, or avoidance of negative evaluations (Ames & Archer, 1988; Elliot, 2005). In this sense, the motivational climate generated by the teacher in the classroom is a precursor of students' goal orientations, which have a powerful influence on motivation and basic psychological needs (Brisimis et al., 2022).

In addition, gender can affect the motivational climate in education due to several social and psychological factors that influence how students perceive and relate

to learning, achievement, and competence. Gender socialization theory argues that, from an early age, boys and girls are socialized into specific gender roles and expectations that affect their behaviors and attitudes towards achievement. These differences in expectations and behaviors can influence the motivational climate, as gender can impact how students interpret their own abilities and the value of educational tasks (Kuśnierz et al., 2020). However, although in line with gender socialization theory, in which the impact of social and psychological needs, and socialization agents (parents, caregivers, school, etc.) can influence students and have an impact on their interpretation of their own abilities, and how they affect their behaviors and attitudes towards achievement (Zhou et al., 2019), several previous research studies highlight a low level of significance with respect to gender (Bilgin et al., 2021; Canli, 2020; Emre et al., 2023).

Despite the importance of the topic covered and the interconnections between the factors discussed, there are thus far no known models that have analyzed the influence and interaction between all of these factors. Thus, due to the above, the hypothetical model of the present research was developed (Fig. 1). This model shows how the motivational climate (mastery motivational climate or performance motivational climate) influences usefulness and behavioral intention, and how these have an influence on usage behavior, considering the influence of gender.

#### 1.4 Objectives

In view of the above, the objectives of the present research were: 1) to analyze the impact of the use of AR technology for analyzing the safety of sport equipment on the motivational climate, behavior, and intention to use of sport science degree students; and 2) to propose and validate a theoretical model for predicting continuance intention to use AR among students.

#### 1.5 Hypothesis

The initial hypothesis of the present study is that AR technology used for analyzing the safety of sport equipment will show higher results in the mastery

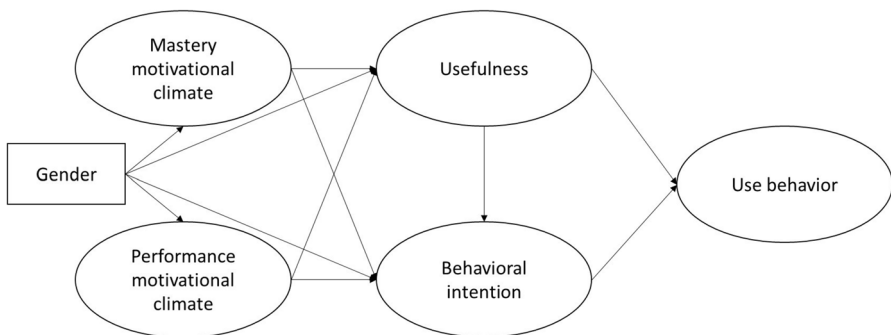


Fig. 1 Research hypothetical model

motivational climate than in the performance motivational climate, and a moderate to high response in usefulness and behavioral intention.

On the other hand, the predictive relationship in the model is presented in Fig. 1. In this sense, the final hypothesis of the present research is that the motivational climate (mastery motivational climate or performance motivational climate) influences usefulness and behavioral intention, and this influences usage behavior, considering the influence of gender.

## 2 Material and methods

### 2.1 Study design

A descriptive cross-sectional design was followed, in accordance with the Strengthening the reporting of Observational studies in Epidemiology (STROBE) guidelines (Cuschieri, 2019). With the participation of university students enrolled in the "Sports equipment and facilities" course of the Sports Sciences Degree at two Spanish universities from the Region of Murcia and Andalusia, an AR session was carried out where they worked on contents related to the safety of different sports equipment. After the session, the students self-completed sociodemographic questions, the usefulness scale (Cózar Gutiérrez et al., 2015), the use behavior scale (Almeida et al., 2019), the behavioral intention factor of the System Usability Scale (Hedlefs Aguilar & Garza Villegas, 2016), and the mastery and performance motivational climate dimensions of the Motivational Climate in Education Scale (Granero-Gallegos & Carrasco-Poyatos, 2020).

