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Increase grit and learning satisfaction in physical education among student-athletes: augmented reality Learning is the Solution?

Aumentar el valor y la satisfacción con el aprendizaje en educación física entre estudiantes-atletas: ¿el aprendizaje con realidad aumentada es la solución?

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Abstract. This study aims to investigate the effect of using augmented reality (AR) on increasing the level of grit and learning satisfaction among student-athletes. We adopted mixed-methods sequential explanatory design. A total of 40 student-athletes, participants were allocated into control group (CG, n = 20), and experiment group (AR, n = 20). The results of quantitative research based on the Paired sample t-test show that there are significant pre- and post-test differences in CG ($p < 0.050$, and AR ($p < 0.05$) in grit and satisfaction. At the same time, the results of 2-Way ANOVA show that there is an effect of time on the variables grit (CoI [$p < .001$, $\eta^2p = 0.810$], PoE [$p < .001$, $\eta^2p = 0.837$] and satisfaction (TaI [$p < .001$, $\eta^2p = 0.812$], PT [$p < .001$, $\eta^2p = 0.726$], TP [$p < .001$, $\eta^2p = 0.649$], IP [$p < .001$, $\eta^2p = 0.796$], there is a group effect on the grit variable (CoI [$p < .001$, $\eta^2p = 0.488$], PoE [$p < .001$, $\eta^2p = 0.451$] and satisfaction (TaI [$p = 0.025$, $\eta^2p = 0.126$], PT [$p = 0.011$, $\eta^2p = 0.159$], IP [$p = 0.048$, $\eta^2p = 0.099$], but not found in the TP variable ($p = 0.079$, $\eta^2p = 0.079$), and there was an interaction between grit (CoI [$p < .001$, $\eta^2p = 0.707$], PoE [$p < .001$, $\eta^2p = 0.718$], and satisfaction (TaI [$p = 0.031$, $\eta^2p = 0.117$], but there was no interaction on PT [$p = 0.113$, $\eta^2p = 0.065$], TP [$p = 0.638$, $\eta^2p = 0.006$], IP [$p = 0.565$, $\eta^2p = 0.009$]. While qualitative findings showed that student-athletes argued that AR has an advantage to create an interactive, interesting, and easy to use learning program to learn various skills in sports.
Based on quantitative and qualitative research findings we conclude that integrated AR in PE is a powerful way to increase aspects of grit and learning satisfaction among student-athletes.
Keywords: Technology teaching; Grit, Learning satisfaction, Physical education

Resumen. Este estudio tiene como objetivo investigar el efecto del uso de AR en el aumento del nivel de determinación y satisfacción con el aprendizaje entre estudiantes-atletas. Adoptamos un diseño explicativo secuencial de métodos mixtos. Un total de 40 estudiantes-deportistas. Los participantes fueron asignados al grupo de control (CG, n = 20) y al grupo experimental (AR, n = 20). Los resultados de una investigación cuantitativa basada en la prueba t de muestras pareadas muestran que existen diferencias significativas antes y después de la prueba en CG ($p < 0,050$ y AR ($p < 0,05$) en determinación y satisfacción. Al mismo tiempo, la Los resultados del ANOVA de 2 vías muestran que existe un efecto del tiempo sobre las variables grit (CoI [$p < .001$, $\eta^2p = 0.810$], PoE [$p < .001$, $\eta^2p = 0.837$] y satisfacción (TaI [$p < . 001$, $\eta^2p = 0.812$], PT [$p < .001$, $\eta^2p = 0.726$], TP [$p < .001$, $\eta^2p = 0.649$], IP [$p < .001$, $\eta^2p = 0.796$], hay un efecto de grupo en el variable grit (CoI [$p < .001$, $\eta^2p = 0.488$], PoE [$p < .001$, $\eta^2p = 0.451$] y satisfacción (TaI [$p = 0.025$, $\eta^2p = 0.126$], PT [$p = 0.011$, $\eta^2p = 0.159$] , IP [$p = 0.048$, $\eta^2p = 0.099$], pero no se encontró en la variable TP ($p = 0.079$, $\eta^2p = 0.079$), y hubo interacción entre grit (CoI [$p < .001$, $\eta^2p = 0.707$], PoE [$p < .001$, $\eta^2p = 0.718$] y satisfacción (TaI [$p = 0.031$, $\eta^2p = 0.117$], pero no hubo interacción en PT [$p = 0.113$, $\eta^2p = 0.065$], TP [$p = 0.638$, $\eta^2p = 0,006$], IP [$p = 0,565$, $\eta^2p = 0,009$]. Mientras que los hallazgos cualitativos mostraron que los estudiantes-atletas argumentaron que la RA tiene la ventaja de crear un programa de aprendizaje interactivo, interesante y fácil de usar para aprender diversas habilidades en los deportes. Con base en los resultados de la investigación cuantitativa y cualitativa, llegamos a la conclusión de que la RA integrada en la educación física es una forma poderosa de aumentar aspectos de determinación y satisfacción con el aprendizaje entre los estudiantes-atletas.
Palabras clave: Enseñanza de tecnología; Valor, Satisfacción con el aprendizaje, Educación física

