

DEVELOPMENT AND INTEGRATION OF AUDIO AND VISUAL MICRO-RESOURCES IN THE LEARNING PROCESS THROUGH THE USE OF ARTIFICIAL INTELLIGENCE SYSTEMS

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Abstract. The paper examines the possibilities of developing and applying additional educational resources through artificial intelligence systems. Microlearning is an effective teaching method in modern education that features concise audio and visual learning resources suitable for students from the digital generation. The research focuses on integrating educational resources into the traditional learning process, which activates the learning process through innovative methods and attractively presented information. A two-directional approach is applied that enables working through the creation of resources by the teacher on the one hand, and on the other hand, the learners themselves generate such resources. At the same time, QR codes are used to introduce learning and game elements to the primary macro resources. The aim is to determine the impact of the integrated approach on learners' engagement, their acquisition of the learning material, and overall learning outcomes.

Keywords: QR codes; artificial intelligence; digital competences; micro-resources; active learning; education

1. Introduction

QR code integration in education introduces an interactive dimension to traditional learning methods. By scanning these codes, students gain success in supplementary micro-resources, expanding their educational experience in and beyond the classroom. These resources offer a range of perspectives, interactive activities, and multimedia content tailored to enhance the curriculum. Micro-resources are short, self-contained educational material designed for quick and easy learning of a specific topic or skill. Taking an active role in the educational process adds value

to learning by summarising complex concepts and processes and enhancing the e-learning experience (Harakchiyska 2016). The integration of QR codes extends learning opportunities, boosts student engagement, and promotes more profound understanding. By harnessing this technology, educators can encourage students to explore, discover, and engage with the subject matter in a more interactive and dynamic way, thereby enhancing the overall quality of education.

The content creation process requires students to analyse, synthesise, and present information clearly and understandably that contributes to their deeper understanding of the teaching material. Students develop digital skills and competencies to use a variety of software tools to create audio and video content, as well as to generate QR codes. The opportunity to be creative and share their knowledge and skills with fellow students motivates, engages and makes students more active participants in learning. As artificial intelligence (AI) becomes more prevalent in educational settings, the technology underlying QR codes is experiencing significant transformation. AI-driven advancements are not only altering how QR codes are created and used but are also reshaping the concept of learning content creation itself. Through AI systems, both educator-produced materials and learner-generated content are becoming more integrated and adaptive, enhancing educational experiences and resource accessibility.

The aim of this report is to present an effective and innovative approach for creating supplementary educational content distributed through AI-generated QR codes. The core idea is to encourage students to actively engage within and beyond their required activities by providing them with various interactive micro-resources. Additionally, this approach aims to empower students to step into the role of educators by creating and generating their materials, thereby fostering their digital competencies. Stepping into the role of educators will help the students to perceive the educational process from a different perspective, to understand better their teachers, and this way reduce the level of anxiety, the latter being pointed out as a major reason for the lack of motivation and dropout of the students (Beloeva & Antonova 2023).

By integrating AI with QR code technology, we can streamline the distribution and accessibility of educational materials, making learning more flexible and on-demand. This method allows students to access various learning tools at their own pace, catering to different learning styles and needs. It also offers a hands-on approach to learning, where students can engage with the material more interactively and practically.

2. Related works

The integration of digital learning objects has shown considerable potential in enhancing the quality and effectiveness of web-based teacher training courses. A specific framework focusing on the interactivity of digital learning objects has

been proposed for evaluating the quality of web-based learning content (Atanasov & Ivanova 2017). This evaluation underscores the growing recognition of the role of digital tools in educational development and students' digital skills. The result includes the ability to search, select, and process information, as well as content creation and internet safety skills (Milenkova & Marinov 2019); in higher education, training in digital skills is crucial for students to navigate the knowledge society (Marrero-Sánchez & Vergara-Romero 2023). However, it's important to note that the concept of digital competence is still evolving, reflecting the changing technological landscape and societal needs. This evolving nature of digital competence keeps us informed and aware of the dynamic educational environment.