Before the study began, approval was obtained from the institutional ethics committee (code CE072207). During the process, the statements of the Helsinki declaration were followed. In addition, the students participating in the research study signed the informed consent form prior to data collection, which informed them of the objectives of the study, as well as the processing of the data obtained, and the confidentiality of the data.

### 2.2 Sampling method and sample size

To calculate the sample size, the methodology from previous studies based on the standard deviation (SD) was used (Bhalerao & Kadam, 2010). The Rstudio 3.15.0 software was used for this purpose. Sample size and power were set according to the standard deviation of mastery climate (SD=0.76) presented by a sample of similar characteristics (López-García et al., 2022). With an estimated error (d) of 0.09, a confidence interval of 95% (95% CI), a power of 95% and a significance level of 0.05, the minimum sample needed for conducting the study was 250 subjects.

A total of 254 students (age:  $20.20 \pm 2.73$  years old; gender: 84.6% male and 15.4% females) from two Spanish universities located in the Region of Murcia and

Andalusia (59% and 41% of participants, respectively) participated in the current study. The participants were volunteer students of the course "Sports equipment and facilities", part of the Degree of Sport Sciences. The study was carried out during the 2022–2023 academic year. The inclusion criteria were: (a) to be enrolled in the course "Sports equipment and facilities" at one of the two universities in the 2022–2023 academic year, and (b) to attend the session in which the project was developed.

### 2.3 Procedures

For the development of the project, the following steps were taken: first, different sports equipment was designed with AR. More specifically, the teaching staff of the subject "Sports equipment and facilities", together with a team of AR experts, designed different football goals, basketball hoops, futsal-handball goals and badminton equipment with different strengths and weaknesses related to their safety. Each of these elements could be accessed via a QR code (Fig. 2).

Subsequently, the AR-designed equipment was used in a practical class with the students, where they had to evaluate different items related to the safety of the equipment, which consisted of a checklist based on the UNE—Spanish Association for Standardization-, created ad hoc for this research (Supplementary file 1). For the development of the practice, the students were put in pairs, and by scanning the QR and projecting the equipment generated with AR, they completed the safety checklist of the equipment. This part of the practical class lasted 45–60 min, after which a general debriefing was held that lasted about 10 min. The development of the practice with the completion of the checklist and subsequent discussion on the analysis of the items analyzed had an overall grade of 1 point out of 10 of the final mark of the subject.

Immediately after the practical class, the students self-completed a questionnaire through Google Forms in Spanish. It included a series of sociodemographic questions about age, gender and university of origin; the usefulness scale, composed of five items with a Likert scale from 1–5, (1 means "completely DISAGREE" and 5 means "completely AGREE"), and a Cronbach' alpha  $\alpha=0.81$  (Cózar Gutiérrez et al., 2015); use behavior scale, composed of six items with a Likert scale from 1–5 and a Cronbach' alpha  $\alpha=0.93$  (Almeida et al., 2019); the behavioral intention dimension of the System Usability Scale, validated in Spanish, composed of five items with a Likert scale from 1–5 and a Cronbach' alpha  $\alpha=0.92$  (Hedlefs Aguilar & Garza Villegas, 2016); and the mastery motivational climate dimension, composed of four items with a Likert scale from 1–5 and a Cronbach' alpha  $\alpha=0.88$ , and the performance motivational climate dimension, composed of three items with a Likert scale from 1–5 and a Cronbach' alpha  $\alpha=0.87$  of the Motivational Climate in Education Scale (Granero-Gallegos & Carrasco-Poyatos, 2020). The self-completed questionnaire for the participants can be found in Supplementary file 2.



