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PEDAGOGICAL ANALYSIS OF AUGMENTED REALITY IN THE EDUCATIONAL ENVIRONMENT DURING STUDYING PHYSICS

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The article describes an augmented reality collaborative physics study called PhysicsARLab. The augmented reality lab is hosted by a teacher, and pupils can join the lab using their mobile phones. All participants can interact with the augmented reality lab, and their actions can be observed in real-time by both the teacher and fellow pupils. To evaluate the proposed system, a user study involving 60 participants (30 female and 30 male) was conducted. The participants were ninth grade and tenth grade high school pupils, ranging from 15 to 17 years of age, with an equal distribution across the two academic groups. The study designed a combination of direct and indirect observations, along with multiple surveys, to collect both quantitative and qualitative data. The data analysis considered various perspectives, including the system's usability, the effectiveness of its collaboration functionality, and its impact on PhysicsARLab. The research findings provide insights into the usability and impact of the collaborative augmented reality PhysicsARLab environment. The results are showed on the system's effectiveness in promoting collaboration, its usability for conducting experiments, and its potential benefits for PhysicsARLab.

Key words: *education; pedagogy; physics; augmented reality; interactive teaching methods.*

ПЕДАГОГИЧЕСКИЙ АНАЛИЗ ДОПОЛНЕННОЙ РЕАЛЬНОСТИ В ОБРАЗОВАТЕЛЬНОЙ СРЕДЕ ПРИ ИЗУЧЕНИИ ФИЗИКИ

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В статье приведены результаты исследования обучения физики с использованием лаборатории дополненной реальности под названием PhysicsARLab. Лабораторию дополненной реальности ведет учитель и ученики могут присоединиться к лаборатории со своих мобильных телефонов. Все участники могут взаимодействовать с лабораторией дополненной реальности, а за их действиями в режиме реального времени могут наблюдать как учитель, так и одноклассники. Для оценки предлагаемой системы было проведено педогогическое исследование с участием 60 участников (30 юношей и 30 девушек). Участниками были учащиеся девятых и десятых классов средней школы в возрасте от 15 до 17 лет, с равным распределением по двум академическим группам. Во время исследования была разработана комбинация прямых и косвенных наблюдений, а также нескольких опросов для сбора как количественных, так и качественных данных. При анализе данных учитывались различные точки зрения, в том числе удобство использования системы, эффективность ее функций совместной работы и ее влияние на PhysicsARLab. Результаты исследования дают представление об удобстве использования и влиянии совместной среды дополненной реальности PhysicsARLab. Результаты проливают свет на эффективность системы в содействии сотрудничеству, удобство ее использования для проведения экспериментов и ее потенциальные преимущества для PhysicsARLab.

Ключевые слова: *образование, педагогика, физика, дополненная реальность, интерактивные методы обучения.*

БІЛІМ БЕРУ ОРТАСЫНДА ФИЗИКАНЫ ОҚЫТУ БАРЫСЫНДА ТОЛЫҚТЫРЫЛҒАН ШЫНАЙЫЛЫҚТЫ ҚОЛДАНУДЫ ПЕДАГОГИКАЛЫҚ ТАЛДАУ

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Мақалада PhysicsARLab деп аталатын толықтырылған шынайылықты қолдану арқылы физиканы оқытудың әсерін зерттеу нәтижелері сарапталған. Толықтырылған шынайылық зертханасын мұғалім ғана басқарады және оқушылар әзірленген зертханаға ұялы телефондары арқылы ерін қосыла алады. Барлық қатысушылар толықтырылған шынайылық зертханасымен өзара қатынасып әрекеттесе алады және олардың әрекеттерін нақты уақытта мұғалім де, сыныптастары да кедергісіз бақылай алады. Ұсынылған жүйені бағалау үшін 60 қатысушының (30 ұл және 30 қыз) қатысуымен педагогикалық зерттеу жүргізілді. Қатысушылар екі академиялық топқа бірдей бөлінген 15 пен 17 жас аралығындағы тоғызыншы және оныншы сынып оқушылары болды. Зерттеу барысында тікелей және жанама бақылаулардың, сондай-ақ сандық және сапалық деректерді жинау үшін бірнеше сауалнамалардың комбинациясы жүйелі түрде әзірленді. Деректерді жіті талдау кезінде әртүрлі перспективалар, соның ішінде жүйенің ыңғайлылығы, оның бірлескен мүмкіндіктерінің тиімділігі және PhysicsARLab-қа әсері ескерілді. Зерттеу нәтижелері PhysicsARLab бірлескен толықтырылған шынайылық ортасының қолайлылығы мен әсері туралы ауқымды түсінік береді. Нәтижелер жүйенің ынтымақтастықты ілгерілетудегі тиімділігін, оның тәжірибе үшін қолайлылығын және PhysicsARLab үшін әлеуетті артықшылықтарын ашатынына көзімізді жеткізді.

