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# USE CASE AND BENEFITS OF AUGMENTED REALITY IN CROSS-CURRICULAR APPROACH

**Abstract**

No matter what subject is taught, making meaningful connections with the real world is always the ultimate goal. This paper provides an overview of the cross-curricular approach and available augmented reality history apps and the potential for utilising them in history classes. Also, it shows how a variety of theoretical approaches to learning and teaching with immersive technologies have been synthesised to create powerful learning scenarios that integrate History, foreign language learning, social studies, and science - math. This didactic approach with interdisciplinary connecting gives an overview on how to achieve higher quality educational goals and provide students with a different experience. Students' experiences and reactions to this cross-curricular approach to learning were investigated. The aim is to assess the benefits of the cross-curricular approach using augmented reality while also recording the learning and behavioural outcomes that result from its implementation.

**Keywords**: cross-curricular, augmented reality, history, math

## Introduction

The regular school day is divided into segments based on subjects. Math, spelling, language arts, and reading can be the order of the day in primary school, followed by recess, music, science, and social studies. This consistent pace is appealing to and necessary for younger children. Students in high school learn how to move between classrooms for various subjects. The easiest approach to manage a large number of pupils and ensure that they each get the opportunity to study and gain the essential skills and information in each discipline is to organise the school day by subject. In many respects, organising topics and subjects like this is a question of pragmatism. However, there is a problem.

Arranging a school day into several isolated disciplines might give the impression that one subject has little (if anything) to do with the others and that the content children are taught in one class has no significance on other aspects of their lives. Why should students bother studying any of that if there appears to be no other use for it outside of the 45-minute timeframe? Moreover, not every student is compelled to learn by the glimpse of a bright high grade at the top of their assignment.

A better way to demonstrate to children that the learning process is not as isolated as it appears throughout the school day - that it is, in fact, made up of many interwoven components – is through cross-curricular teaching.

The better the mind can comprehend and remember ideas, the more connections it can build. Cross-curricular education allows students to create more connections between subjects and skills they are learning, giving them more meaning and significance. While we may not be able to fully answer the question "Why do I need to know this?" we can at least begin to demonstrate to the students that the concepts they are learning have implications outside of the classroom. Applying this cross-curricular concept in teaching history, foreign language, and science topics is especially easy.

## Cross-curricular approach

As stated by Novak (2005), people have an innate desire to learn, which is reflected very early on through children's curiosity when asking their parents numerous questions. Interdisciplinary connection motivates the student because we know that learning does not happen just because we teach but because of the desire and the student's effort to learn something.

International enactments of cross-curricular methods are important to study because they provide feedback on their enactment in various contexts, demonstrating which type of cross-curricular approach may suit a specific educational situation. Cross-curricular pedagogies have been a source of dispute for the past fifty years, with a recent upsurge in the previous two decades. Fragmented teaching schedules, concerns about curriculum relevance, and a lack of connections and linkages between topics have all been cited as causes for a rise in demand for cross-curricular approaches in the American educational system. (Jacobs, 1989)

In recent years, schools and education systems have moved away from teaching facts and concepts in isolation, adopting a more constructivist approach to learning. According to Drake (2012), the demand for a cross-curricular approach is linked to schools' aim to educate students for the pace and complexity of the twenty-first century, which necessitates individuals' ability to draw from a variety of fields and solve problems with associated components.

Croatia has been in the process of completing a significant curriculum reform over the last few years. The focus is on reshaping how pupils are educated. In all subject curricula across all educational cycles, the relevance of a research-based learning approach, an interdisciplinary approach and a cross-curricular approach is emphasised.

The Decision of the Ministry of Education on the enactment of The Curriculum for subject History for primary schools and gymnasiums in the Republic of Croatia (Official Gazette "Narodne novine", Vol 27/19, 557: 52) states that the purpose of teaching and learning History is to develop in students the ability of historical thinking within five areas of human activity, namely: social, economic, scientific-technological, political and philosophical-religious-cultural. By learning History, students develop basic skills related to asking questions about sources, considering context, looking at events from different perspectives, rethinking views and conclusions, and forming opinions based on assumptions.