Basketball goals



Badminton



Basketball goals NBA



Football goals



Futsal-handball goals

Fig. 2 QR code of the designed sports equipment

### 2.3.1 Statistical analysis

The analysis was conducted in two phases. For Objective 1, descriptive statistics (means and standard deviations) of the different constructs were calculated for the data analysis.

For Objective 2, first, a confirmatory factor analysis (CFA) was performed on all selected dimensions to verify the reliability and validity of each instrument in this study. Second, the goodness-of-fit of the variable's ordinals, which refers to how well the model fits, was evaluated by measurements of absolute fit: Chi-square  $\chi^2$  p-value) and Root Mean Square of Approximation (RMSEA); measurements of incremental fit: Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Normed Fit Index (NFI), and goodness-of-fit index (GFI), following previous studies (Makransky & Petersen, 2019; Shih et al., 2019); and measurements of parsimony fit: Normalized Chi-square. Acceptable fits were indicated by a p-value  $\chi^2 > 0.05$ , an RMSEA  $\leq 0.06$ , an SRMR  $< 0.08$ , TLI scores  $\geq 0.90$ , CFI scores  $\geq 0.90$ , NFI scores  $\geq 0.90$ , GFI scores  $\geq 0.90$  and a normalized Chi-square value between 2 and 3 (Hair et al., 2014).

To assess the internal validity of the items of each latent variable, factor loading values must be above 0.5 to be significant (Hair et al., 2014). The reliability of the questionnaire was assessed based on convergent validity and discriminative validity. The convergent validity of the scale items was assessed using three criteria, namely Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). Acceptable fits were indicated by Cronbach's alpha  $> 0.7$ , CR  $> 0.7$  and AVE  $> 0.5$  (Hair et al., 2014). The Fornell-Larcker cross-loading criterion was used to assess discriminant validity (Hair et al., 2017). Fornell and Larcker (Fornell & Larcker, 1981) suggested that "the square roots of the AVE on each latent variable can be used to establish discriminant validity if the value is higher than other correlation values between the latent variables".

SEM was performed to provide a more precise measurement of the structural relationships between all the constructs. The estimator used was diagonally weighted least squares (DWLS) as it included a categorical variable (gender). The items were treated as ordinal variables except for gender, which was treated as a categorical variable. The analysis was performed in R software version 3.6.0. Copyright (C) 2019 (R Foundation for Statistical Computing) with the Lavaan package.

## 3 Results

Table 1 shows the scores of the mastery and performance motivational climate; behavioral intention; usefulness; and intention to use variables on a Likert scale from 1 to 5. All the dimensions obtained values above 4, except for "Performance motivational climate", for which the values were between 2.10 and 3.

To validate the theoretical model for predicting continuance intention to use AR among Physical Activity and Sport Science students, a confirmatory factor analysis

**Table 1** Validity and reliability analysis

Construct—Items	M	SD	Loading	$\alpha > 0.7$	CR > 0.7	AVE > 0.5
Mastery motivational climate						
Item 1	4.45	0.74	0.83	0.74	0.74	0.50
Item 2	4.38	0.83	0.76			
Item 3	4.20	0.96	0.65			
Item 4	4.50	0.69	0.78			
Performance motivational climate						
Item 1	2.10	1.45	0.98	0.78	0.80	0.58
Item 2	2.24	1.51	0.87			
Item 3	3.00	1.14	0.57			
Behavioral intention						
Item 1	4.34	0.78	0.85	0.83	0.83	0.51
Item 2	4.35	0.78	0.80			
Item 3	4.51	0.70	0.75			
Item 4	4.29	0.80	0.84			
Item 5	4.65	0.65	0.75			
Usefulness						
Item 1	4.20	0.9	0.86	0.81	0.81	0.50
Item 2	4.03	0.94	0.68			
Item 3	4.13	0.80	0.78			
Item 4	4.09	0.88	0.60			
Item 5	4.22	0.95	0.78			
Intention to use						
Item 1	4.38	0.89	0.90	0.93	0.93	0.69
Item 2	4.19	1.04	0.87			
Item 3	4.34	0.84	0.91			
Item 4	4.32	0.93	0.86			
Item 5	4.35	0.89	0.93			
Item 6	4.49	0.86	0.91			

M: mean; SD: standard deviation;  $\alpha$ : Cronbach's alpha; CR: composite reliability; AVE: average variance extracted

was carried out, to subsequently carry out a construct reliability and validity analysis, continuing with a model fit analysis, and finishing with a path analysis.