***Түйінді сөздер:** білім беру, педагогика, физика, толықтырылған шынайылық, оқытудың интерактивті әдістері.*

Introduction

The use of augmented reality in remote PhysicsARLab has the potential to bridge the gap between physical and virtual collaboration, allowing pupils to interact and collaborate while visualizing virtual objects and their peers' work. Some recent augmented reality systems have been designed with multi-user environments, allowing for collaborative interactions [1, p. 198]. Although the study was thorough, it had limitations. This scientific research presents a novel system that fills a gap in the existing landscape by providing a network-based augmented reality collaboration platform with voice support for multiple users [2, p. 307]. The researchers offer comprehensive insights into the usability, effectiveness, and PhysicsARLab impact of their proposed system, providing valuable contributions to the field of collaborative augmented reality PhysicsARLab. By incorporating an even number of female and male pupils in the user study and forming groups that include both genders, the research aims to understand potential gender differences in the use of augmented reality technology in an educational environment [3, p. 235]. The study extensively analyzes the effectiveness and impact of the collaborative augmented reality educational environment. Such comprehensive analysis and user studies are essential for understanding the implications and applications of augmented reality technology in educational environments [4, p. 4]. In the following sections, we will first present the design and development of the collaborative augmented reality system. In the following section, the user study is detailed with the hypothesis and experiment setup [5, p. 106]. The subsequent sections of the research paper detail the design and development of the collaborative augmented reality system, provide an in-depth explanation of the implemented physics experiment, and offer a walkthrough of the system demo. The results are presented, followed by a detailed discussion, and the paper concludes with a summary of the findings [6, p. 217]. This toolkit provides a set of tools and components that enable user interaction in environments, enhancing the immersive and engaging nature of the collaborative augmented reality experience. To facilitate the connection between the instructor and pupils, a scientific research lobby was implemented [7, p. 307]. The instructor hosted the session, and pupils were able to join the session by connecting to the server, establishing a collaborative environment for the augmented reality PhysicsARLab experience. The choice of this experiment was based on a survey of pupils and faculty members, who recommended it as an experiment with an intermediate level of difficulty and a potential positive effect on pupils' performance in a collaborative environment [8, p. 1893]. In the experiment, pupils are tasked with identifying the identity of anions in an unknown mixture. Pupils are provided with an unknown solution and must follow the pre-defined steps to determine the composition of the unknown solution [9, p. 795]. This system provides a collaborative and immersive virtual laboratory experience, where users can perform experiments, interact with virtual equipment, communicate with instructors and fellow pupils, and benefit from shared learning and immediate intervention when needed [10, p. 41].

Aim of research has indicated that the existing body of literature primarily focuses on the impact of augmented reality (AR) technology on enhancing academic achievement and learning motivation. However, there is a lack of research examining the underlying mechanisms of these technologies. This study aims to investigate the influence of AR technology applied in physics education on students' self-efficacy and their beliefs about learning, as well as to uncover the fundamental reasons for any observed effects. Hence, the research questions addressed in this study are as follows:

1) Does students' self-efficacy in learning change when exposed to an AR learning environment? If so, what specific changes occur?

2) Do students' perceptions of learning transform as they engage in an AR learning environment? If yes, what specific transformations are observed?

3) This study will assess the effectiveness of integrating AR technology in physics education and its impact on students' self-efficacy and perceptions of learning.

Materials and Methods

The user study conducted to evaluate the system included 72 participants within the age range of 17-19 years. The participants were divided into 12 groups, each consisting of 6 pupils. The groups were structured to have an equal number of male and female participants. Half of the pupils were from the first year, while the other half were from the second year. To ensure a diverse range of experiences, three groups from each category (first-year and second-year) were randomly assigned, while the remaining three groups in each category were open for enrollment by choice. This allowed pupils who were already familiar with each other to join a particular group, while also providing an opportunity to gauge the impact and effectiveness of cooperation among pupils with varying levels of familiarity. The study aimed to measure the system's usability, user experience (UX), effectiveness as a PhysicsARLab tool, and its impact on PhysicsARLab. The following parameters were used to evaluate usability: ease of use, effectiveness with good utility, and ease of adapting to PhysicsARLab. These parameters likely involved collecting feedback from participants regarding their experience using the system and assessing their perception of its usability.