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Introduction

The implementation of physical education (PE) worldwide during or after the COVID-19 crisis era has transformed from an offline to online learning system and involved the application of sophisticated technology (Jumareng et al., 2022). Basically, to optimize the online learning process, it was necessary to involve technology such as a laptop which connected to an internet platform (e.g., zoom meeting, google meet, moodle), as a media for interaction between student-athletes and lecturers (Raman et al., 2022). Data recorded about the advantages of using a technology, for example it can be implemented anytime and anywhere, saves time, enable to access knowledge more quickly (Jumareng et al., 2021). However, there were also drawbacks such as poor internet connection, student-athletes without laptops, lack of computer facilities in several schools and universities, and internet access not reaching rural areas (Raman & Thannimalai, 2021). Previous studies reported that online learning became popular and widely used at all levels of education, but the effectiveness in PE was still doubtful (Jumareng et al., 2022; Sortwell & Ramirez-Campillo, 2022), as it was difficult to teach various types of complex movement to student-athletes when using an online system. If this issue is ignored, it

will have a negative impact on student-athletes particularly on their grit and satisfaction which will gradually decline.

Researchers focused their attention on grit which has been the subject of a great deal of study to date (Elnaem et al., 2023; Martin et al., 2023; Tannoubi et al., 2023; Totosy de Zepetnek et al., 2021), as it plays an important role for student-athletes in their long term academic experience and support them to gain high academic achievement (Hernández et al., 2020; Sulla et al., 2022). Previous research reported the positive impact of developing grit among student-athletes, for example, to prepare them academic success (Frontini et al., 2021), and in life (Lytle & Shin, 2023). In addition, it was reported that grit can support a good physical health which was useful for them to undergo the academic process (Liu et al., 2022). However, if grit is not properly nurtured and developed, it would have negative consequences such as easy giving and lack of self-confidence which can lead failure in achieving goals (Lee, 2022).

Student-athletes satisfaction is another aspect that attracted attention as it was claimed to be significantly decreasing (Baños et al., 2020; Rojo-Ramos et al., 2022; Shpakou et al., 2022). Data reported that the level of satisfaction in terms of sports (Mehrsafar et al., 2021; Shpakou et al., 2022), studying (Al Awamleh, 2020; Suhandiah et al., 2022), or living life is increasingly low (Xitao et al., 2021). According to Keržič et al. (2021), student-athletes satisfaction is a predictor for determining the level of success in academics. Meanwhile, low level of satisfaction has an impact on reducing the level of participation and motivation in learning (Younas et al., 2022).

One type of learning, augmented reality (AR) is becoming increasingly popular. Basically, AR is a learning process that involves sophisticated technological media, which combines the real situations and 3D animation (Castaño-Calle et al., 2022). Through AR, student-athletes can observe animation that appears in reality (Chang et al., 2019). AR technology is one of the aspects related to the development of information and interactive technologies, ranging from watching videos with animations of various technical and tactical elements for training athletes (Tannoubi et al., 2023), injury prevention (Kozina et al., 2021). AR technology is a qualitative leap in the development of information technologies in sports (Neumann et al., 2018). It determines the future in the study of movements and relevant for the modern world with the predominance of online learning in PE (Gani et al., 2023). Previous studies reported that AR has proven effective in increasing learning motivation, concentration and attractiveness of student-athletes (Chang et al., 2019). Even the research of Moreno-Guerrero et al. (2020), revealed that the key of success in AR depend on its benefits for student-athletes, for example increase learning interest and academic achievements.

There were several studies about AR in PE which had been well documented (Calabuig-Moreno et al., 2020; Castaño-Calle et al., 2022; Chang et al., 2019; Gómez-García et al., 2018; Loia & Orciuoli, 2019). Unfortunately to the best of our current knowledge, no study has reported the application of AR to improve student-athletes' grit and satisfaction in the context of PE. In addition, previous studies only focused on researching AR through experimental research (Moreno-Guerrero et al., 2020), and systematic reviews (Mokmin & Rassy, 2022). This study aims to investigate the effect of using AR to increase student-athletes' grit and satisfaction.