QR codes are such technological tools and have increasingly been utilised in active learning scenarios, as explored in various studies. The potential of QR codes to engage learners and facilitate easy access to information (Roznik 2023; Karia, Hughes & Carr 2009). Additionally, advanced techniques such as deep learning for QR code detection are explored, potentially advancing their application in active learning environments (Blanger & Hirata 2019). The integration of QR codes with cutting-edge technologies like augmented reality, as suggested by (Toma & Turcu 2022) and (Fonseca & Puig 2011), promises to enrich the learning experience further. Furthermore, (Vaithilingam & Mohan Shankar 2024) investigates the use of arithmetic patterns in QR code generation, demonstrating AI's versatility and innovative potential in QR code creation. Practical implementations by (Bala & Bicena 2016) and (Subhash & et.al. 2018) show improved academic achievements and the development of innovative systems like intelligent attendance management, highlighting the practical and impactful use of QR codes in education.

3. Methodology for implementing QR codes in the educational process

In the proposed study, students from different faculties and specialties: engineering and education were included. For all learners, the technology of creating AI based QR codes appears to be new. Interdisciplinarity and creativity are central to the research. The study was conducted in two directions according to the differences in the educational and technological training of the learners. From one side, students of pedagogical specialties need to be aware of the technology that is increasingly entering the educational space and this further increases their competences. On the other hand, students, future computer engineers understand the essence of technology. A new aspect of learning is the creation and implementation of AI systems. The methodology presented in this study includes **both aspects of the research.**

3. 1. Educational resources created with QR codes with AI systems by the educator

By implementing QR codes in the educational process, students could efficiently access micro- and micro- resources, engage with content, and participate in learning

activities. The methodology, presented on figure 1, introduces a step-by-step guide in effectively integrating AI content generation and QR technology, empowering the educators to transform the learning experience:

Create Content: Develop the micro-resource to link through QR codes. This could include video tutorials, downloadable PDFs, interactive websites, or online quizzes. Ensure the content is mobile-friendly, as students will likely access it on their devices.

Generate and Test QR Codes: Link the content to the chosen QR code generator. Each piece of content will have its own unique QR code. Test each QR code with different devices and QR scanners to ensure it works seamlessly.

Integrate into Educational Materials: Decide how to integrate the QR codes into educational materials. This could be in textbooks, worksheets, posters around the classroom, or presentation slides. Ensure the placement is logical and the QR codes are visible.

Educate Students and Staff: It's crucial to educate both students and staff on how to use QR codes. Provide a brief tutorial on scanning QR codes and accessing the linked materials. Highlight the benefits and encourage their use during the learning process.

Monitor and Adapt: Use the tracking capabilities of your QR code generator to monitor engagement with the content. Gather feedback from students and staff about their experiences. Rest assured, QR codes are adaptable. Use this feedback to make adjustments, whether it's updating the linked content, changing the placement of QR codes, or finding new ways to integrate them into the learning process. Review and Expand: Regularly review the effectiveness of QR codes in meeting your educational objectives. As you become more comfortable with their use, consider expanding their application to other areas, such as linking to online

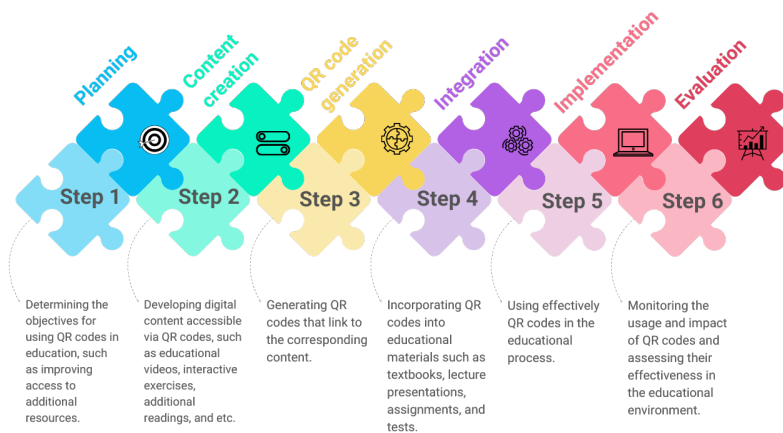


Figure 1. Methodology of implementing AI generated content via QR codes

resources in the school library, facilitating parent-teacher communication, or even organising school events.