Figure 1. – The scheme of process designed on academic preferences

The research design followed the scheme of process, which is shown in the Figure 1. The user experience was assessed by measuring various positive and negative factors related to the participants' interaction with the system. It could involve collecting qualitative data through surveys or interviews to understand the participants' subjective experiences, emotions, and satisfaction levels. The real-time collaboration components of the system were evaluated separately through a survey to assess participants' satisfaction and the usefulness of the collaboration features during the experiment. This feedback likely helped in understanding the impact of collaborative features on the overall user experience and effectiveness of the system. The diverse composition of participant groups allowed for a comprehensive evaluation of the system's performance across different scenarios and user backgrounds. The study involved 12 groups, each with specific criteria based on gender and academic level. Two groups were exclusive for female pupils, two for male pupils, and two for mixed-gender groups. The structured experimental flow and data collection methods provided a comprehensive understanding of the system's performance and user perceptions. The methodology is presented together with a detailed description (Table 1).

Table 1. – Six contributions to the field of collaborative PhysicsARLab in augmented reality.

№	Indicator	Description
1	Design of a Novel Collaborative PhysicsARLab augmented reality Environment	The researchers have developed a new collaborative augmented reality environment that enables multi-user interaction in real-time. This environment allows pupils to collaborate and perform experiments together, fostering a sense of engagement and interactivity.
2	Development of a Complex Augmented Reality Chemical Experiment	The study includes the development of a sophisticated augmented reality chemical experiment within the augmented reality environment. This experiment involves multiple intricate steps, requiring precision and collaboration among the participants.

Continuation of table 1

3	Comprehensive User Study	A thorough user study is conducted to evaluate the effectiveness and impact of the collaborative augmented reality PhysicsARLab environment. The study involves participants with diverse levels of academic experience and familiarity with each other, ensuring a comprehensive analysis of the system's performance.
4	Analysis of Collaboration Effectiveness	The study includes an analysis of collaboration effectiveness in the AR-based remote PhysicsARLab setting. The researchers examine how pupils' familiarity with each other and their academic seniority impact collaboration outcomes, providing valuable insights into the dynamics of collaborative PhysicsARLab.
5	Statistical Data Analysis	The study employs statistical data analysis from multiple perspectives to identify and classify the parameters that influence collaboration and PhysicsARLab in the collaborative augmented reality environment. This rigorous analysis enhances the understanding of the factors that contribute to successful collaborative PhysicsARLab experiences.
6	Comparison with Face-to-Face PhysicsARLab	The researchers compare AR-based remote PhysicsARLab with traditional face-to-face PhysicsARLab, aiming to identify scenarios where AR-based remote PhysicsARLab can serve as an effective substitute for in-person experiences. This comparison helps determine the potential benefits and limitations of using augmented reality technology in remote PhysicsARLab settings.

They need to handle various equipment such as test tubes, droppers, water baths, centrifuges papers to perform the required tests accurately. By developing this complex augmented reality experiment, the researchers aimed to create a challenging and realistic scenario that simulates the intricacies of a real-world physics laboratory (Table 2).

Table 2. – List of key components in evaluating the effectiveness and impact of the collaborative augmented reality PhysicsARLab environment

№	Key component	Description
1	Login	Users are required to log in to access the system. This step ensures that only authorized individuals can use the platform.
2	Lobby	Upon successful login, users are taken to a lobby where they have two options: create a new session or join an existing session. This allows users to either start their own experiments or participate in ongoing sessions.
3	Session Setup	Once a session starts, the user is prompted to point their camera towards a surface. The system uses computer vision or augmented reality techniques to identify the surface and overlay the experiment setup onto it. This allows users to visualize the equipment and materials virtually on the real-world surface.
4	Zoom Functionality	The system provides zoom controls in the form of '+' and '–' buttons. This allows users to adjust the level of magnification or zoom in and out of the virtual experiment setup. It enables users to view the experiment details more closely or get a broader overview of the setup.
5	Synchronous scientific research Environment	The system operates in a synchronous scientific research environment, which means that multiple users can participate in the same session simultaneously. This enables collaboration and real-time interaction among users.
6	Instructor Demonstration and Pupil Participation	In this collaborative setting, the instructor can demonstrate the experiment or instruct specific pupils to perform certain steps. The instructor and pupils can communicate over the network, making it easy to guide, correct mistakes, or assist each other in real-time.
7	Collaborative Experimentation	Each pupil has the opportunity to take turns or guide their fellow pupils during the experiment. This collaborative approach allows for shared learning experiences, where pupils can learn from each other, correct mistakes, and support their peers. The system facilitates this intervention by providing easy communication and interaction among users.
8	Multiple Devices	The system supports multiple devices connected over the network. This means that users can access the virtual laboratory from different devices, such as smartphones, tablets, or computers.

