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Using 3D animation with interactive multimedia web learning principles for teaching mini volleyball

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Abstract
This study explores the development and implementation of a 3D animated multimedia application aimed at teaching volleyball skills to children, incorporating cognitive multimedia learning principles. By combining 3D animation with real-life video demonstrations, the application seeks to enhance learning by providing both theoretical explanations and practical visualizations of volleyball techniques. The software development process involved the use of various tools, including Adobe Photoshop, Autodesk Maya, and Moodle, to create realistic 3D models, animations, and an interactive learning environment. The application presents key volleyball skills such as passing, setting, and serving, emphasizing critical body movements and techniques. The project followed a structured workflow, divided into pre-production, production, and post-production phases, with a strong focus on cognitive engagement and clarity. The animation features two main characters, Lambros and Niki, who demonstrate the technical aspects of each skill, while Coach Eleni, a real-life figure, provides verbal explanations. The integration of quizzes at the end of each module enables learners to assess their understanding and track their progress. This multimedia approach offers an innovative way to teach sports skills, enhancing both comprehension and engagement through interactive visual and auditory elements. The study concludes with a discussion on expanding this model to other sports, such as basketball or soccer, and the potential for incorporating advanced technologies like augmented reality (AR) and artificial intelligence (AI) to further personalize the learning experience. Future research could explore the impact of this approach across different age groups and skill levels, providing valuable insights for the improvement of sports education.

Keywords: 3D animation, multimedia learnin, sports education, volleyball skills, cognitive theory

Introduction

The prospect of using animated multimedia presentations for learning purposes has aroused a growing interest in the educational system and accordingly has generated a substantial amount of research results (e.g., Beautemps, Bresges, & Becker-Genschow, 2025; Huang & Janakiraman, 2024; Mayer & Moreno, 2002; Utaminingsih, Machfud, Santosa, & Kassymova, 2024; Zhang, Li, & Wang, 2024) [2, 6, 14, 22]. Especially, in subjects of physical education and sport science, the educational potential for animation illustrating movement patterns of sports activities has attracted researchers' attention (e.g., Hodgins, Wooten, Brogan, & O'Brien, 2023; Liu & Li, 2022; Li & Zhou, 2025; Rosendahl *et al*., 2024; Rosendahl & Wagner, 2023; Kioumourtzoglou, Zetou, & Antoniou, 2022) [5, 8, 11, 13, 18].

Animated multimedia learning material is associated with grand expectations among educational policy makers. Several attempts to introduce this new technology with the purpose of enhancing learning have been made in recent years. The schooling system has, however, been rather hesitant and not so ready to adopt this kind of teaching aid.

Considering animations in education, Mayer and Moreno (2002) [14] recommend that instead of asking "does animation improve learning?" we should ask "when and how does animation affect learning?" (p. 88). The authors contend that animation is a potentially powerful tool for multimedia designers, and they also provide research-based examples of ways in which animation can be used to promote learner understanding. However bright their prospects for multimedia use in education they also observe that: "Yet, animation (and other visual forms of presentation) is not a magical panacea that automatically creates understanding. Indeed, the worldwide web and commercial software are replete with examples of glitzy animations that dazzle the eyes, but it is fair to ask whether they promote learner understanding that empowers the mind" (p. 97).

For computer animation to become a powerful learning tool and support knowledge construction, Kleftodimos (2024) [9] suggest that the software has to involve specific didactic goals, integrated educational scenarios, metaphors with pedagogical meaning and include didactic and learning outcomes.

The use of 3D animations enables new ways of representing movement patterns of sports activities that can otherwise only be indirectly demonstrated with, for example, experiments. By means of digital technology, we can create animations that visualise the process of acquiring a skill by which the learner, through practice and assimilation, refines and makes automatic the desired movement. Animated pictures in contrast to static illustration render it possible to convey information about both spatial and temporal structures by visualising dynamic characteristics of the depicted movement patterns (Zhang, Li, & Liu, 2022; Georgiou & Georgiou, 2021; Liu, Liu, & Liu, 2024; Talha, 2022) [4, 12, 21, 23]. Hence, from an educational point of view there could be learning benefits from dynamical visualisation of movement pattems and directions of locomotion in mini volleyball.