Materials and Methods

Mixed method design

This research adopts a mixed method type with a sequential explanatory design. Quantitative research was carried out experiment and qualitatively through in-depth interviews.

Participants

We planned to involve eighty student-athletes who studied from first to fourth years of the PE department of Suryakancana University (Indonesia). All participants were informed about the benefits of the study and signed written informed consent. They were selected based on the inclusion criteria: (i) They did not participate in other activities outside the program, (ii) They had healthy and did not experiencing injuries. Exclusion criteria: (i) injury in the last 2 months, (ii) absence in the last 1 month. We calculated a priori power analysis using G*Power (v. 3.1.9.4). A sample size of 40 participants was required to have sufficient power (> 0.80) based on a chosen alpha of 0.05. Student-athletes were allocated to control group (CG) and augmented reality (AR) through random analysis (https://www.randomizer.org/). Therefore, there was in the CG (n = 20) and AR (n = 20) completed this research program (CONSORT Fig. 1). Table 1 presented the participant's information.

Ethical approval for research procedures was obtained from the main author's institutional body (Research Ethics Committee of Suryakancana University with number: 458/LPM/UNSUR/2024). In addition, to carry out this research, we followed the latest guidelines of Helsinki Declaration for Humans (World Medical Association, 2013).

Table 1.
Participant characteristics

Information	CG (n = 20)	AR (n = 20)
Age (year)	19.40 ± 1.14	20.11 ± 1.04
Boys	10 (50%)	10 (50%)
Girls	10 (50%)	10 (50%)
Height (cm)	159.35 ± 3.39	160.05 ± 2.67
Weight (kg)	56.40 ± 2.25	58.00 ± 2.00
Years of education (year)		
First year	9 (45%)	6 (30%)
Second year	6 (30%)	10 (50%)
Placement year	2 (10%)	3 (15%)
Final year	3 (15%)	1 (5%)
BMI (kg/m^2)	20.80 ± 1.60	21.21 ± 1.03

Note: CG: Control group, AR: Augmented reality, BMI: Body mass index.

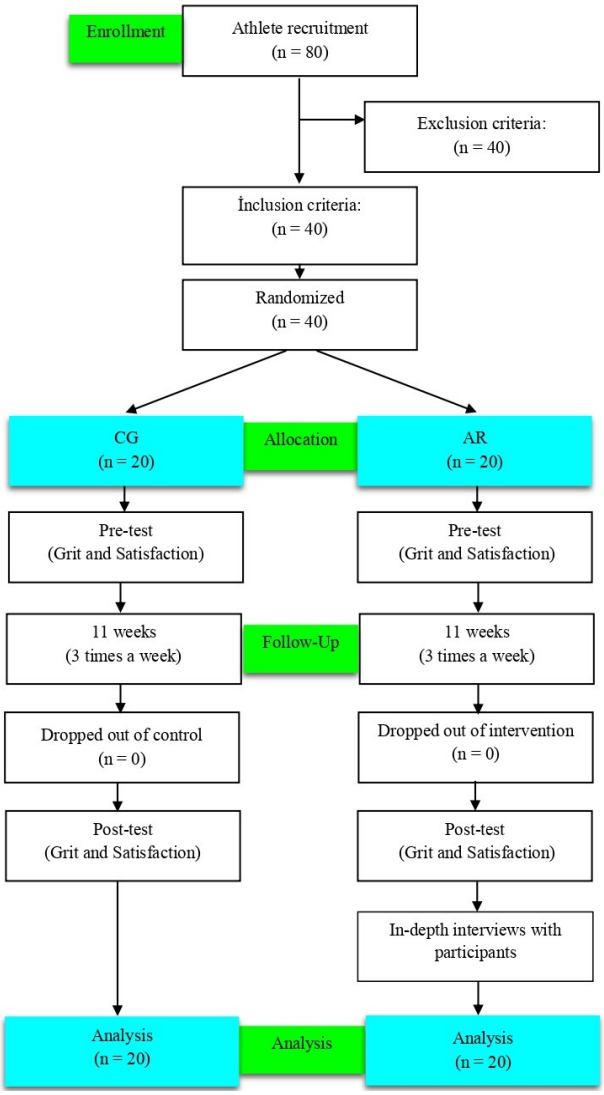

Figure 1. CONSORT flow chart

Instruments

Quantitative Instruments

Grit scale

The grit scale had been widely used in previous studies (Martínez-Moreno et al. 2021). This instrument covers 8 questions with 2 subscales, namely the consistency of interest (CI) which has four question items, for example: "I often set goals but then choose to pursue others" and perseverance of effort (PoE) which also has four question items, for example "I am a hardworking athlete" (Rumbold et al., 2022). The score was calculated using a Likert scale from 1 (not reflecting me at all) to 5 (extremely reflecting me) (Frontini et al., 2021; Lytle & Shin, 2023). The reliability value of this instrument is presented in intraclass correlation (ICC) in Table 2.