Based on the description provided, it seems that the system we are referring to is a collaborative virtual laboratory or experiment platform. Kazakhstan lags behind in the production of school textbooks with augmented reality technology. It turns out that even in neighboring Russia; there are physics textbooks with built-in augmented reality technology. The entire methodology of this experiment is freely available at https://www.geogebra.org/u/beckemn. On the sheet, all laboratory work is carried out with augmented reality (Figure 2).

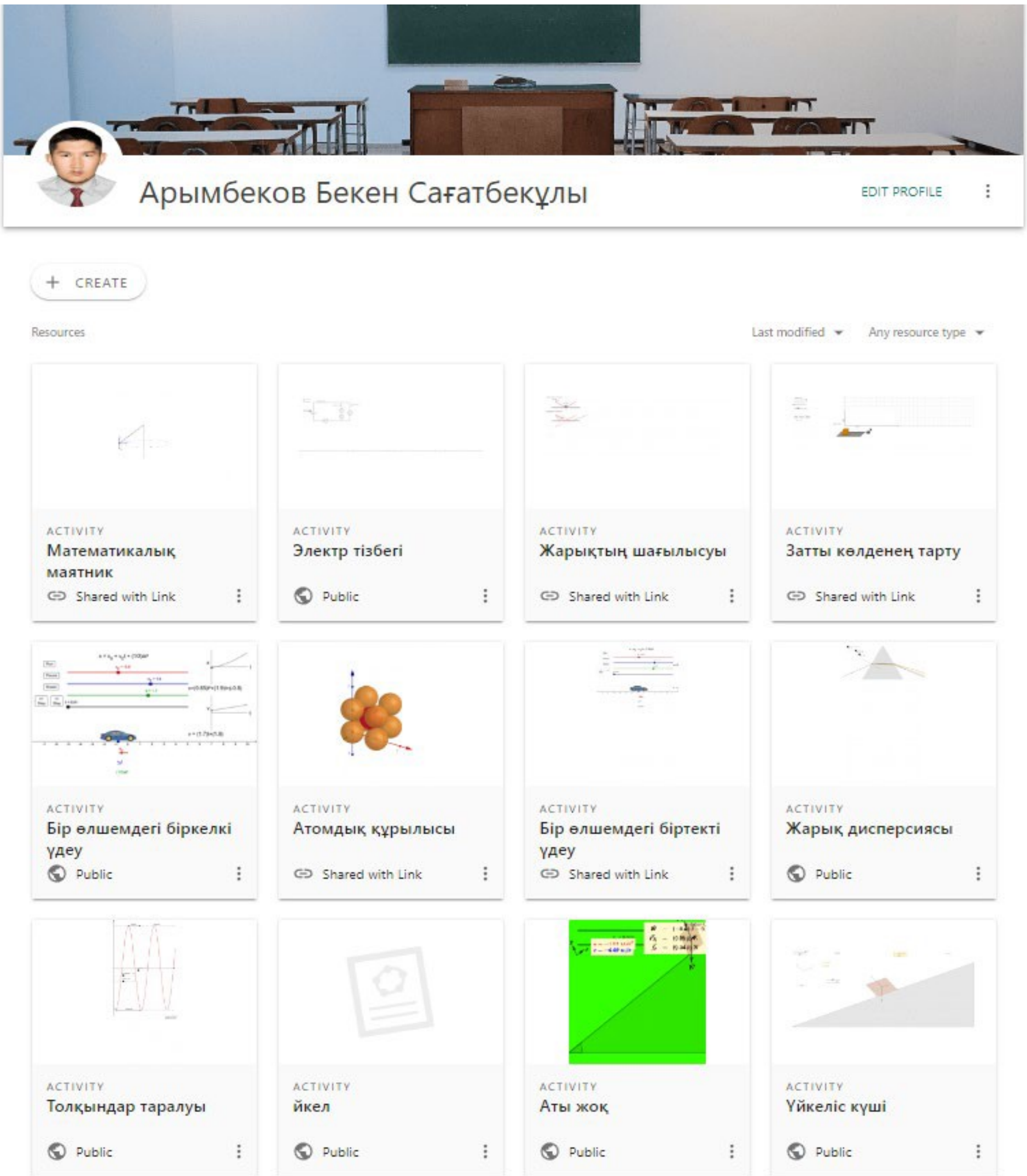

Figure 2. – Outline of the methods developed by the authors during the experiment

Results

Based on the information provided, it seems that data analysis was conducted on the usage data of the app for both individual and collaborative sessions. The analysis aimed to identify if any parameters, such as pupils' academic level or gender, had a significant impact on the app's usage. The analysis aimed to determine if there were any statistically significant variations in the app's usage based on gender, academic level, or group composition. By testing these hypotheses, researchers could gain insights into potential variations or biases in the system's usage and evaluate if any specific factors influenced participants' performance. The results of the analysis would help validate or reject the null hypotheses and provide valuable information about the impact of these factors on the app's usage and effectiveness.By examining the p-values obtained from the analysis, the researchers could determine whether these factors had a statistically significant impact on the time taken to complete the experiments (Figure 3).