Interdisciplinary linkages must be properly planned and organised in the classroom. As Hodnik Čadež (2008) concludes, it is vital to remember that in an interdisciplinary connection, the educator begins by connecting educational content or goals and then attempts to show or tackle a specific content or problem as fully as possible.

**History education and Augmented Reality**

Contemporary technological advancement has immensely improved and enriched the possibilities of transferring knowledge and delivering content. Each student can see the inside of the pyramids, tour the Taj Mahal, inspect a mummy sarcophagus with x-rays (fig.1), hold terracotta warriors in the palm of their hand, visit museums and historical sites using augmented reality technology.

AR (Augmented Reality) is a new technology that allows a person to observe his or her surroundings with additional visual characteristics that "enhance" reality. As mentioned by Fink (2018), Augmented Reality has been around since the 1950s, when Morton Heilig, a cinematographer, believed that going to the movies should allow a person to engage with the surroundings by using all of their senses effectively. In the mid-1990s, the computing capacity of mobile devices was insufficient to allow the growth of mobile Augmented Reality applications. Applications began to reach the general public as the device power, and the number of embedded sensors increased. The way we work, learn, play, and interact with the world around us is changing thanks to augmented reality. It is the ideal technique for visualising something that would be difficult or impossible to see otherwise.

With hundreds of millions of compatible devices and dozens of augmented reality apps in the app stores, augmented reality is becoming an enormous ecosystem. According to Bhola (2018), major worldwide brands are not even considering new ways to sell themselves without using AR/VR, and tech goliaths are continuously on the lookout for start-ups to invest in and contribute to new ideas for this notion. They want to be a part of something so exciting, but they also want to be the ones who set the trends rather than merely following them.

Immersive technology engages our students in learning in a way that we previously could not. Many historical events have been treated in traditional Human History education as a collection of dates, localities, and a few opposing sides with a final result of triumph or defeat. In the same manner, many well-known battles and wars are misunderstood due to poor handling in various media representations. To address these shortcomings, a work by Blanco-Fernández et al. (2014) offers a revolutionary technology-enhanced instructional approach targeted at immersing groups of people in immersive experiences in order to deepen their understanding of historical battles and wars from the perspectives of creators and historians.

Schiavi et al. (2018) describe an augmented reality application for middle school History teaching in their article. The example demonstrates how to teach

students how to create a 3D mental model of a Mesopotamian temple as it was in the past using only a 2D image of the current ruins and a text description.

While learning new subjects might be difficult for teachers, and they have neither knowledge nor time to create such complex experiences, many tools do not require educators to be tech-savvy and allow us to dive right into these experiences.

There is a short yet concise overview given by VirtualiTeach[1] on how to bring history easily into the classrooms by using augmented reality.

Figure 1. X-raying a sarcophagus in a classroom with the CivilisationAR app. Author's own work, CC BY-SA

On the other hand, it is easy to create custom AR content with some apps not mentioned in the given overview. These apps are mentioned in work by Rakovac Bekeš (2021), where amongst other apps for history education, Eyejack app and AssemblrEDU stand out. For creating a cross-curricular learning scenario described below, an Eyejack app was used. Because it is simply confined to overlaying a brief video (or a gif format file) on top of a trigger image, the

1 https://www.virtualiteach.com/post/2018/03/12/artifacts-using-ar-to-bring-history-into-the-classroom

EyeJack app is one of the easiest platforms to use. The creator version must be downloaded and installed on a desktop computer. A voice-over or ambient sound can be uploaded as an audio file. This application was primarily intended for the art industry and is incredibly user-friendly. Its goal was to bring pieces of art to life. The educators instantly saw the potential of this app in their classrooms. By choosing a trigger image after making a short animation or video with basic tools like PowerPoint or Keynote, textbooks, workbooks, and even the classroom walls can suddenly become alive. It does not involve a high level of digital literacy or coding, and it can be completed in minutes. It can be used to generate an introduction to a specific topic, motivation before addressing a difficult-to-model problem, or simply as a tool for presenting information in a unique way. The downside is that it only supports gif formats and videos with a duration of up to 30 seconds.

**Example of cross-curricular learning scenario and its implementation**

Putting a particular topic in a broader context while connecting it with a science subject and combining it with augmented reality technology creates an authentic and knowledge-building learning experience.