Following these steps, educators can seamlessly integrate QR codes into the educational process, creating a more interactive, engaging, and efficient learning environment.

3.2. Educational content created by students and generated with QR codes from AI systems

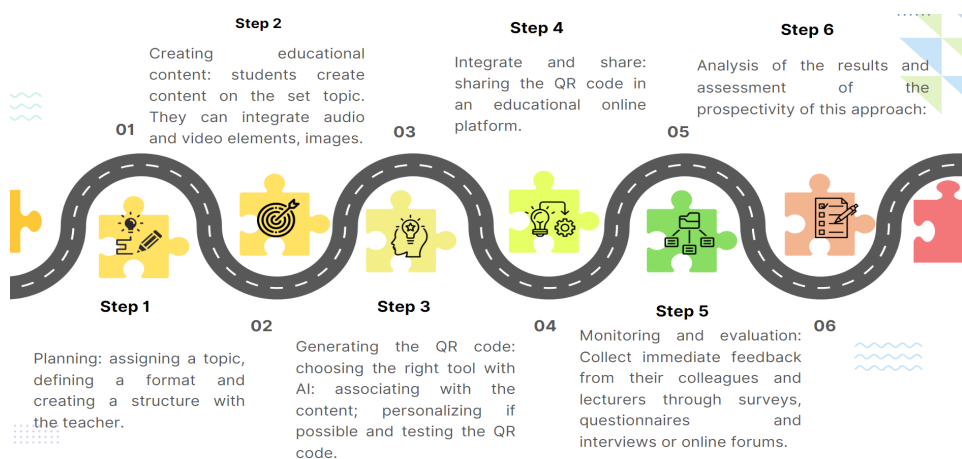


Figure 2. Methodology of AI generated content from students via QR codes

Generating micro-resources from the students themselves:

Planning and conceptualization: Topic assignment – the topic is aligned with the course content. The teacher selects the topics according to the individual characteristics and interests of the students.

Students consider which format would be most appropriate for the chosen topic. The options include: Video lesson: Suitable for explaining processes, demonstrations or presenting interviews; Audio files to illustrate musical examples; Presentation, Interactive quiz; Infographic: Suitable for visually presenting information, data or statistics; Other formats: Students can be creative and experiment with different formats such as podcasts, virtual walkthroughs, interactive maps, etc.

Creating educational content: Preparation of a detailed content plan outlining the main points to be covered and the sequence in which they will be presented. This will help to organise the information and provide a logical structure for the resource. They create the content of the selected resource using appropriate

tools and software. Students can include a variety of multimedia elements such as images, audio recordings, videos, animations, interactive elements. Students review the content carefully to make sure there are no errors, inaccuracies, or omissions. They may ask their colleagues or tutors to peer review the resource and provide feedback.

QR code generation: Students use any of the numerous free online QR generators, such as QRCode Monkey, QRStuff, QRCode Tiger and others. It is important to choose a generator that provides options for customising the QR code and tracking scan statistics. Learners can customise the QR code by modifying the colours, adding a logo or image, choosing a different frame design, etc. This can make the QR code more attractive and recognizable.

Integration and sharing: Learners print the QR codes and attach them to appropriate places in learning materials such as textbooks, worksheets, posters, presentations, etc. They can choose to share the QR codes on online learning platforms (Moodle, Google Classroom), social media (Facebook, Twitter), blogs or websites. They can also add a short description or instructions to the QR code to make it easier to access the content.

Monitoring and evaluation: Collect immediate feedback from their colleagues and lecturers through surveys, questionnaires and interviews or online forums. They can ask about the clarity of the content, the ease of usage of the QR code, the usefulness of the resource and suggestions for improvements.

Analysis of the results and assessment of the perspectivity of this approach: Analyse the feedback collected and identify areas where they can make improvements. They can update the content, change the format of the resource, add new elements or correct mistakes.

Particular in the research, which was conducted with students - future pedagogues, are the disciplines: all music disciplines, which are included in the curriculum of students of the specialties Pre-school and Primary School Pedagogy and Primary School Pedagogy and Foreign Language. This is exactly the idea of paying special attention to audio and visual micro-resources in the learning process. Therefore, the topics that are developed according to the described methodology are related to music education.