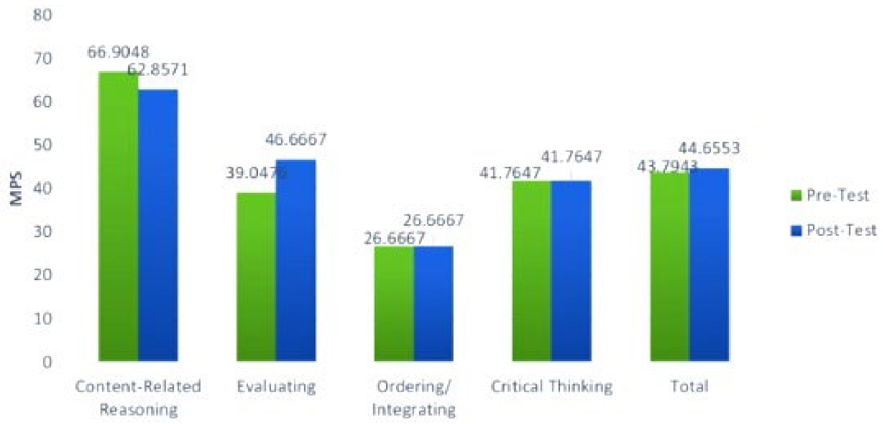

Figure 3. – Individual sessions based on academic level of participants

The individual session times for the 72 participants were analyzed using single-factor ANOVA (Figure 4). The analysis aimed to determine if there was a statistically significant effect of academic level (first-year vs. second-year pupils) on the participants' experiment completion time.

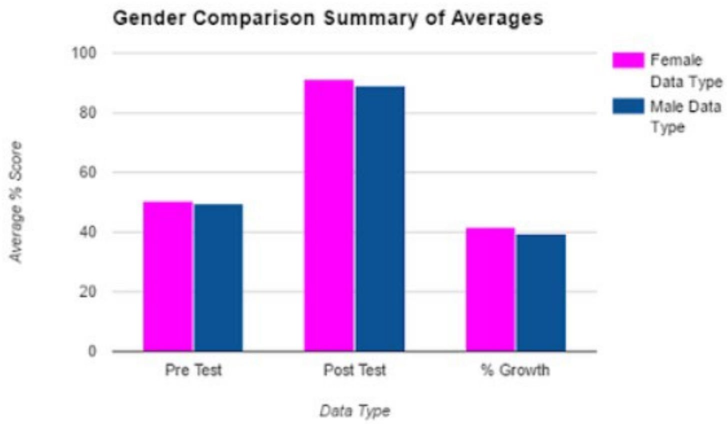

Figure 4. – Individual sessions based on gender of participants

The results of the analysis, as we mentioned, indicated that there was no statistically significant effect of academic level on experiment completion time. Since this p-value is greater than the chosen significance level (usually set at 0.05), the null hypothesis (which states no significant difference between academic levels) cannot be rejected. Therefore, based on the analysis, it can be concluded that both first-year and second-year pupils performed at a similar level of efficiency and productivity in completing the experiments.

The analysis aimed to determine if there was a statistically significant effect of academic level within each gender on the participants' individual experiment completion time. However, the interpretation provided above is based on the information we provided regarding the lack of a statistically significant effect of academic level within each gender on experiment completion time (Figure 5).

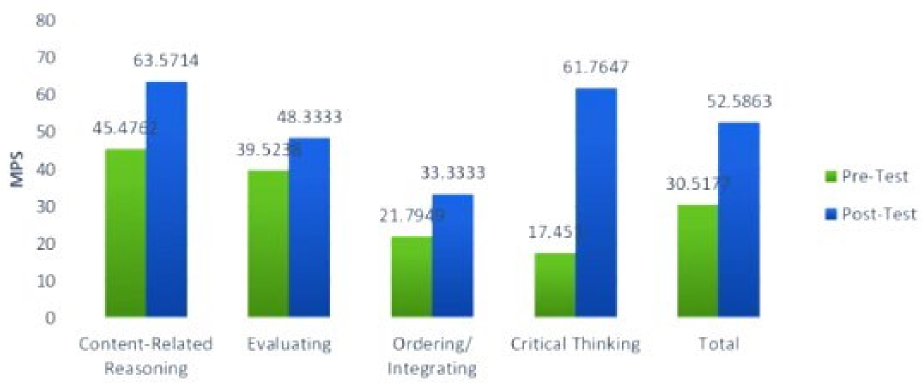

Figure 5. – Single-factor individual experimental sessions

Based on the analysis conducted in our study, it can be concluded that none of the factors, including academic level, gender, and the combination of gender and academic level, had any significant influence on the efficiency and productivity of participants in terms of experiment completion time.