Satisfaction

The present study utilized the Athlete Satisfaction Questionnaire (ASQ) for evaluating the satisfaction level among athletes (Jawoosh et al., 2022). This instrument has 14 items from 4 subscales namely: training and instruction (3 items), personal treatment (5 items), team performance (3 items) and individual performance (3 items). The question items in ASQ were answered with the Likert scale from 1 (very dissatisfied) to 7 (very satisfied). The ASQ reliability value is presented in ICC in Table 2.

Qualitative Instruments

Whereas, the qualitative instruments in this study used in depth interviews for 30-40 minutes per individual. Interviews were conducted directly to the participants in experimental group using Bahasa. This instrument has been widely used by previous studies and has proven effective (Jumareng et al., 2022; Gani et al., 2023).

Procedure

This mixed-methods sequential explanatory design included quantitative and qualitative research. Quantitative research through true experimental which was conducted in January-March 2024. The first activity (05 January 2024) carried out an pre-test, participants filled in the grit and satisfaction questionnaire. The second meeting (07 January 2024), the CG carried out their daily learning activities, such as: learning martial arts conventionally or without the use of AR and the experimental group carried out the AR program (e.g., martial arts), until 16 March 2024. CG and AR activities were carried out 3 times a week. The post-test (18, March 2024), all participants should fill in the grit and satisfaction questionnaires.

On March 20, 2024, a qualitative research study was conducted at the Suryakancana University Hall and applied in-depth interviews as the primary data collection method. The interview was carried out from 10.40 am until finished. Interviews were conducted using Bahasa for 30 minutes per individual regarding their perceptions of the advantages, disadvantages and impacts of the AR. The interviews were focused on participants in the AR. The researchers were able to interview 10 participants in one day.

CG and AR Program

In this research, there were two groups, namely the experimenter who implemented the AR program and the CG who only carried out daily learning that participants usually do (non-AR). On the first day, the lecturer who will teach participants in the CG group has the initials "EF", while the lecturer who teaches in AR has the initials "MA", both lecturers have more than 5 years of teaching experience in PE. Before the activity started, participants in CG and AR were instructed to do a warm-up (5 min). The first activity carried out by the experimental group was using the AR application that was installed on each participant's smartphone, where they used the AR application to observe every movement (e.g., kicks and punches) in karate and pencak silat. After the activity is complete, participants put down their smartphones and then carry out a kick and punch practice session independently (60 min). If participants forget the movement, they are allowed to reopen the AR application to observe the punching and kicking movements (Fig. 2), This activity aims to increase aspects of grit and satisfaction among student-athletes. Then the exercise closed with all

participants stretching for 5 minutes. CG and AR activities will end on March 16 2024.

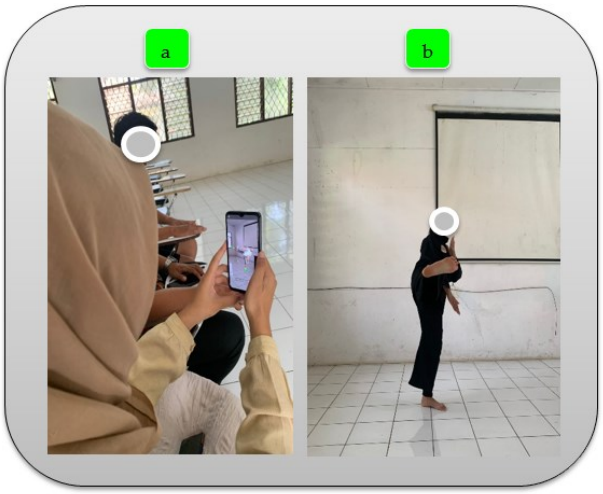

Figure 2. Implementation of AR learning. (a) Observing the kicking movement in AR, (b) Excuting the kicking movement