### 3.1 Confirmatory factor analysis

A CFA was performed to analyze the hypothesized model shown (Fig. 1). The first analysis of the hypothetical model reported an adequate goodness-of-fit;  $\chi^2$  p-value < 0.05, RMSEA = 0.053, SRMR = 0.05, TLI = 0.945, CFI = 0.951, NFI = 0.863, GFI = 0.874, Normalized Chi-square = 2. However, one item of a latent variable showed a factor loading lower than 0.5 (items 1 of behavioral intention:

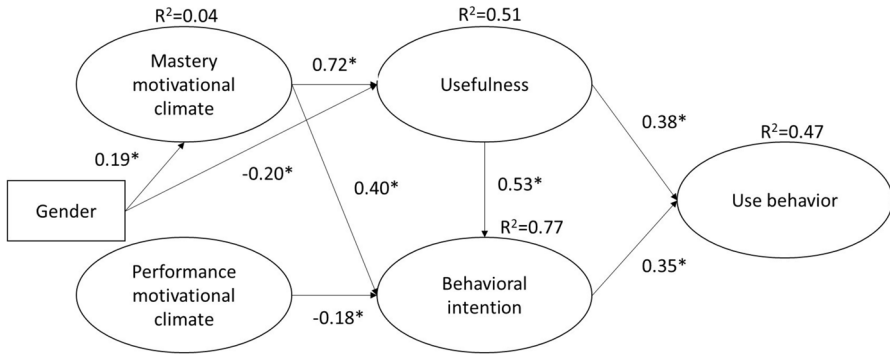


Fig. 3 Verification of the research model

factor loading=0.46) and some paths were not significant. Therefore, one item of behavioral intention and some paths were deleted through an interactive procedure. Each of these paths was evaluated and eliminated one by one based on the largest mismatch until all paths were significant.

The results revealed the final version model (Fig. 3). All factor loadings of the items were weighted above 0.571, indicating a significant internal validity of the latent variable (Table 1). The CFA indicated the goodness-of-fit of this structure:  $\chi^2$  p-value < 0.05, RMSEA = 0.055, SRMR < 0.05, TLI = 0.993, CFI = 0.942, NFI = 0.878, GFI = 0.885, normalized Chi-square = 2.1. Although the  $\chi^2$  p-value and RMSEA do not reach the required thresholds, it was because the number of comparisons was high and normal. In this case, if the other indices show a good fit, the internal validity is considered acceptable (Hair et al., 2014).

### 3.2 Construct reliability and validity analysis

First, the reliability of the questionnaire was evaluated based on the convergent validity and discriminative validity. The convergent validity of the scale items was assessed using three criteria, namely Cronbach’s alpha, composite reliability (CR), and average variance-extracted (AVE). The convergent validity of the scale is shown

Table 2 Discriminant validity—Fornell-Larcker criterion

Construct	1	2	3	4	5
Mastery motivational climate	<b>0.71</b>				
Performance motivational climate	-0.07	<b>0.71</b>			
Behavioral intention	0.58*	-0.10	<b>0.71</b>		
Usefulness	0.49*	0.05	0.64*	<b>0.71</b>	
Intention to use	0.33*	0.02	0.53*	0.48*	<b>0.83</b>

Values on the diagonal (bolded) represent square root of AVE while off-diagonals represent correlations. \*: p-value < 0.05

in Table 1. Cronbach's alpha values of all the constructs ranged from 0.74–0.93, the CR values ranged from 0.73–0.93, and AVE from 0.5–0.69, greater than the minimum loading criterion in each case. Hence, all three conditions of convergent validity were met.