To measure collaboration, we manually logged the number of interactions between pupils during the experiment, specifically instances where participants helped each other either verbally or by performing actions on behalf of their peers. This measure allowed us to quantify the level of collaboration within the groups and its impact on experiment completion time. By analyzing these results, we will gain insights into the specific factors that may have contributed to differences in performance and collaboration among the groups (Figure 6).

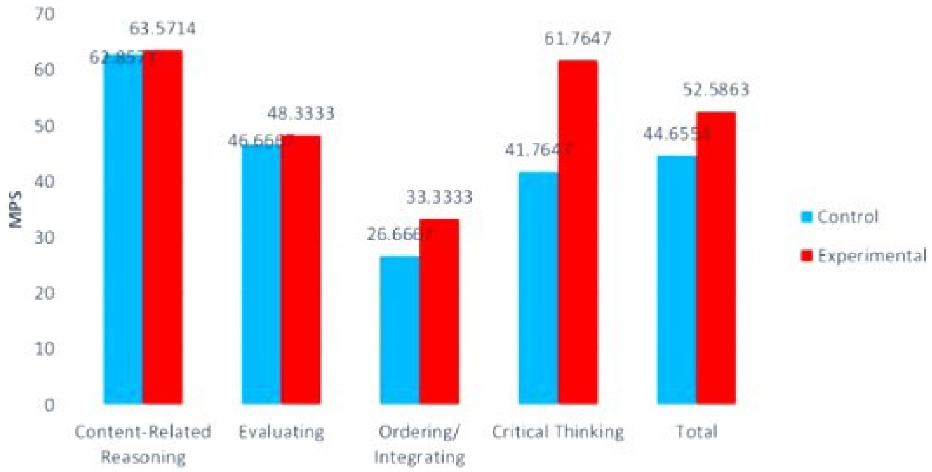

Figure 6. – Collaborative sessions completion time (academic level and collaborative group formation)

In the analysis of the collaborative sessions, participants' performance was evaluated based on their academic level (Figure 7). The participants were divided into six groups of first-year pupils and six groups of second-year pupils. The quantitative data collected included the experiment completion time and the number of interactions within each group. The data was analyzed to determine if there were any significant differences based on academic level.

Pupils in self-enrolled groups were able to complete the experiments more efficiently compared to those in randomly formed groups. However, the level of interaction among participants was not significantly affected by the method of group formation. These results provide insights into the collaborative dynamics within the augmented reality educational environment and highlight the benefits of allowing pupils to choose their group members in terms of efficiency and productivity during collaborative experiments (Figure 7).

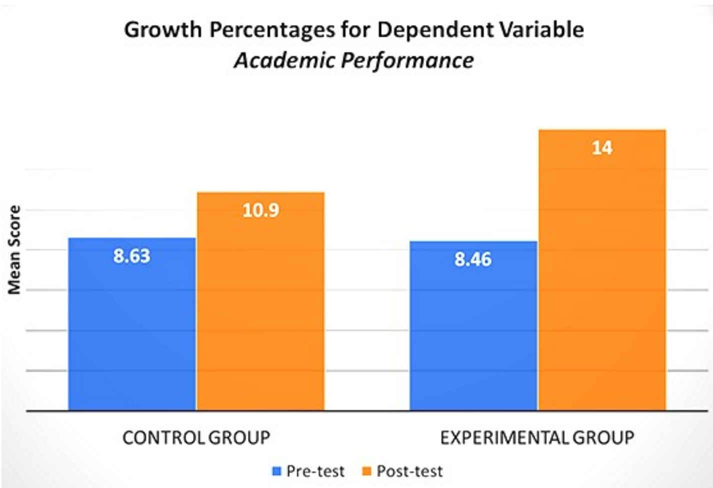

Figure 7. – Collaborative sessions assessed time performance with pretest

These findings indicate that academic level does not play a significant role in determining the experiment completion time or the level of interaction during the collaborative sessions. However, the method of collaborative group formation has a significant impact on both metrics.

Specifically, the participants' performance in terms of experiment completion time and the level of interaction was significantly influenced by the collaborative group formation (Figure 8.). Participants in self-enrolled groups, where they were familiar with their group members, exhibited better performance and higher levels of interaction compared to participants in randomly formed groups. The results suggest that collaborative group formation, based on familiarity and self-enrollment, contributes to improved performance and increased interaction in the augmented reality educational environment, regardless of the participants' academic levels. These findings highlight the importance of considering group dynamics and familiarity when designing collaborative experiences in such environments (Figure 8).