Data analysis

Quantitative analysis

Normality (Shapiro-wilk) and homogeneity (Levene-test) tests were carried out in this study. Descriptive statistic was expressed in mean ± standard deviation. Parametric analysis was chosen, because the data shows the assumption of data normality, so the Paired sample t-test was used to test differences scores in grit and satisfaction in the CG and AR pre- and post-test. Meanwhile, 2-way ANOVA repeated measures to test the effect time (pre-test x post-test), effect group (CG x AR), and their interaction (time x group) on the grit and satisfaction scores. Partial eta squared (ηp^2) effect size values were reported and classified as 0.01 (small), 0.06 (medium) and 0.14 (large). In addition, effect size (ES) analysis uses the following Cohen's (d) criteria: very large (>2.0), large (1.2 – 1.99) medium (0.60 – 1.19), small (0.2– 0.59) and trivial (<0.2) (Cohen, 1988). Sixth, calculated the delta percentage value (%Δ) with the formula: (posttest–pretest / pretest) × 100. Analysis was using the Jamovi statistics software (v.2.3.28) and the significance level was set at $p < 0.05$. The significance level was determined as $p < 0.05$. The reliabilities of all dependent variables were assessed by calculating intra class correlation coefficients (ICC).

Qualitative analysis

The qualitative data obtained from in-depth interviews was subjected to analysis utilizing a qualitative thematic approach. The initial stage of the in-depth interviews involved coding the obtained results, followed by categorization into three distinct themes. Three themes are presented in Figure 3.

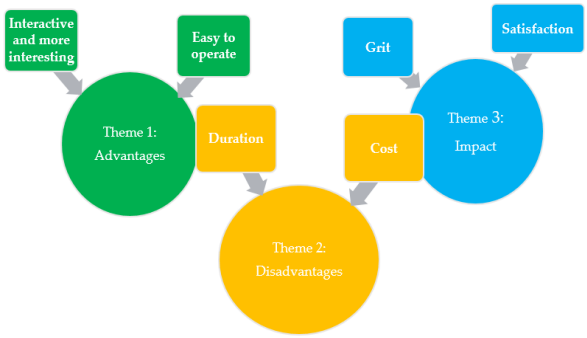

Figure 3. Concept of Three Big Themes

Results

Quantitative results

Test-retest reliabilities were generally above the accepted threshold, with ICC ranging from 0.913 to 0.982, normality ($p > 0.05$), and homogeneity ($p > 0.05$) of grit and satisfaction variables (Table 2).

Table 2.
İntra-class correlation coefficients (ICC) of change of grit and satisfaction

Variables	ICC	95% CI	Sw CG (pre-post)	Lt CG (pre-post)	Sw AR (pre-post)	Lt AR (pre-post)
			Grit			
CoI (score)	0.913	0.817–0.924	0.766	0.356	0.132	0.231
PoE (score)	0.938	0.858–0.972	0.166	0.183	0.319	0.145
			Satisfaction			
TaI (score)	0.982	0.969–0.990	0.089	0.084	0.104	0.219
PT (score)	0.969	0.933–0.977	0.151	0.260	0.070	0.354
TP (score)	0.927	0.849–0.965	0.057	0.190	0.126	0.249
IP (score)	0.948	0.873–0.979	0.099	0.158	0.175	0.183

Note: CG = Control group, AR = Augmented reality, CoI = Consistency of interest, PoE = Perseverance of effort, TaI = Training and instruction, PT = Personal treatment, TP = Team performance, IP = Individual performance, ICC = Intra-class correlation coefficients, CI = Confidence interval, Sw = Shapiro-wilk's, Lt = Levene's- test.

Effect CG and AR on Grit and Satisfaction

Based on the results of the Paired sample t-test in Table 3, we found that there were pre- and post-test differences in the grit variable (CoI [Δ =+8.1, p = 0.043, ES = -0.48], PoE [Δ = +10.4, p = 0.005, ES =-0.70]) and satisfaction (TaI [Δ = +27.3 p < .001 , ES = -1.72], PT [Δ = +19.3, p < .001, ES = -1.27], TP [Δ = +21.4, p < .001, ES = -1.21], IP [Δ = +18.9 p < .001 , ES = -2.05]) in CG. At the same time, pre- and post differences also occurred in AR on the grit variable (CoI [Δ = +62.4 p < .001, ES = -3.65], PoE [Δ = +68.0, p < .001, ES = -3.49]) and satisfaction (TaI [Δ = +37.9, p < .001, ES = -2.32], PT [Δ = +26.1, p < .001, ES = -1.94], TP [Δ = +22.8, p < . 001 , ES = -1.45], IP [Δ = +23.0, p < .001 , ES = -1.84]). These results show that the increase in grit and satisfaction variables is greater in AR than in CG (Table 3 and Figure 4)

The ANOVA results in Table 4 show that for the CoI there is a main effect of time ($F_{[1.38]} = 162.1$, $p < .001$, $\eta^2 p = 0.810$), PoE ($F_{[1.38]} = 194.6$, $p < .001$, $\eta^2 p = 0.837$).