Discriminant construct validity was assessed to determine whether the factors of one variable are different from those of another variable. The Fornell-Larcker cross-loading criterion was used to assess discriminant validity (Hair et al., 2017). Table 2 shows that the square roots of the AVE were greater than the absolute values of the correlation coefficient, so the discriminant validity of each construct was considered acceptable (Hair et al., 2014).

### 3.3 Model fit analysis

A SEM was conducted to examine the relationship between the variables. Figure 3 shows the structural relationship between the variables. The fit indices indicated that the proposed model sufficiently explained the data ( $\chi^2$  p value < 0.05, RMSEA = 0.054, SRMR < 0.05, TLI = 0.993, CFI = 0.993, NFI = 0.983, GFI = 0.985, Normalized Chi-square = 2.1).

### 3.4 Path analysis

Figure 3 and Table 3 reveal that both usefulness ( $\beta = 0.38$ ,  $p < 0.001$ ) and behavioral intention ( $\beta = 0.35$ ,  $p < 0.001$ ) played a positive role in intention to use. In addition, usefulness ( $\beta = 0.377$ ,  $p < 0.001$ ), mastery motivational climate perception ( $\beta = 0.53$ ,  $p < 0.001$ ) and performance motivational climate perception ( $\beta = -0.18$ ,  $p < 0.001$ ) influenced behavioral intention. Likewise, mastery motivational climate perception ( $\beta = 0.72$ ,  $p < 0.001$ ) and gender ( $\beta = -0.20$ ,  $p < 0.001$ ) influenced usefulness

**Table 3** Proposed model evaluation results

Relationship	Std $\beta$	Std Error	z value	R <sup>2</sup>
Intention to use				
Usefulness	0.38*	0.06	6.39*	0.47
Behavioral intention	0.35*	0.06	5.60*	
Behavioral intention				
Usefulness	0.53*	0.06	9.02*	0.77
Mastery motivational climate	0.40*	0.06	6.45*	
Performance motivational climate	-0.18*	0.03	-6.12*	
Usefulness				
Mastery motivational climate	0.72*	0.04	17.36*	0.51
Gender	-0.20*	0.13	-3.64*	
Mastery motivational climate				
Gender	0.19*	0.11	4.04*	0.04

Std error: standard error; Std  $\beta$ : beta value standardized; \*: p value < 0.05

positively and negatively, respectively. Finally, it is shown that gender ( $\beta=0.19$ ,  $p<0.001$ ) has a significant influence on mastery motivational climate.

The coefficient of determination, the  $R^2$  value, was determined to evaluate the predictive accuracy of the structural models. From the structural model,  $R^2$  values of 0.47, 0.51, and 0.77 were observed for intended use, usefulness, and behavioral intention, respectively. This implies that the variance of this construct is explained by the proposed construct by 47%, 51% and 77%, which signifies a moderate to high explanatory power (Hair et al., 2017). Gender explains 3.7% of the variance of mastery, which is a low explanatory power (Hair et al., 2017).