Many teachers struggle to keep their students engaged and motivated in their classrooms. According to Schug et al. (1984), students consider social studies to be boring, while Dweck (2000), National Research Council (2001) and Institute for Social Research in Zagreb (2003) indicate that mathematics is one of the most difficult subjects to master in school.

The biggest issue is attitude. We cannot engage students and improve their achievement if we do not change their attitude; the attitude that math is not only hard but also something dislikeable. Different students' views about learning math and social studies have been documented by Stodolsky et al. (1991). In math, students categorised good and negative experiences based on their success or ability to complete the task, but in social studies, students categorised positive and negative experiences based on whether they were attractive or uninteresting.

The easiest way to change this is by using a cross-curricular approach enhanced with technology and gamification, connecting math, history, foreign language learning, etc. When a person engages in an activity that makes him/she happy and fulfilled, additional motivational factors rise out like eagerness to succeed, self-confidence, and comprehension.

We immediately think of the mafia and Sicily when the word "Goodfellas" is mentioned. However, what about the Milieu and the French mob and how to implement this in history and math class? The Bonnot gang is one of the first organised crime groups to emerge. It resulted in the development of mugshots and other forensic processes. The Bonnot gang, also known as the "Auto bandits," was an anarchist group of men and women who were the first to utilise military-grade firearms in a criminal act and devised the "getaway car." All of this resulted in new developments in forensics, such as the development of current mugshot photographs and the use of galvanoplastic compounds to preserve footprints, as well as ballistics and the dynamometer, which is used to assess the degree of force used in breaking and entering. Alphonse Bertillon, a police officer, used his skills to develop some of the forensic processes. Using Bertillion's original mugshots of the Bonnot gang, combined with Augmented Reality, transforms a static worksheet into an interactive, immersive experience. Students use the augmented reality app Eyejack to learn about the gang's history while tackling math problems.

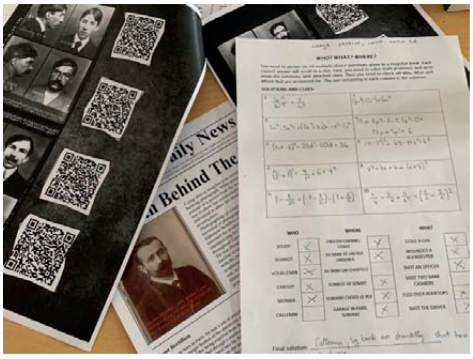

Figure 3. Mugshot book and worksheet. Author's own work, CC BY-SA

Figure 4. Students activating AR experience. Author's own work, CC BY-SA

They are given a mugshot book (Fig. 3.) with ten mugshots and matching QR codes. When a mugshot is scanned, it comes to life! Each animation that appears on top of the mugshot (Fig. 4.) presents a math task with numerous options for solutions. Each response yields a hint. Students acquire a final solution – who committed a crime, what was the crime, and where was the crime – by successfully completing all of the problems and writing down the clues in the Who-What-Where worksheet.

With live worksheets, students lose sight of the fundamental goal: math practice by learning history. This teaching-learning scenario named "True Crime AR Eyejacked" was published in the digital booklet Teaching with Europeana best practices 2019 - 2020 and translated into 9 European languages[2]. The learning scenario includes many subjects in the STEM field and History, Social studies, and English as a foreign language. By implementing this scenario, various topics are covered: Science – forensics in use, Math - Simplifying Algebraic Expressions, Technology – using Augmented Reality, English – past tense contrast, new vocabulary, writing an essay, skills round up, History – pre-war events WW1, social studies – Crime and punishment, social groups (illegalists and anarchists).

**Benefits and experiences**

According to some educators, as Hodnik Čadež (2008), interdisciplinary connections are the easiest to prepare in the first three grades of primary school, where all subjects are mostly taught by one teacher. Maybe they are easier to prepare at this level, but on a higher level, it is possible to make richer and more engaging content as described earlier.

Connecting various disciplines and curriculums has proven to be successful. Experience and research by Sicherl Kafol (2008) show that students develop interest and motivation to learn in interdisciplinary learning situations and deepen the understanding and use of knowledge. In addition, they achieve better educational success, show better interpersonal relationships and commitment to learning, express self-confidence, cooperation, and mutual respect, better remember and understand educational material and more easily transfer skills between different subject areas.