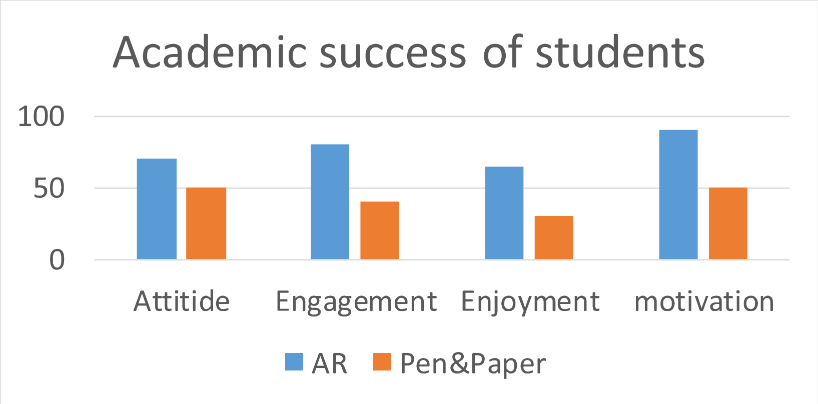

Figure 8. – The results based on academic levels of students

Based on the analysis of the quantitative data from the perspective of genders in the collaborative sessions, the results indicate that there is no statistically significant effect of gender on participants' collaborative experiment completion time. This means that regardless of the gender composition of the collaborative groups, they performed at similar levels of efficiency and productivity during the collaborative sessions. Similarly, the analysis shows that there is no statistically significant effect of gender on participants' interaction during a collaborative session. These findings contribute to a better understanding of the role of gender in collaborative settings within an augmented reality educational environment.

Discussion

The survey conducted to evaluate the usability, impact on PhysicsARLab, and collaboration effectiveness provides valuable insights into pupils' perceptions of the augmented reality PhysicsARLab system. While the positive feedback can be partly attributed to the novelty of the AR-based system, it is crucial to assess how well the system fulfills its core purpose of enhancing the overall PhysicsARLab experience and preparing pupils for real-world environments. The majority of pupils responded positively to most of the survey questions. This suggests that the app is well-received and has a positive impact on pupils' PhysicsARLab experience. However, two points of difference among pupils' opinions are worth noting. If the augmented reality lab can completely replace the face-to-face lab, most pupils expressed the view that it should not be used as a complete replacement. This aligns with the understanding that while the augmented reality lab offers unique advantages and convenience, the real-world face-to-face experience still holds value and is preferred by many pupils. Whether the augmented reality lab adequately prepares pupils for similar tasks in a real-world environment, also showed some variation in opinions. This highlights the importance of ensuring that the augmented reality lab effectively simulates real-world physics experiments and provides pupils with the necessary skills and understanding to navigate physical lab settings. The survey results provide valuable feedback on pupils' perceptions of the augmented reality PhysicsARLab system. While the majority of pupils view it positively and acknowledge its impact, there is recognition that it should be used as a complementary tool alongside face-to-face PhysicsARLab experiences. This insight can inform future developments and improvements in the system to better align with pupils' preferences and expectations. The positive response from pupils regarding the remote PhysicsARLab experience as a complement to face-to-face PhysicsARLab aligns with the growing understanding that blended learning approaches, combining both virtual and physical components, can enhance pupils' learning experiences. By providing a viable collaborative solution for pupils who cannot attend in person, the remote PhysicsARLab offers flexibility and accessibility without compromising the collaborative nature of the learning process. The statistical data analysis further strengthens the findings and supports the conclusions drawn from the study. Comparing the AR-based remote PhysicsARLab to traditional face-to-face PhysicsARLab and examining its impact on PhysicsARLab provides valuable insights into the advantages and limitations of using augmented reality for educational purposes. This comparison helps highlight the potential of augmented reality as a complementary tool in PhysicsARLab and sheds light on the benefits it brings to the learning process. Our scientific research contributes to the advancement of AR-based educational environments and provides valuable evidence for the effectiveness of interactive augmented reality PhysicsARLab. The findings from our study can inform future developments in the field and inspire further research on the integration of augmented reality technology in educational settings (Table 3).

Table 3. – List of the limitations and proposed future work

№	Limitations	Description
1	Lack of video chat	Participants expressed the desire for audio and video communication features in the app. Currently, the app does not include video chat to avoid information overload and maintain focus.
2	Cumbersome manipulation of test tubes	The manipulation of test tubes in the app was found to be overly cumbersome. This issue can be addressed in future iterations by refining the interaction design and making it more intuitive and user-friendly.
3	Comparison of ARs	With the availability of wearable smart glasses, a natural deployment solution for the app would be to use these devices.
4	Deployment with AR	The app can be further developed as a comprehensive augmented reality solution for an entire augmented reality environment.