Like all educational tools computer-based 3D animation brings with it certain problems. One problematic consequence of animations used for educational purposes is that interpretation of the depicted movement patterns seems to be highly dependent on the learners' preconceptions (Karlsson, 2010; Ploetzner, Bodemer, & Neudert, 2020). In a study of how students learned to explain computer-

animated events, Roth (2001) showed that animated episodes can be interpreted in multiple ways and therefore do not embed unambiguous meanings: "What and how entities are salient is therefore an empirical matter" (p. 45). Krange and Ludvigsen (2008) contend that, not having access to the specific knowledge domain where only a small part is illustrated in the media "means that the students only get access to the top of the iceberg of this knowledge base, and what part of this that they manage to realise in practise is an empirical question" (p. 29).

Animation, visualising movement patterns of sports activities, can be positioned into the broader classification of computer simulations defined as: "programs that contain a model of a system (natural or artificial, e.g., equipment), or a process" (de Jong & van Joolingen, 1998, p. 180) [3]. A general assumption is that animations enhance learning and should be the preferred mode for presenting graphics of dynamic processes (e.g., Schrum, *et al*., 2005) [20]. With an animated display it is also presumed that we can rectify some of the above-mentioned problems associated with the use of static images for illustrating a scientific concept.

Considering the above, it seems worthwhile to create 3D animation to educate the children and teenagers about the movement patterns, the rules and the process of mini volleyball, presenting a unique fun and graphical way of teaching.

Therefore, through this study, an approach to combine the cognitive multimedia web learning principle with Animation based Learning techniques was designed. Generally, multimedia web learning involves images and video along with text, still 3D animation techniques are employed to attain a level of sophistication through which a strong message and lesson on education can be portrayed.

Methods

Software development tools

Several software tools were used to develop this 3D animation, based on multimedia web learning using the cognitive theory and principles of audio and visual effects with limited channel capacity. The software development tools, and their use are described below:

- Adobe Photoshop is software used for photo editing, digital art composition, animation and graphic design. One of the major benefits of using Adobe Photoshop is its ability to create multiple layers that can be modified independently of each other. In this research it was used for making textures and using color schemes.
- Adobe Premiere Pro is widely used software for editing videos, commercials and other films, television, and online videos. It can be used to import video, audio and graphics, as well as to create new, edited versions of video which can be exported to the medium and format necessary for distribution. In this research it was used for editing the videos and some effects as final touches.
- Adobe Audition is a comprehensive toolset that includes multitrack, waveform, and spectral display for creating, mixing, editing, and restoring audio content. This audio software is designed to accelerate video production workflows and audio finishing. In this research it was used for audio mixing, cutting and adjusting according to the scenes.
- Autodesk Maya software is 3D computer graphic software used for creating realistic 3D models, 3D applications, animated movies, TV serials, technical-non-technical commercials, 3D video games, visual effects and many other effects. In this research it was used for modelling all the characters, scenes, interior, exterior, lightning, cameras, texturing on models and animation.
- Moodle is a free and open-source learning management system (LMS) written in PHP and developed on pedagogical principles. Moodle is used for blended learning, distance education, flipped classroom and other e-learning projects in schools, universities, workplaces and other sectors (Moodle, 2021) [15]. In this research it was used for the implementation of the mini volleyball LMS web site, as well as for structuring and sharing the course material with learners and in monitoring and assessing their progress.

Project workflow

The project was divided into three phases: pre-production, production, and post-production, with each phase requiring the completion of specific tasks (Aleem, Capretz, & Ahmed. 2016) [1]. The pre-production phase involved the process of identifying the concept of the 3D animated multimedia product as well as the constraints under which it was designed and produced. The production phase was a creative activity in which 3D animated multimedia product components were identified and developed based on a set of multimedia design rules and theories. Finally, the post-production phase aimed at finalizing and enhancing the final product. It involved a set of activities that composed all actual scenes together based on a set of authentic aspects and verified that these scenes confirm to expectation. This entire pipeline is listed below, along with each key phase of the project and flow.

- **Pre-production**

1. Feasibility study
2. List of mental abilities and cognitive background
3. List of needs
4. The general idea
5. List of objectives
6. Educational content
7. production programs
8. research team
9. Script
10. Story board

- **Production**

11. Modeling
12. Material & Texture
13. Light & Shadow
14. Camera Position
15. Objects Animation
16. Render
17. Sound Record
18. Montage “Film editing”

- **Post-production**

19. Product registration
20. Storage media
21. Final product

Procedure

At the beginning of the project the research team got together, to identify the concept of the 3D animated multimedia product of mini volleyball as well as to discuss the general aspects of the characters, the locations, the

objects, and the props that will be used. Then a physical education (PE) teacher and a 3D art designer fully selected and took photos of the locations, the objects and the frame decomposition of the movement skills of elite athletes. For the movement techniques of mini volleyball (serving, setting and digging) photos of the frontal axis, vertical axis and other multi-angle and multi-directional photos were taken. Reference sketches were created based on those photos for modeling purposes. These consisted of orthographic views, reference views, and character sheets depicting the character in a variety of poses.