There was a group effect on CoI ($F_{[1.38]}$ = 36.3, p < .001, η^2p = 0.488), PoE ($F_{[1.38]}$ = 31.2, p < .001, η^2p = 0.451). There was an interaction effect on CoI ($F_{[1.38]}$ = 91.6, p < .001, η^2p = 0.707), PoE ($F_{[1.38]}$ = 96.9, p < .001, η^2p = 0.718). At the same time, the results of the 2-way ANOVA repeated measures test (Table 4) also show that there are differences in the effect of time on the variables TaI ($F_{[1.38]}$ = 163.88, p < .001, η^2p = 0.812), PT ($F_{[1.38]}$ = 100.56, p < .001, η^2p = 0.726), TP ($F_{[1.38]}$ = 70.133, p < .001, η^2p = 0.649), IP ($F_{[1.38]}$ = 148.301, p < .001, η^2p = 0.796). Similar results found that there were significant differences in group effects on the variables TaI ($F_{[1.38]}$ = 5.47, p = 0.025, η^2p = 0.126), PT ($F_{[1.38]}$ = 7.19, p = 0.011, η^2p =0.159), IP ($F_{[1.38]}$ = 4.16, p = 0.048, η^2p = 0.099), but no difference was found in TP ($F_{[1.38]}$ = 3.27, p = 0.079, η^2p = 0.079). Finally, we observed an interaction on the TaI variable ($F_{[1.38]}$ = 5.02, p = 0.031, η^2p = 0.117), but no differences were found on other variables such as PT ($F_{[1.38]}$ = 2.64, p = 0.113, η^2p = 0.065), TP ($F_{[1.38]}$ = 0.225, p = 0.638, η^2p = 0.006), IP ($F_{[1.38]}$ = 0.336, p = 0.565, η^2p = 0.009).

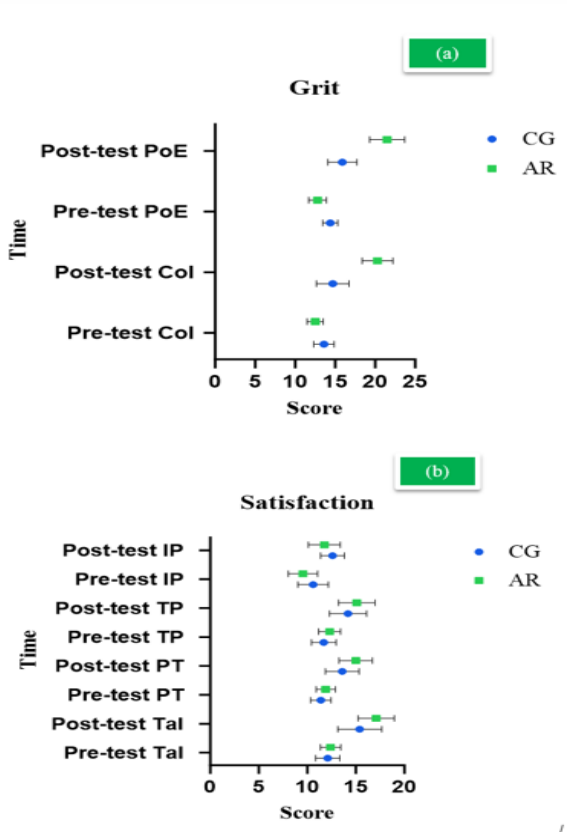

Figure 4. Changes in (a) grit and (b) perceived satisfaction in the CG or AR conditions. *Significant difference between CG and AR in any condition (p < 0.05)

Table 3.
Pre- and post-11-week changes in grit and satisfaction variables among student-athletes

Variables	CG (n = 20)					AR (n = 20)				
	Pre	Post	Δ	p	ES [d]	Pre	Post	Δ	p	ES [d]
Grit										
CoI (score)	13.6 ± 1.28	14.7 ± 2.03*	+8.1	0.043	-0.48 [small]	12.5 ± 1.00	20.3 ± 1.94*	+62.4	< .001	-3.65 [very large]
PoE (score)	14.4 ± 0.94	15.9 ± 1.82*	+10.4	0.005	-0.70 [medium]	12.8 ± 1.11	21.5 ± 2.19*	+68.0	< .001	-3.49 [very large]
Satisfaction										
TaI (score)	12.1 ± 1.25	15.4 ± 2.26*	+27.3	< .001	-1.72 [large]	12.4 ± 1.05	17.1 ± 1.86*	+37.9	< .001	-2.32 [very large]
PT (score)	11.4 ± 1.05	13.6 ± 1.73*	+19.3	< .001	-1.27 [large]	11.9 ± 0.99	15.0 ± 1.71*	+26.1	< .001	-1.94 [large]
TP (score)	11.7 ± 1.26	14.2 ± 1.91*	+21.4	< .001	-1.21 [large]	12.3 ± 1.12	15.1 ± 1.88*	+22.8	< .001	-1.45 [large]
IP (score)	10.6 ± 1.57	12.6 ± 1.23*	+18.9	< .001	-2.05 [very large]	9.55 ± 1.50	11.75 ± 1.65*	+23.0	< .001	-1.84 [large]