4. AI Generated Audio and Visual Micro-resources

In Fig. 3, there is a circular graphical representation of various AI applications. These applications are classified into six categories, namely: Audio files, Video files, Images, Text applications, Evaluation tests, and QR codes. The authors have only included the AI systems that they have used in their work. The primary objective is to improve digital competencies by incorporating AI in the creation, implementation, and evaluation of micro resources.

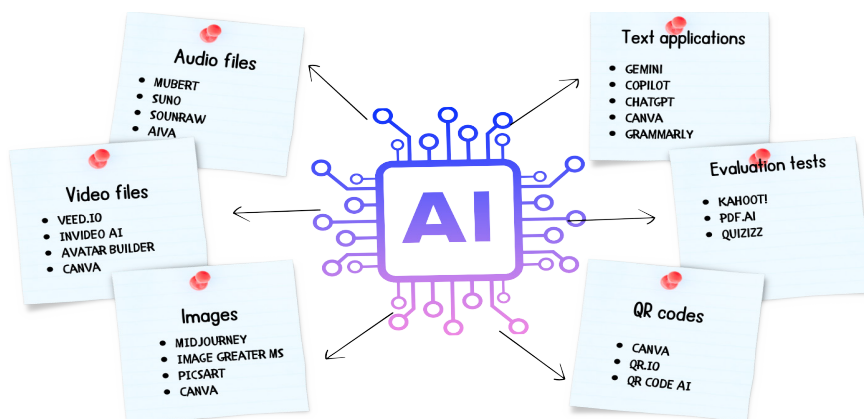


Figure 3. Incorporating AI in the creation, implementation, and evaluation of micro-resources

Educators can utilise AI tools such as Mubert and AIVA to create customised background music or soundscapes for their educational videos or digital classrooms, thereby enhancing auditory learning experiences. By creating engaging and interactive video tutorials using AI platforms such as InVideo AI and Canva, teachers can easily incorporate animations, text overlays, and quizzes that can adapt to student responses, making learning more dynamic. Tools like MidJourney and Canva make it easy to create compelling visual resources, from infographics to customised illustrations that aid in visual learning. These images can be used to simplify complex subjects or to represent data and processes visually. AI-driven text applications such as Grammarly and ChatGPT help create clear and grammatically correct educational content, while also generating interactive text-based learning activities like story-based learning scenarios or problem-solving exercises. Furthermore, platforms like Kahoot! and Quizizz utilise AI to provide immediate feedback on quizzes and tests, supporting adaptive testing and gamified learning environments. This feature motivates students and helps educators identify areas needing reinforcement, which reassures educators in their assessment processes. By integrating these AI-powered tools, educators can develop micro-resources that cater to different learning styles and needs, fostering a more inclusive and effective educational environment. These resources also help in building digital competencies among students as they engage with advanced technology in varied learning contexts. This approach not only makes learning more interactive but also prepares students for a technology-driven world.

5. AI generated QR codes

In educational technology, integrating AI has notably enhanced the functionality and application of QR codes, leading to the development of dynamic QR codes. These

AI-optimised QR codes boast a more robust structure, making them highly resistant to damage and environmental degradation. Moreover, AI enables the personalization of QR codes to align with specific educational content or user needs, enhancing the learning experience through customised interactions. The application of computer vision for reading QR codes represents another significant advancement facilitated by AI. This process involves collecting a dataset of QR code images, which is then used to train machine learning models to detect and decode QR codes within complex images accurately. The trained models can identify QR codes from various angles and lighting conditions, making them highly versatile for educational purposes. Once the model is sufficiently trained, it can be deployed through applications that integrate seamlessly into educational platforms, allowing instantaneous access to a wealth of educational resources simply by scanning a QR code. This technology not only streamlines the process of accessing educational materials but also enriches the learning environment by bridging digital and physical learning aids.