By addressing these limitations and exploring future directions, the augmented reality lab application can be enhanced to provide a more immersive, user-friendly, and collaborative learning environment for pupils in the field of physics and other sciences. The positive feedback regarding the user experience (UX) of the system is encouraging, indicating that participants found the system easy to use and navigate. However, the negative feedback regarding the test tube handling is valuable and should be addressed in future iterations. Implementing a simpler drag-and-drop mechanism for handling test tubes in the mobile app would enhance the user experience and align with user expectations.

Conclusion

The analysis of both individual and collaborative sessions using single-factor ANOVA revealed that there were no statistically significant differences based on gender or academic level. Even when considering different academic levels within each gender, no significant differences were observed. However, the analysis did identify group formation as a significant factor in collaborative sessions. Pupils in self-enrolled groups demonstrated higher levels of interaction, efficiency, and productivity, indicating that familiarity and self-selection contribute to enhanced collaboration in the augmented reality educational environment. Several surveys were conducted to evaluate different aspects of the application. The usability survey indicated a high level of usability, while the survey on collaborative support highlighted the system's effectiveness in facilitating collaboration among users. The UX survey generally received positive feedback, although some issues related to the manipulation of test tubes and the absence of video chat were identified. The survey assessing the impact of PhysicsARLab demonstrated the effectiveness of the application as a complementary tool to face-to-face PhysicsARLab experiences. The positive results from the surveys affirm the usability, collaborative support, and impact of the system. For future work, the researchers plan to deploy the augmented reality lab on different augmented reality devices, expanding the range of platforms for evaluation. They aim to implement the same experiment in a virtual reality (VR) environment and compare the results with those obtained from the augmented reality environment. These advancements will provide further insights and contribute to enhancing users' efficiency and productivity within new augmented reality and VR paradigms.

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ГОТОВНОСТЬ УЧИТЕЛЕЙ ГЕОГРАФИИ К ПРИМЕНЕНИЮ STEAM-ТЕХНОЛОГИИ

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В данной статье показана методология и результаты исследования по реализации STEAM-технологии. Целью данного исследования является определение готовности учителей географии, осуществляющих преподавательскую деятельность в организациях среднего образования области Жетісу Республики Казахстан, к применению STEAM-технологии в обучении географии.

Методологическая основа исследования представлена анализом отечественной и зарубежной литературы об актуальности и развитии образовательных технологий STEAM-образования. Проведены анкетирование и анализ частоты ответов и процентов учителей географии из 37 общеобразовательных учреждений области Жетісу Республики Казахстан,

В результате исследования было выявлено, что большее количество опрошенных учителей предпочитают использовать традиционные методы обучения в своей работе. Также было обнаружено, что многие педагоги не владеют STEAM-технологиями. В связи с чем была определена необходимость обновления и модернизации учебного процесса, акцентируя внимание на межпредметной интеграции и развитии навыков, и возможности соответствующей подготовки и переподготовки учителей географии в этой области, что существенно повлияет на качество образования.

Данные результаты могут быть использованы для разработки рекомендаций по повышению эффективности образовательного процесса в области географии.

Ключевые слова: *STEAM-технология, компетенция, интеграция, образовательный процесс, качество образования, модернизация образования, естественнонаучные дисциплины.*

ГЕОГРАФИЯ МҰҒАЛІМДЕРІНІҢ STEAM-ТЕХНОЛОГИЯСЫН ҚОЛДАНУҒА ДАЙЫНДЫҒЫ

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Бұл мақалада STEAM технологиясын енгізу бойынша зерттеудің әдістемесі мен нәтижелері көрсетілген. Бұл зерттеудің мақсаты Қазақстан Республикасы Жетісу өңіріндегі орта білім беру ұйымдарында педагогикалық қызметтін жүзеге асыратын география мұғалімдерінің STEAM технологиясын географияны оқытуда қолдануға дайындығын анықтау болып табылады.

Зерттеудің әдістемелік негізі STEAM білім берудің білім беру технологияларының өзектілігі мен дамуы туралы отандық және шетелдік әдебиеттерді талдаумен ұсынылған. Қазақстан Республикасы Жетісу облысындағы 37 білім беру ұйымдарының география пәні мұғалімдерінің жауап беру жиілігі мен пайыздық үлесіне сауалнама өтуізіліп, талдау жүргізілді.

Зерттеу барысында сауалнамаға қатысқан мұғалімдердің көбі өз жұмысында дәстүрлі оқыту әдістерін қолдануды қалайтыны анықталды. Сонымен қатар, көптеген мұғалімдердің STEAM технологияларын меңгермейтіні анықталды. Осыған орай, пәнаралық ықпалдастық пен