Note: CG = Control group, AR = Augmented reality, CoI = Consistency of interest, PoE = Perseverance of effort, TaI = Training and instruction, PT = Personal treatment, TP = Team performance, IP = Individual performance, Δ = Delta percentage value, ES = Effect size. *Significant differences in pre- and post-test levels were set at p < 0.05.

Table 4.
Results of the 2-way ANOVA repeated measures on grit and satisfaction between control group (CG) and augmented reality (AR)

Variables	Time (Pre-test x post-test)			Group (CG x AR)			Interaction (time x group)		
	$F[^{1.38}]$	p	η^2_p	$F[^{1.38}]$	p	η^2_p	$F[^{1.38}]$	p	η^2_p
Grit									
CoI (score)	162.1	< .001^s	0.810	36.3	< .001^s	0.488	91.6	< .001^s	0.707
PoE (score)	194.6	< .001^s	0.837	31.2	< .001^s	0.451	96.9	< .001^s	0.718
Satisfaction									
TaI (score)	163.88	< .001^s	0.812	5.47	0.025^s	0.126	5.02	0.031^s	0.117
PT (score)	100.56	< .001^s	0.726	7.19	0.011^s	0.159	2.64	0.113^{NS}	0.065
TP (score)	70.133	< .001^s	0.649	3.27	0.079^{NS}	0.079	0.225	0.638^{NS}	0.006
IP (score)	148.301	< .001^s	0.796	4.16	0.048^s	0.099	0.336	0.565^{NS}	0.009

Note: CG = Control group, AR = Augmented reality, CoI = Consistency of interest, PoE = Perseverance of effort, TaI = Training and instruction, PT = Personal treatment, TP = Team performance, IP = Individual performance, NS: Not significant. ^{s}The statistical significance 2-way ANOVA repeated measures level was set at p < 0.05.

Qualitative results

The results of qualitative research through in-depth interviews are as following:

Theme 1: Advantages of AR

Interactive and more interesting

The first advantage was the duration of using AR. In this case the participants revealed that:

"According to us, an obvious and main advantage of AR is it can provide various interesting motion experiences. Because there are many tasks or skills in the AR program that we have to learn" (Interviews with participants 3, 5, 9, 11, 12, 16, 18).

Using AR, we can gain more knowledge in less time. For example, we can know the hitting movements in martial arts or forehand strokes in tennis (Interviews with participants 2, 4, 6, 7, 14, 17, 19). Some participants also argued that:

"When compared to traditional learning, AR program has more advantages in terms of being interactive and more interesting. Whereas traditional learning tends to be monotonous and boring. We can learn some sports skills presented in 3D animation by using AR" (Interviews with participants 1, 8, 10, 13, 14, 15, 20).

Easy to operate

Some participants argued that:

"In our opinion, using AR help us to gain more knowledge in an easy way and can be done anywhere and anytime. For example, when PE lessons are finished, we can still use AR in class during recess" (Interviews with participants 1, 2, 4, 5, 7, 8, 10).

The presence of AR, help us to be easier and more efficient in acquiring and learning skills, for example we can learn it at home (Interviews with participants 3, 6, 9, 13, 16, 18, 19). Some participants argued that:

"We agree!!!..AR is proven to be more efficient in learning sports skills faster than traditional learning. We can learn new skills on campus and at home with more time" (Interviews with participants 11, 12, 14, 15, 17, 20).

Theme 2: Disadvantages of AR

Duration

One of the drawbacks is duration. For example, using AR for a long duration can cause headache or dizzy and eyesore (Interviews with participants 5, 7, 10, 15, 17, 19, 20). Some participants argued that:

"In our opinion, using AR with a long duration can cause us feel boring, because there is no interaction with friends or lecturers" (Interviews with participants 1, 4, 6, 11, 13, 14, 16, 18)

Of course, using AR with a long duration would be a major drawback. Therefore, you should not spend time too long in using AR, because it has a negative impact, such as sore eyes (Interviews with participants 2, 3, 8, 9, 12).

Cost

The second drawback is related to high-cost. In this case the participants gave their opinion that:

"In our opinion, AR is a high cost technology, so if student-athletes or universities have a limited quantity of AR, the learning process will not be optimal" (Interviews with participants 1, 4, 6, 9, 11, 14).