6. Survey Results

The survey results are presented in fig. 4 and contain four distinct bar graphs, each representing survey results on various educational topics, including active learning (a) accessibility and user experience (UX) (b), engagement and interactivity (c), and the use of micro-resources via QR codes (d). Starting with active learning, the graph illustrates the participants' responses on the effectiveness of different active learning strategies, such as opportunities to learn by doing, stimulation from interactive methods, and technology integration with coursework. Most respondents agreed or strongly agreed (68,42%) that these strategies enhance learning, with technology integration showing the highest approval among all. Moving on to accessibility and UX, this graph shows the participants' perceptions of accessibility and user experience when providing information and resources through QR codes compared to other methods. The majority of respondents (86,84%) preferred QR codes over traditional methods, agreeing that QR codes offer better accessibility and user experience. Next, the graph on engagement and interactivity depicts participant responses on the accessibility of resources via QR codes and whether they stimulate interest and are always found engaging. A significant majority agreed that resources accessed through QR codes engage and stimulate interest, highlighting the effectiveness of QR codes in maintaining learner engagement. Lastly, the graph on micro-resources via QR codes measures satisfaction with QR-coded resources regarding informativeness, direct relation to the subject matter, flexibility in learning, and whether they encourage new teaching methods. The responses were predominantly positive, with many agreeing that QR coded resources are informative and directly related to the subject. They are also recognized for their flexibility and encouraged to use innovative teaching methods. Overall, these graphs collectively suggest a positive reception towards the

use of QR codes in education, reflecting their potential to enhance active learning, improve accessibility, boost engagement, and provide effective micro-resources.

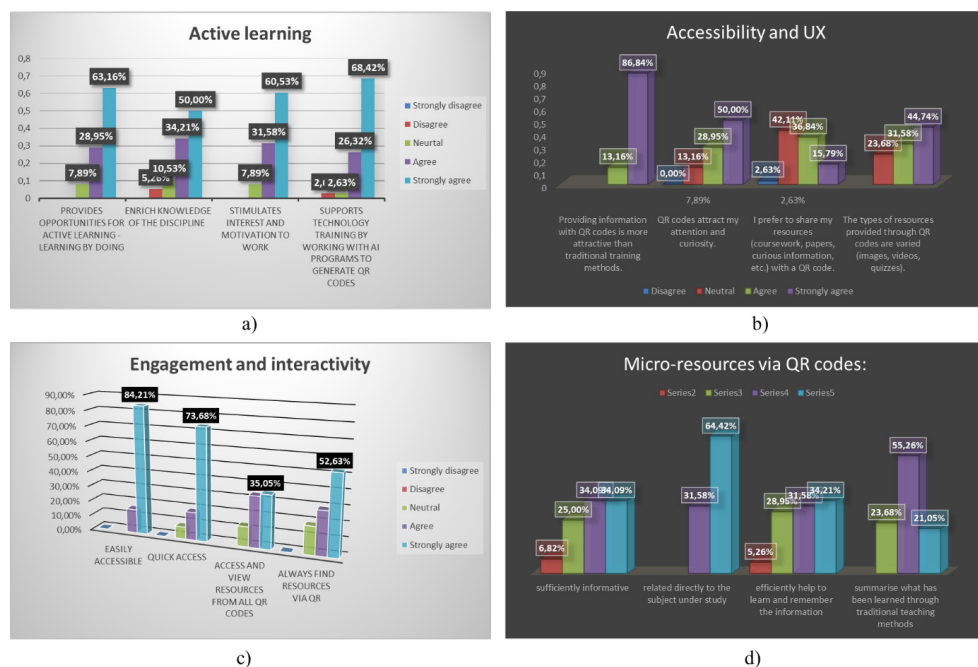


Figure 4. Incorporating AI in the creation, implementation, and evaluation of micro-resources

7. Conclusions

In conclusion, the deployment of AI-generated QR codes in education not only enhances the dissemination and engagement with learning materials but also plays a crucial role in developing the digital competencies of students by involving them directly in the content creation process. This innovative strategy not only supports the educational framework but also aligns with modern educational trends toward more interactive, student-centred learning environments. Two-way learning, in which both teachers and learners create audio and visual micro-resources in the learning process is a powerful instrument for stimulating creativity, active learning, and deeper understanding of the learning material. This approach changes the traditional teaching paradigm by transforming students from passive recipients of information into active participants in the learning process. Furthermore, distributing content through QR codes promotes cooperative learning and peer-to-peer interaction among students.