Some of the main benefits distinguished by Polšak (2008) of the cross-curricular approach for teachers are that individual teachers' personalities and professionalism are enhanced through interdisciplinary connections, which contributes to their personal and professional development. It connects teachers and sparks interest in pedagogy and collective responsibility, in which one or more teachers share responsibility for student accomplishment.

Teachers also develop new experiences and abilities because of interdisciplinary linkages, which broadens their knowledge to include other professional fields.

2 https://pro.europeana.eu/post/teaching-with-europeana-best-practices-2019-2020 (mentioned learning scenario can be found in the english version on page 28)

By this, they extend their perspectives by learning about various subjects and overcome biases about other disciplines by utilising interdisciplinary links. The main benefit is that it encourages teachers to adopt new teaching methods.

When it comes to benefits for students from interdisciplinary connection, a result from Pavlič Škerjanc (2010) and Hodnik Čadež (2008) can be summed that they:

- encourage students to take an active role
- allow students to achieve taxonomically higher goals and generic skills, including critical thinking and problem solving, data processing, ICT use, project task implementation, active learning, reading, writing, and listening, consider and promote problem-solving from multiple perspectives
- aid the student in deepening what they have learnt and improving knowledge in the long term
- promote students' creativity and motivation
- encourage the student's process of connecting areas, in which the student learns that the contents are linked, independently seeking connections between subjects, and thus builds stronger relationships between concepts.

When it comes to augmented reality and its application in education, there have been documented effects and experiences, mostly in the last decade.

According to surveys, AR learning objects have addressed a wide range of topics and have been designed for a wide range of audiences. Geroimenko's (2020) first complete research monograph on the use of augmented reality in education was published by a group of 58 world-leading scholars, practitioners, and artists from 15 nations who pioneered the use of augmented reality as new teaching and learning technology and tool. The authors investigate the current state of educational augmented reality and its applications in a wide range of fields, including medical education and training, English language learning, chemistry learning, environmental and special education, dental training, mining engineering teaching, and historical and fine art education. The reviews provided by Koutromanos et al. (2015), Sommerauer and Müller (2018), Weerasinghe et al. (2019), and Bacca-Acosta et al. (2014) indicated that science, such as biology, chemistry, and physics, had been extensively investigated. Other subjects addressed include mathematics, history, language learning, psychology, humanities and arts, agriculture, health, engineering, and some others. All of them mainly stated that AR technology increases students' engagement, motivation, and overall satisfaction

after conducting activities and have the ability to facilitate new different learning styles while enhancing the teaching process.

In a survey paper by Ređep and Hajdin (2021), fifty-two papers describing different aspects of augmented reality used in the field of education were selected for the analysis. The authors used a research approach described by J. W. Creswell (2014). The work includes a review of the literature related to this topic in the period of last decade and analyses the research topics on the use of augmented reality technology in education with possible integration of game elements to obtain a synthesis of previous knowledge. Among the other two conclusions stated by this analysis, the relevant one is that incorporating augmented reality into teaching activities, particularly those that include game elements, increases student efficiency, stimulates attention and interest, improves collaboration and perceptions of fun, enhances teaching and learning processes, and generally encourages innovation and improvement through educational technology. Additionally, by this analysis, an extensive study on teachers' and students' interests and views toward the use of augmented reality in education was identified primarily in papers focusing on higher education.

**Study Case**

Previously mentioned research show that there is a potential for integrating a cross-curricular approach with gamification based on AR technology, but also that this form of work is generally not used. One of the reasons is the lack of digital (AR) learning materials adapted to the curricula of mathematics and history (or other subjects) as well as the developed learning model that would make better use of this potential. Savage (2010) elaborated on the idea that cross-curricular methods of teaching and learning can result in a powerful, innovative form of subject-based teaching and learning in secondary school. Additionally, for effect to long-term change, he points out that models of cross-curricular teaching and learning must become established in the pedagogies of individual teachers and then inform and maybe redefine the subject cultures in which they work.

Therefore, the idea of developing a model of cross-curricular gamified approach with augmented reality naturally arises. The aim of this research was to conduct a pilot study for further development of a model of cross-curricular gamified approach in teaching using augmented reality.