#### Discussion.

The first objective of this research was to analyze the impact of the use of AR technology on the motivational climate, behavior, and intention to use of Sports Science degree students in the analysis of sports equipment safety. An outstanding result of the present research was that the AR stands out as an innovation in the field of education, showing high values in mastery motivational climate, the perceived usefulness of the tool, and the behavioral intention and intention to use of the participants. These results are in line with those found in previous studies that found that the inclusion of AR in education improved student performance, learning gains (Amores-Valencia et al., 2022; Garzón & Acevedo, 2019; Mokmin & Rassy, 2024; Ozdemir et al., 2018; Tolba et al., 2022), and motivation (Amores-Valencia et al., 2022; Khan et al., 2019; Saadon et al., 2020). More specifically, the inclusion of AR in education has been shown to improve student engagement, motivation, active participation, and learning outcomes. This approach fosters a more interactive and enjoyable learning environment, leading to improved academic performance and a positive change in students' attitudes towards learning (Lampropoulos et al., 2022). This could be due to the fact that AR can improve students' learning attitudes and professional skills in a real-world situation, by making learning more interactive and engaging in the area of sports (Hwang et al., 2016). In fact, use of AR in sports provides the participant with additional information and lets them experience the content, which could offer advantages for learning, feedback, and a meaningful experience (Soltani & Morice, 2020). AR has numerous benefits, allowing for more effective and motivating learning experiences (Petrovich and Foster, 2021; Tolba et al., 2022). Thus, in line with previous studies, the present research demonstrates that AR approaches may be used for learning and providing feedback and additional information (Soltani & Morice, 2020), and may also improve the student's experience in the teaching of content related to the safety of sports equipment.

A second objective of this research was to propose and validate a theoretical model for predicting continuance intention to use AR among students. It was found that mastery motivational climate could affect usefulness and behavioral intention, with both playing a positive role in the intention to use (use behavioral). An adequate coefficient of determination ( $R^2$  value) was determined to evaluate the predictive accuracy of the structural model's for intended use, usefulness, and behavioral intention, which signified a moderate to high explanation of the variance of mastery (47%, 51%, and 77%, Table 3) following the methodology from previous studies (Cózar Gutiérrez et al., 2015; Cupani, 2012).

On the interaction of mastery motivation climate and usefulness, numerous studies have been found that AR increases student's mastery motivation in the learning process and interest, achieving a high involvement in the teaching–learning process (Bujak et al., 2013; Chang et al., 2014; Di Serio et al., 2013; Rodríguez Caldera, 2021; Tuli et al., 2022). Also, it has been found that the use of AR is considered useful and easy to use by students, favoring their perception of usefulness when AR is used for training in the field of safety (Shamsudin et al., 2023). Continuing with this relationship, previous studies that analyzed the inclusion of AR in education found that the use of AR improved students' motivation and perceived usability, which benefited their learning process and academic performance (Cabero-Almenara et al., 2019; Garzón & Acevedo, 2019).

Regarding the relationship between mastery motivational climate and behavioral intention found in the present research, previous studies have pointed out that AR use is related to a mastery motivational climate and perceived enjoyment, which means that AR has a significant relationship with the behavioral intention variable in the educational context, and may therefore be a key resource in education (Balog & Pribeanu, 2010).

Another key finding of the present research is that usefulness and behavioral intention significantly influence use behavior. This is in line with previous studies that showed that when AR is used as an educational resource, the predisposition to use found in these contexts may be related to a greater willingness to learn and explore educational content in an interactive and hands-on way (Cabero-Almenara et al., 2019). Along the same line, some studies have also shown that AR technology is suitable for self-learning methods (Lewis et al., 2013; Mendez et al., 2020), as it promotes a more immersive learning experience (Garzón et al., 2020). Not surprisingly, previous studies have found that using AR as a didactic resource increases behavioral intention, affecting present and future use behavior (Uymaz & Uymaz, 2022), which is consistent with the results of the present research. In the same vein, it has been found that students enjoy using AR technology, and the main reason is that it allows students to play an active role in its application (Volioti et al., 2023); Similarly, previous studies suggest that when users perceive technology as beneficial and easy to handle, they are more likely to plan to use it (Bathini et al., 2022).

Therefore, the incorporation of AR in the teaching–learning process has a great potential to enrich educational experiences at different educational levels and areas of study (Cabero-Almenara et al., 2019).