Disseminating content via QR codes encourages collaboration and interaction between students, allowing them to share knowledge and resources, work together on projects, and learn from one another. This approach to learning by 'doing' and 'sharing' promotes a deeper understanding of the content and develops skills that are essential for success in the 21st century. In addition, the usage of QR codes can contribute to overcoming some of the challenges facing education today. For example, QR codes can facilitate access to educational resources for students from distant areas, and provide personalised learning by allowing them to study at their own pace and choose content according to their interests. Although implementing QR codes in education may require an initial investment in time and resources, the potential benefits are significant. By continuing to explore innovative ways to use this technology, we can create an even more engaging, interactive, and effective learning environment for all students.

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REFERENCES

- ATANASOV, V. & IVANOVA, A., 2022. A framework for evaluation of web-based learning content. *International Journal on Information Technologies & Security*, vol. 14, no. 4, pp. 13 – 24.
- BELOEVA, S. & ANTONOVA, D., 2023. Controlled anxiety in the academic environment as a stimulus for students' creativity and innovation. *Strategies for Policy in Science & Education-Strategii na Obrazovatelna i Nauchna Politika*, vol. 31, no. 6, pp. 622 – 638, doi.org/10.53656/str2023-6-4-con.
- BAL, E. & BICENA, H., 2016. Computer hardware course application through augmented reality and QR code integration: achievement levels and views of students. *Procedia Computer Science*, vol. 102, pp. 267 – 272. <https://doi.org/10.1016/j.procs.2016.09.400>.
- BLANGER, L., & HIRATA, N.S., 2019. An Evaluation of Deep Learning Techniques for QR Code Detection. *2019 IEEE International Conference on Image Processing (ICIP)*, pp. 1625 – 1629.
- FONSECA, D., & PUIG, J., 2011. *QR-Codes Applied to Architecture Data and Teaching*.
- HARAKCHIYSKA, T., 2010. Learning objects and their role in enhancing the quality of web-based teacher training courses. *Conference Proceedings of “eLearning and Software for Education” (eLSE)*, Carol I National Defense University Publishing House, issue No 01, pp. 181 – 186.

- KARIA, C.T.; HUGHES, A.J. & CARR, S., 2019. Uses of quick response codes in healthcare education: a scoping review. *BMC Medical Education*, no. 19. <https://doi.org/10.1186/s12909-019-1876-4>.
- MARRERO-SÁNCHEZ, O. & VERGARA-ROMERO, A., 2023. Digital competence of the university student. A systematic and bibliographic update. *Revista Amazonia Investiga*.
- MILENKOVA, V. & MANOV, B., 2019. Digital Competences and Skills in the Frame of Education and Training. *2019 2nd International Conference on Contemporary Education and Economic Development (CEED 2019)*.
- ROZNIK, M., 2024. A New Way of Learning: Quick Response Codes in Nursing Development. *Journal for nurses in professional development*, vol. 40, no. 2, pp. 100 – 103. <https://doi.org/10.1097/NND.0000000000001001>.
- SUBHASH, J.S., SUDHAKAR, G.A., VICRAM, G.P., & VIDYA, A.P., 2018. Android Based Smart Attendance System using QR Code: A Review. *International Journal of Advance Research and Innovative Ideas in Education*, vol. 4, no.3, pp. 1096 – 1099.
- THORNE, T., 2016. Augmenting Classroom Practices with QR Codes. *TESOL Journal*, vol. 7, pp. 746 – 754.
- TOMA, M. & TURCU, C.E., 2022. Towards Education 4.0: Enhancing Traditional Textbooks with Augmented Reality and Quick Response codes. *2022 International Conference on Development and Application Systems (DAS)*, pp. 144 – 149.
- VAITHILINGAM, S. & SHANKAR, M., ARADHYA, S., 2024. Enhancing Security in QR Code Technology Using AI: Exploration and Mitigation Strategies. *International Journal of Intelligence Science*, vol. 14. DOI: 10.4236/ijis.2024.142003.

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