The authors conducted a case study with n = 42 students in two secondary school classes averaging 16-year-olds during the second half of the school year

2020/2021 to determine if there are any links between students' motivational and emotional orientations and their emotional and behavioural engagement using AR activities. The above-described learning scenario was used as teaching material. The authors aimed to describe students' experiences and reactions to this cross-curricular approach to learning using self-reports and process data referring to the students' interactions with the given worksheets and activities. The goal is to evaluate the benefits of using augmented reality as the implement of a cross-curricular approach while also recording the learning and behavioural outcomes.

Several questionnaires were used for this study to examine students' motivation and attitudes towards the use of AR in cross-curricular activities.

Before the conducted activities, the authors operationalised students' motivational and emotional orientations through self-reports, inquiring about students' anxiety, self-concept, and enjoyment on 4-point Likert scales, with 1 being the least acceptable claim and 4 representing the most acceptable.

The PISA ANXMAT by OECD (2003) scale with five questions (Cronbach's alpha = 0.84) was used to assess mathematics-related anxiety:

- I often worry that it will be difficult for me in mathematics classes
- I get very tense when I have to do mathematics homework
- I get very nervous doing mathematics problems
- I feel helpless when doing a mathematics problem
- I worry that I will get poor in mathematics

The PISA SCMAT by OECD (2016) scale with five questions (Cronbach's alpha = 0.88) was used to assess a student's self-concept in mathematics:

- I am just not good at mathematics
- I get good in mathematics
- I learn mathematics quickly
- I have always believed that mathematics is one of my best subjects
- In my mathematics class, I understand even the most difficult task

The adapted FAILMAT by OECD (2016) scale (6 items, Cronbach's alpha = 0.64) was used to assess students' attributions to Failure:

- I'm not very good at solving problems
- My teacher did not explain the concepts well this week
- This week I made wrong guesses on the quiz
- Sometimes the course material is too hard
- The teacher did not get students interested in the material
- Sometimes I am just unlucky

The adapted PISA INTMAT by OECD (2003) scale with eight items (Cronbach's alpha = 0.89) was used to assess students' enjoyment. The scale included statements:

- I enjoy reading about mathematics and history
- I enjoy reading about history
- I look forward to my mathematics lessons
- I look forward to my history lessons
- I look forward to my English lessons
- I do mathematics because I enjoy it
- I enjoy doing history assessments
- I am interested in the things I learn in mathematics

Regarding anxiousness, M = 2.05 (SD = 0.66) of students reported experiencing it. Their self-concept was M = 2.42 (SD = 0.50), attribution to failure was M = 2.04 (SD = 0.65) and their enjoyment was M = 2.73 (SD = 0.60), indicating that there was considerable variation in the sample's motivational and emotional orientations.

Similarly, emotional engagement was assessed following the intervention using self-reports on 4-point Likert scales. Using the M = 2.50 (SD = 0.43) AR activities, students indicated an innate drive to learn algebraic expressions.

The findings of the first questionnaire, which was a math worksheet, are encouraging because everyone completed the assignments. They completed the worksheet without making any errors and in a faster time than predicted. The time it took to solve the problem was only 10 minutes, although it was expected to take 30 minutes (the standard duration of this activity while using classical worksheets in a non-cross-curricular approach based on the authors' previous experience).

After the conducted activities, the second questionnaire reported competence support was M = 3.00 (SD = 0.35), and their perceived autonomy support was M = 2.92 (SD = 0.41). M = 2.62 (SD = 0.56) was their situational interest. Using the cross-curricular approach with AR activities, they reported a perceived demand of M = 2.17 (SD = 0.56). Taking these values into account, it can be stated that students demonstrated significantly different levels of emotional engagement when studying algebraic expressions using the proposed learning scenario. A student's feedback confirms the above claims of a cross-curricular approach.

In order to determine what the students rated as positive and what was negative in the conducted cross-curricular activities with AR, as a part of the second questionnaire, they were offered two open-ended questions (adapted from Kay and Knaack, 2009):

- What did you like about learning in a cross-curricular lesson with the use of mobile phones and AR?
- What did you dislike about learning in a cross-curricular lesson with the use of mobile phones and AR?