Art design and storyboarding

The animation development for the multimedia volleyball web application followed a structured process, incorporating the phases of pre-production, production, and post-production. The project was designed based on cognitive theory of multimedia learning principles, with the goal of teaching volleyball skills to children through 3D animated scenarios. The storyboard included a detailed breakdown of all scenes, actions, dialogues, and narration, ensuring a consistent pedagogical approach.

Each scene was meticulously planned with attention to purpose, visuals, and narration. Content was logically organized, allowing learners to process and retain information effectively. Each scene focused on a specific volleyball skill or game format, and transitions between scenes were carefully designed to maintain cognitive engagement.

Location design

The locations developed for the animation included an Olympic-style volleyball court filled with animated spectators and vibrant visual elements, creating an engaging atmosphere for learners. Additional environments were designed to represent various volleyball formats, including beach, grass, and sitting volleyball courts. All environments were modeled using Autodesk Maya and polygon modeling techniques, with realistic textures created in Adobe Photoshop for grass, sand, indoor flooring, and net materials.

To support cognitive processing, background details were simplified to minimize distractions, allowing learners to focus on key actions. The court dimensions, net heights, and player positioning were modeled accurately, reflecting real-world volleyball standards.

Characters

The primary animated characters, Lambros (the boy) and Niki (the girl), served as the main presenters and guides throughout the educational content. These characters were designed with stylized human forms to appeal to young learners. Skinning and rigging techniques allowed for natural movement and interaction with virtual props such as volleyballs and nets. Expressions and gestures were carefully crafted to enhance communication and engagement.

Character design was child-friendly and culturally sensitive, using bright colors, expressive facial animations, and clear, distinct clothing to help learners easily identify and emotionally connect with the characters.

A third character, Coach Eleni, was introduced as the mentor. Coach Eleni was a real-life figure, not a 3D animated character. She appeared in video recordings throughout the application, providing detailed explanations and instructions. While Lambros and Niki demonstrated the exercises in 3D animation, Coach Eleni appeared in real video footage, explaining the techniques in real-time and guiding learners through each skill. Her role was crucial in providing clear, authoritative explanations, while the 3D animation of Lambros and Niki focused solely on illustrating the technical aspects of each skill.

Exercise presentation

A key aspect of the application was the incorporation of real-life athletic performance. The execution of the volleyball exercises was demonstrated by real athletes, who were videotaped performing the exercises. This provided a realistic and relatable reference for learners to understand how the skills should be executed in real life.

While the athletes showed the actual execution of the exercises in the videos, the 3D animation of Lambros and Niki was reserved for demonstrating the technical components of each volleyball skill. For example, when demonstrating the technique for passing or setting, Lambros and Niki would be shown in 3D animation performing the precise movement, such as arm and hand positioning, foot placement, and body balance, ensuring that learners understood the mechanics of the technique. This distinction between real-life performance and technical demonstration helped learners focus on the crucial technical elements while also seeing how the skills looked in action.

Coach Eleni, in her real-life video role, further enriched this presentation by offering detailed commentary, providing additional insights into the correct technique, common mistakes, and helpful tips. She guided learners through both the real video demonstrations and the 3D animations, ensuring clarity and understanding of each skill.

Story of the project

The storyboard followed a structured approach where Lambros and Niki demonstrated volleyball skills, while Coach Eleni provided verbal explanations and insights through video. The story was structured as follows:

1. **Introduction:** Lambros and Niki introduced volleyball and its variations (indoor, beach, sitting, grass, mini volleyball), while Coach Eleni outlined the importance of learning each format.

2. **Skill Demonstration:** Lambros and Niki demonstrated basic volleyball skills (passing, setting, serving) through 3D animation. Simultaneously, real athletes showed the actual execution of these skills in video form, providing a direct link between technique and practice. Coach Eleni offered verbal explanations to connect the theory with practice.