A relevant finding of the present research is that gender explained 3.7% of the variance of mastery motivation climate, which is a low explanatory power. Moreover, it had no influence on the rest of variables. Previous literature on this subject is very confusing. While previous studies found that learning was not influenced by gender in an educational intervention based on AR at university, (Cabero-Almenara et al., 2019); other studies did find motivational differences in learning with AR as a function of gender, with male students showing greater motivation and confidence than female students when applying this technology (Amores-Valencia et al., 2022; Potts & Yee, 2019). In contrast, in the study by Dirin et al. (Dirin et al., 2019), female students were more motivated than male students to use AR.

Gender can affect the motivational climate in education due to various social and psychological factors, which influence how students perceive and relate to learning, performance, and competence. Therefore, these results can be explained by gender socialization theory. According to Bettis & Ferry (Bettis & Ferry, 2016), social institutions play a fundamental role in shaping gender identities, while society reinforces specific behaviors and roles assigned to males and females (Eagly & Wood, 2016). Furthermore, studies such as Mason and Mudrack (Mason & Mudrack, 1996) revealed significant differences in ethical behavior between genders, highlighting variations in the norms and expectations that guide the actions of both genders. These theories highlight how gender socialization is deeply intertwined with social structures, shaping both behaviors and expectations in different contexts. These differences in expectations and behaviors can influence motivational climate, as gender can impact how students interpret their own abilities and the value of educational tasks.

Regarding the novelties of this study, the innovative theoretical model that relates the motivational climate with the perception of usefulness and the intention to use, validated by structural equations, can be highlighted, as it provides a predictive framework that integrates AR in higher education, particularly in the prevention of risks in the equipment found in sports facilities. And we can add the use of AR technology to analyze the safety of sports equipment, after analyzing the effect of this approach on the motivational climate, behavior, and intention to use it in Sports Science undergraduate students. Thus, a new way to approach this type of content is presented that could be an alternative to the traditional way of teaching it, which forced the students to travel to sports facilities to attain experiential learning (Diacin, 2018).

Numerous theoretical and practical implications are highlighted in this study. From a theoretical perspective, it deepens our knowledge not only on the use of AR technology, but also on the impact of its use on the motivational climate, highlighting its influence on the perception of usefulness and the intention to use it, with these being fundamental elements to promote and improve teaching–learning situations in the classroom. On the other hand, from a practical perspective, AR significantly improved the educational experience by motivating students in their own use of this interactive technology and its direct application in teaching for the analysis of sports equipment safety. This knowledge not only reduces risks and prevents accidents, but is also useful in other areas, as it creates dynamic and effective learning and decision-making environments that resemble those that students will experience as part of their future professions. Therefore, as a practical application in sports management, this type of experience is a motivational technique that can help in the ongoing training of technicians, maintenance managers, and managers of sports facilities to reduce the risk of accidents that users may have.

The present study shows certain limitations. The first limitation found is that the students' experiences with AR were obtained voluntarily in the form of a questionnaire. Thus, only the students who volunteered completed it. This may represent an error of inclusion bias. On the other hand, the non-use of a control group in any form is also considered a limitation of the present study, since the results obtained could not be compared with the use of another methodology. Thus, given the absence of a

control group, the results may not be conclusive regarding the effectiveness of AR in the educational context; but they can be indicative of the positive and attractive use of this technology by students, without the need to apply the control group in the study (Dirin et al., 2019; Potts & Yee, 2019). Another possible limitation is that the data on motivational climate, behavior, and intention to use are self-reported, which could be a bias of the present research due to the influence of external factors (Hornsveld et al., 2019). Therefore, future studies should explore this issue further with more objective instruments to investigate the relationships between these variables.

In conclusion, the use of AR for teaching aspects related to the safety of sports equipment in an experiential manner, but without having to travel to a sports facility, could favor the mastery motivational climate, as well as the usefulness perceived by the student of this type of content, behavioral intention, and use behavior. Furthermore, a model found whereby the mastery motivational climate could predict the usefulness and behavioral intention of students, with the latter two affecting use behavior.

#### 4 Data availability statement

The database can be obtained from the corresponding author.

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#### Declarations

**Competing interests** The authors report there are no competing interests to declare.

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