To analyse these responses to open-ended questions, a code plan was used to categorise student responses from the Learning Object Evaluation Scale for Students (LOES-S) into three categories: learning, engagement, and quality (Kay and Knaack, 2009: 155). This model was evaluated using 44 different learning objects on a sample of 1113 primary and secondary school students and 33 teachers in Canada.

Regarding responses to the question about the learning, 21% of students (9 out of 42) said they liked everything, while when asked what they did not like, 46% (19 out of 42) of students gave negative feedback for the English language, stating that they had problems with English vocabulary and found text as too hard to read. Of the visual features that encourage learning, 37 students (88%) cited the use of AR animations as positive.

In the assessment analysis of student engagement in accordance with the code plan, some answers point out why students prefer the cross-curricular AR approach over traditional teaching: It is more engaging because it combines interesting historical stories with new technology; It is like playing a state-of-the-art game while finding pieces of a puzzle; we did not realise we were doing math or learning history, we saw it as a fun activity.

Concerning technological shortcomings, three students (7%) identified a potential issue with the mobile phone app's effective functioning and highlighted device compatibility as problematic.

The experience was a success on a qualitative level, and the students' feedback was good. A large percentage of the students, almost 88% of them, stated that they were extremely motivated by the story of the real crime. Not a small percentage, 73% said they were interested in the topic and that they researched sources on their own in search of additional facts and explanations.

The activities in the implemented learning scenario have been shown to be more enjoyable, motivating and facilitate a better and faster grasp of the exercise and the expected work that had to be done. Finally, all students, including those who were having some academic difficulties, were able to grasp the math principles employed in the exercises (an assessment has been given during the next teaching session one week after the implemented scenario).

The study's limitations include the small sample size, time frame, and the materials used. The purpose of this study was to provide hypotheses for future research on the impact of motivational and emotional orientations, as well as engagement, on learning in technologically enhanced environments and developing a model of cross-curricular gamified approach with augmented reality. The authors reported on a case study involving only two classes, n = 42, and a single learning scenario implemented only once. This study has inherent limitations due to its design, which should be considered when interpreting the findings. Due to the fact that all 42 students were taught by the same instructor, authors were unable to address issues about the teacher's unique influence on students' emotional and behavioural engagement during the intervention.

This study did not include a control group and students learning the content in a "conventional, non-technology-enhanced" environment. Future studies should examine the effect of motivational and emotional orientations, emotional engagement, and behavioural engagement on accomplishment in various classroom environments. This is an obviously significant question since it has the duty to teach professionals about the underlying mechanics of classroom learning and potential similarities or differences between teaching in cross-curricular AR settings and those that are not. Additional research is required to investigate the underlying model fully.

**Conclusion**

It was stated that interdisciplinary problem-solving of problems or circumstances relating to educational themes affects students' motivation, causing them to gain interest, improve their learning, and apply their knowledge.

When an interdisciplinary connection is developed in the classroom, students gain skills that are not content-specific and may be applied to different contexts. Problem-solving, critical evaluation, critical thinking, active listening, reading and writing, and creating are examples of such skills. Because they are tied to real life, interdisciplinary linkages drive pupils to learn.

Cross-curricular education enables students to establish stronger links between the courses and the skills they are studying. The emphasis is on altering the way children are taught. The importance of a research-based learning approach, an interdisciplinary approach, and a cross-curricular approach is stressed in all topic curricula throughout different national curriculums.

The term "augmented reality" refers to a new technology that enables a person to see his or her surroundings with the addition of visual qualities that "improve" the reality. However, there are also numerous benefits in an educational context, and examples of their use have been provided.

Since educators struggle to maintain student engagement and motivation in their courses because students dislike almost all subjects, and since mathematics is found to be one of the most challenging topics to grasp in school, educators need to try to explore different approaches to make a shift in their attitudes.