3. **Mini Games**: The characters engaged in mini volleyball matches, showcasing game strategies and player positioning, while Coach Eleni provided tactical advice and tips in video form.

4. **Interactive Activities:** Short interactive games allowed learners to practice and reinforce what they had learned, with both the real athlete demonstrations and the 3D technical animations guiding them.

Throughout the process, the combination of real-life video footage and 3D animation helped maintain engagement and allowed learners to benefit from both realistic action and clear technical explanation.

Key skills of volleyball

Each volleyball skill was analyzed and broken down into key movements and phases. For example:

1. **Passing (Setting):** Correct arm and hand positions, foot placement, knee flexion.
2. **Bumping (Forearm Pass):** Proper arm positioning, body angle, and direction control.
3. **Serving:** Ball toss, striking hand position, and body balance.

The 3D animation of Lambros and Niki highlighted these key poses using keyframe techniques in Maya. Special overlays, such as arrows and labels, were added to emphasize critical body alignments and ball trajectories, supporting the learners' understanding of the technical aspects. Meanwhile, the real athlete videos showed how these movements looked in practice, offering a relatable and dynamic example of each skill in motion.

Visual and audio enhancements

Incorporating animated icons, sound effects, and dynamic subtitles, the application enhanced comprehension and engagement. The color palette was bright and cheerful, and the navigation interfaces were simple to ensure accessibility for young learners.

Sound design was synchronized with both the 3D animations and the real-life videos, including background music, audience reactions, and ball contact sounds, creating a multisensory learning experience. Narrations by Coach Eleni were recorded in a clear, enthusiastic tone, ensuring emotional engagement and effective communication with the target audience.

Learning assessment: quizzes

At the end of each module, quizzes were integrated to assess learners' understanding and reinforce the skills they had just learned. These quizzes included multiple-choice, true/false, and short-answer questions, all designed to evaluate the learner’s grasp of the volleyball techniques and their ability to apply them in various contexts.

The quizzes were interactive, with immediate feedback provided after each question to guide learners toward the correct understanding. This allowed learners to test their knowledge in a low-pressure environment while reinforcing key concepts. By engaging in these assessments, learners had the opportunity to track their progress, identify areas for improvement, and build confidence in their newfound skills.

Conclusion

The development of the multimedia volleyball application combining 3D animation and real video footage represents an innovative step in utilizing technology for teaching sports skills to children. By integrating 3D graphics with real-life video demonstrations of athletes performing exercises, the application offers an effective educational approach underpinned by principles of cognitive theory of multimedia learning. The use of 3D animation to present the technical aspects of each skill, alongside real-life video showcasing the execution of the exercises, enhances learners' understanding by providing both theoretical guidance and practical representation.

The inclusion of interactive quizzes at the end of each module proved to be an effective learning assessment tool. These quizzes not only assessed the learners’ knowledge but also helped maintain their engagement, providing continuous feedback to reinforce the concepts taught. This process enabled learners to identify areas needing improvement while boosting their confidence in mastering new skills.

This educational model, combining real content with 3D animation, could be expanded to other sports, creating a dynamic and engaging learning experience for students across various athletic domains. Moreover, the use of quizzes and ongoing assessments provides a valuable mechanism for evaluating the educational process and tailoring it to individual learner needs.

Further research could focus on improving and adapting the 3D graphics to incorporate more dynamic movements and interactions, enhancing the realism of the skills being taught. Additionally, applying the same methodology to other sports such as basketball, soccer, or swimming would create an integrated platform for sports education, providing a diverse range of content for learners.

The integration of real-time feedback and advanced analytics using cutting-edge technologies such as artificial intelligence could further personalize the learning experience, allowing the application to adapt to each learner's needs. Future studies might also explore the use of augmented reality (AR) and virtual reality (VR) to create even more interactive and immersive educational experiences, expanding the capabilities of modern sports education.

Moreover, researching the effectiveness of these applications across different age groups and skill levels would provide valuable insights into how to tailor educational programs to individual needs. Long-term studies measuring the impact of this multimedia approach on learning outcomes and athletic performance would also be beneficial for understanding the potential of these technologies in sports education.

In conclusion, integrating multimedia learning with interactive and immersive technologies paves the way for educational advancements in sports, with significant potential for improving both learning outcomes and athlete performance. Further exploration into these areas will undoubtedly contribute to the refinement and expansion of such educational tools, offering new possibilities for learners worldwide.

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