"We agree!!.Not all universities in Indonesia have AR technology, so this is a general weakness" (Interviews with participants 2, 3, 5, 10, 12, 15).

In our opinion, this is the main reason of the limited implementation of AR in Indonesia, especially in PE learning, because it is an expensive technology and not affordable for several student-athletes (Interviews with participants 7, 8, 13, 16, 17, 18, 19, 20).

Theme 3: Impact of the AR program on grit and satisfaction

The third theme is the impact of AR on grit and satisfaction. The participants argued that:

"In our opinion, the AR program has clearly proven to be able to help us in gaining grit and satisfaction which is much better than before" (Interviews with participants 1, 2, 4, 5, 8, 9, 10, 14, 15, 17).

"We realize that our grit level is slowly increase. When we fail to learn a sports skill, we are still trying it again and again, until we can master it properly. With this advantage, we are satisfied (Interviews with participants 3, 6, 7, 11, 12, 13, 16, 18, 19, 20).

Discussion

The present study aims to investigate the effect of AR on increasing grit and satisfaction levels of student-athletes.

The first finding in quantitative research shows that there was no difference in grit and satisfaction in the CG and AR at the initial-test stage. But the second finding shows different result, there were differences at the final-test. Among findings we observed that AR program positively increased the level of grit in student-athletes. Indeed, AR provided various kinds of motion experiences to student-athletes directly in virtual situations, so that they could pay attention and analyze each sport skill (Castaño-Calle et al., 2022). Using AR, student-athletes observed and learned various kinds of sports skills in the real world and virtual situations (Ding et al., 2022; Loia & Orciuoli, 2019), this experience indirectly taught them to keep trying and persistent in mastering a skill (Moreno-Guerrero et al., 2020). This study result is in line with previous research which reported that AR was an effective pedagogical tool in improving the psychology of student-athletes (Le Noury et al., 2022). Other studies report similar findings, which showed that technologies such as VR or AR have the power to improve overall psychological aspects (Gani et al., 2023; Liang et al., 2023). This study also found that AR has a positive effect in increasing learning satisfaction among student-athletes. This is was due to the fact that the PE learning

which was presented in the AR program provided new sensory experiences and interactions for student-athletes to deepen a lesson (Gómez-García et al., 2018). In addition, AR learning was more interesting and fun than traditional. In this case, Chang et al. (2019), argued that AR helped student-athletes to understand a skill and increase motivation to learn better, so that they were more satisfied in learning activities. Research by Moreno-Guerrero et al. (2020), also reported similar results, AR promoted learning which was interesting, new, triggered interest and curiosity. In addition, it was the basis in creating a satisfied learning process. Moreover, results showed an increase in academic achievement (Fidan & Tuncel, 2019). Recent research reported that AR was one of the technologies that can be integrated into education and has great power to improve learning outcomes (Castaño-Calle et al., 2022; Garzón et al., 2021). Other research revealed that using AR can assist lecturers convey lessons to student-athletes, so that they can create the correct concepts for them in understanding the process of movement in sports (Liang et al., 2023).

The findings in qualitative research through in-depth interviews showed various kinds of perceptions from student-athletes, such as the advantage of AR which was easy to implement in learning various kinds of sports skills and it could be used anytime and anywhere without any supervision from lecturer. While the weakness is learning through AR in a relatively long period, could trigger sore eyes and headache. However, according to student-athletes, if they used AR in a short duration it was proven to be effective increasing grit and satisfaction levels.

The main strength of this research is carrying out research using a combination of quantitative (true experiments) and qualitative (in-depth interviews), so that this produces unique and new findings regarding AR research. In addition, the AR program that is integrated into the PE class is designed as well as possible, so that participants can easily use the AR application and learn every movement demonstrated by the virtual avatar. Lastly, AR applications also have the advantage of being able to be used anytime and anywhere by participants.

In this study there were several limitations in terms of using a few numbers participants and only covered one PE faculty in Indonesia which may limit the generalizability of the results. Furthermore, using a quantitative study design can cause difficulties in establishing a causal connection. Therefore, it is recommended that future research could consider to involve a large number of participants from other faculties and universities in Indonesia or other countries. In addition, the future research can compare AR learning with other learning method, such as flipped or involving other technologies.

Conclusions

Based on these results, it can be concluded that AR has a positive effect on grit and satisfaction levels. This research contributes to the development of innovation in the PE learning process that involves AR technology, so that later it can provide information to teachers, trainers, lecturers, or other stakeholders about the importance of implementing AR to the development of student-athletes.

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