Several disciplines in the STEM fields are included in the proposed and conducted learning scenario, but so are history, social studies, and English as a foreign language. The prime advantage is that it motivates instructors to experiment with novel teaching approaches. Augmented reality technology boosts students' engagement, motivation, and overall pleasure. It has the potential to promote new and diverse modes of learning while also enhancing the educational process itself. The purpose of this study is to determine the advantages of using augmented reality in a cross-curricular approach and, at the same time, recording learning and behavioural results. It has been shown that the activities in the adopted learning scenario are more fun and inspiring. The students' evaluation has been overwhelmingly positive, both qualitatively and quantitatively. They were able to accomplish the same goals as in classical worksheets in less time with a higher level of engagement. They are also more enthusiastic and motivated, and they have a better comprehension of the content.

This study's boundaries are set by the small sample size, the limited time span, and the extension of the materials employed. The authors were unable to explore the impact of the teacher on students' emotional and behavioural involvement. Unfortunately, there was no control group in this research, and students were taught the topic in a "traditional, non-technology-enhanced" context. The aim of this study was to propose elements for further research in order to continue developing a model of cross-curricular gamified instruction utilising augmented reality.

**References**

1. Bacca-Acosta, J., Baldiris, S., Fabregat, R., Graf, S., Kinshuk, Dr. (2014) Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Educational Technology and Society*, vol. 17., p. 133-149.

2. Bhola I. (2018) *Magic: How Augmented Reality Will Change Our World*. Independently published

3. Blanco-Fernández, Y., López-Nores, M., Pazos-Arias, J., Gil, A., Cabrer, M., García-Duque, J. (2014) REENACT: A step forward in immersive learning about Human History by augmented reality, role playing and social networking. *Expert Systems with Applications*, vol. 41, p. 4811-4828. DOI: 10.1016/j.eswa.2014.02.018.

4. Creswell, J. W. (2014) *Research design: qualitative, quantitative, and mixed methods approaches (4th ed)*. Thousand Oaks: SAGE Publications.

5. Drake, S. M. (2012) *Creating Standards-based integrated curriculum: the common core state standards edition*. CA: Thousand Oaks.

6. Dweck, C. (2000) *Self-theories: their role in motivation, personality, and development*. Philadelphia: Psychology Press

7. Fink C. (2018) *Metaverse - An AR Enabled Guide to AR & VR*. Cool Blue Media, 1st edition.

8. Geroimenko, V. (ed.) (2020) *Augmented Reality in Education: A New Technology for Teaching and Learning*. Springer Series on Cultural Computing, Springer Nature.

9. Hodnik Čadež, T. (2008) Učitelj kot raziskovalec medpredmetnega povezovanja. In: Krez, J. et. al. (eds.) *Učitelj v vlogi raziskovalca: akcijsko raziskovanje na področjih medpredmetnega povezovanja in vzgojne zasnove v javni šoli*. Ljubljana: Pedagoška fakulteta, p. 131-149.

10. https://www.virtualiteach.com/post/2018/03/12/artifacts-using-ar-to-bring-history-into-the-classroom (Accessed 08/12/2021)

11. Institut za društvena istraživanja (2003) *Evaluacija nastavnih programa i razvoj nacionalnog kurikuluma za obvezno obrazovanje u Hrvatskoj*. Zagreb. https://www.idi.hr/cerd/uploads/DOKUMENTI/summaryhrvatskifinal2.pdf , (Accessed 29/11/2021)

12. Jacobs, H. H. (1989) *Interdisciplinary Curriculum: Design and Implementation*. Alexandria, VA: Association for Supervision and Curriculum Development.

13. Kay, R. H., Knaack, L. (2009) Assessing learning, quality and engagement in learning objects: the Learning Object Evaluation Scale for Students (LOES-S). *Educational Technology Research and Development*, vol. 57, no. 2, p. 147-168.

14. Koutromanos, G., Sofos, A., Avraamidou, L. (2015) The use of augmented reality games in education: A review of the literature. *Educational Media International*, vol 52. DOI: 10.1080/09523987.2015.1125988.

15. National Research Council (2001) *Adding it up: helping children learn mathematics*. Washington: National Research Council.

16. Novak, M. (2005) *Vloga učitelja v devetletni osnovni šoli*. Nova Gorica: Educa, Melior.

17. OECD (2003) *The PISA assessment framework – Mathematics, Reading, Science and Problem Solving Knowledge and skills*. https://www.oecd.org/pisa/publications/ , (Accessed 12/06/2021)

18. OECD (2016). *The PISA assessment framework – Mathematics, Reading, Science and Problem Solving Knowledge and skills*. https://www.oecd.org/pisa/pisaproducts/PISA%202012%20Technical%20Report_Chapter%2016.pdf. (Accessed 15/08/2021)

19. Pavlič Škerjanc, K. (2010) Smisel in sistem kurikularnih povezav. In: Rutar Ilc, Z., Pavlič Škerjanc (eds.) M*edpredmetne in kurikularne povezave, priročnik za učitelje*, Ljubljana: ZRSŠ, p. 19-49,

20. Polšak, A. (2007) Medpredmetno povezovanje in učni načrti. *Geografija v šoli*, vol. 16, no. 2, p. 33-44

21. Rakovac Bekeš, E (2021) Creating multisensory learning experiences that go beyond the limitations of traditional media. In: *44th International Convention on Information, Communication and Electronic Technology (MIPRO)*, p. 587-590, DOI: 10.23919/MIPRO52101.2021.9596652.

22. Ređep, T., Hajdin, G. (2021) Use of Augmented Reality with Game Elements in Education – Literature Review. *Journal of Information and Organizational Sciences*, vol. 45, no. 2, p. 473-494. DOI: 10.31341/jios.45.2.7

23. Savage, J. (2010) *Cross-Curricular Teaching and Learning in the Secondary School*. London: Routledge. DOI: 10.4324/9780203844205

24. Schiavi, B., Gechter, F., Gechter, C., Rizzo, A. (2018) Teach Me a Story: An Augmented Reality Application for Teaching History in Middle School. In: *IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, p. 679-680. DOI: 10.1109/VR.2018.8446412.

25. Schug, M. C., Todd, R. J., Berry, R. (1984) *Why kids don't like social studies*. Social Education, https://files.eric.ed.gov/fulltext/ED224765.pdf, (Accessed 12/12/2021)

26. Sicherl Kafol, B. (2008) Procesni in vsebinski vidiki medpredmetnega povezovanja. In: Rutar Ilc, Z., Pavlič Škerjanc (eds.) *Učitelj v vlogi raziskovalca, akcijsko raziskovanje na področjih medpredmetnega povezovanja in vzgojne zasnove v javni šoli*, Ljubljana: Pedagoška fakulteta, p. 112-130.

27. Sommerauer, P., Müller, O. (2018) Augmented Reality in Informal Learning Environments: Investigating Short-term and Long-term Effects. In: *Hawaii International Conference on System Sciences (HICSS) 2018*. DOI: 10.24251/HICSS.2018.176.

28. Weerasinghe, M., Quigley, A., Ducasse, J., Pucihar, K., Kljun, M. (2019) Educational Augmented Reality Games. In: Geroimenko, V. (ed.) *Augmented Reality Games II*, Cham: Springer. DOI: 10.1007/978-3-030-15620-6_1.

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# UPOTREBA I PREDNOSTI PROŠIRENE STVARNOSTI U MEĐUPREDMETNOM PRISTUPU

**Sažetak**

Bez obzira na temu koja se poučava, stvaranje smislenih veza sa stvarnim svijetom uvijek je krajnji cilj. Ovaj rad daje pregled međupredmetnog pristupa i dostupnih aplikacija proširene stvarnosti za učenje povijesti te potencijala za njihovo korištenje u nastavi povijesti. Također pokazuje kako su različiti teorijski pristupi učenju i poučavanju s imerzivnim/virtualnim tehnologijama sintetizirani kako bi se stvorili snažni scenariji učenja koji integriraju povijest, učenje stranih jezika, društvene znanosti i prirodoslovlje - matematiku. Ovaj interdisciplinarni didaktički pristup ukazuje na mogućnosti postizanja kvalitetnijih obrazovnih ciljeva i pružanja drugačijeg iskustva učenicima. Istražena su iskustva i reakcije učenika na ovaj međupredmetni pristup učenju. Cilj je procijeniti prednosti međupredmetnog pristupa koristeći proširenu stvarnost, istodobno bilježeći ishode učenja i ponašanja koji proizlaze iz njegove primjene.

**Ključne riječi**: međupredmetni, proširena stvarnost, povijest, matematika