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Enhancing Students' Coding Skills With Bloom's Taxonomy And The Competence Approach Through Educational Game Design

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Abstract. **This paper explores an innovative approach to enhancing students' coding skills by integrating Bloom's Taxonomy and the Competence Approach through the design and implementation of educational games. The rapid evolution of technology necessitates a dynamic pedagogical framework that not only imparts technical knowledge but also fosters higher-order thinking skills. Bloom's Taxonomy provides a structured hierarchy of cognitive skills, ranging from basic understanding to advanced synthesis and evaluation, offering a comprehensive framework for curriculum development. Concurrently, the Competence Approach emphasizes the practical application of knowledge, focusing on real-world skills and problem-solving. In this study, we propose the synthesis of these two pedagogical frameworks to create a robust and effective methodology for teaching coding to students. By aligning specific coding tasks with Bloom's Taxonomy levels and integrating real-world problem-solving scenarios using the Competence Approach, educators can develop a curriculum that caters to diverse learning styles and cognitive abilities. To implement this approach, we advocate the use of educational games as a powerful and engaging tool for active learning.**

Keywords: Coding Skills, Bloom's Taxonomy, Competence Approach, Educational Game Design.

I. INTRODUCTION

In a world dictated by rapid technological advancements, the imperative to equip students with robust coding skills has become more pronounced than ever. However, the traditional methods of teaching coding often fall short in fostering the multifaceted development required for success. This paper introduces an approach to address this gap, blending the cognitive levels of Bloom's Taxonomy with the practical orientation of the Competence Approach, all within the immersive context of educational game design.

The intersection of Bloom's Taxonomy and the Competence Approach offers a framework that not only guides the acquisition of coding proficiency but also foster the development of critical thinking and problem-solving skills. While Bloom's Taxonomy provides a structured hierarchy for cognitive skill development, ranging from basic knowledge to advanced synthesis and evaluation, the Competence Approach emphasizes the application of knowledge in real-world contexts. By integrating these two educational paradigms, we aim to create a comprehensive strategy that exceed the traditional confines of coding education.

Recognizing the potential of educational games as powerful tools for engagement and active learning, this paper advocates for their integration into the coding curriculum [4]. These games are designed not only to teach coding concepts but also to immerse students in scenarios that demand practical application, aligning seamlessly with the principles of the Competence Approach. Through this integrated approach, we seek to transform coding education into a dynamic, interactive, and intellectually stimulating experience that resonates with the diverse learning preferences of today's students.

Throughout this paper, we delve into the theoretical underpinnings of Bloom's Taxonomy and the Competence Approach, illustrating how their synergy can be harnessed to enhance coding education. Case studies of educational games developed under this framework will be presented, offering tangible insights into the practical implementation of this innovative approach.

II. LITERATURE REVIEW

The area of computer science education has witnessed significant evolution in recent years, driven by the escalating demand for proficient coders in the workforce [7, 8]. However, the traditional approaches to teaching

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coding often struggle to keep pace with the dynamic requirements of the field. In the literature review we examine key themes surrounding coding education, with a specific focus on integrating Bloom's Taxonomy, the Competence Approach, and educational game design to enhance students' coding skills.

A. Coding Education Challenges

Numerous studies highlight the challenges associated with conventional coding education methods. These challenges include a lack of engagement, limited opportunities for practical application, and a narrow focus on memorization rather than holistic skill development [1], [5].

B. Bloom's Taxonomy in Education

Bloom's Taxonomy has long been recognized as a foundational framework for structuring educational objectives. Its hierarchical structure, ranging from lower-order cognitive skills (remembering and understanding) to higher-order skills (applying, analysing, evaluating, and creating), provides a roadmap for curriculum development [3].

C. Competence Approach in Education

The Competence Approach emphasizes the practical application of knowledge in real-world contexts. By focusing on the development of skills relevant to professional practice, this approach aligns with the demands of the workforce and enhances students' ability to tackle complex challenges [2].

D. Integration of Bloom's Taxonomy and the Competence Approach

A synthesis of Bloom's Taxonomy and the Competence Approach offers a comprehensive framework for curriculum development. By aligning specific coding tasks with Bloom's Taxonomy levels and embedding them in real-world scenarios, educators can bridge the gap between theoretical knowledge and practical application [9].

E. Educational Game Design in Coding Education

Educational games have gained traction as effective tools for engaging students in the learning process. By combining coding challenges with game scenarios, educators create environments that motivate students intrinsically, fostering active learning and problem-solving skills [10], [6].

Successful implementation of an integrated approach requires adequately trained educators. Studies emphasize the importance of teacher training programs to equip instructors with the skills necessary for effective integration and utilization of these pedagogical approaches.

III. METHODOLOGY GUIDELINES

The proposed methodology for combining Bloom's Digital Taxonomy with a Competence Approach in the context of coding education through educational game design is designed to create a comprehensive and effective framework. This approach seeks to integrate theoretical knowledge acquisition, cognitive skill development, and practical application within the engaging context of educational games.

A. Aligning coding tasks and learning objectives with Bloom's Digital Taxonomy

Identifying specific coding concepts and skills associated with each level of the taxonomy, ensuring a structured progression from basic understanding to advanced application and creation.

Integrating real-world problem-solving scenarios into the curriculum to align with the Competence Approach. These scenarios should mirror challenges students are likely to encounter in professional settings.

B. Educational Game Design Tasks

Developing game design tasks that incorporate coding challenges aligned with Bloom's Taxonomy. Each level of the taxonomy is represented within the game's progression, providing a scaffolded learning experience.

Embedding real-world scenarios within the game design to reinforce the Competence Approach. These scenarios should require students to apply coding skills to solve practical problems, promoting a deeper understanding of how coding concepts translate to real-world applications.

C. Cognitive Skill Integration

Incorporating cognitive skills from Bloom's Taxonomy into the game design. For example, creating game levels that require students to analyse, evaluate, and create solutions using coding concepts.

Integrating reflective elements within the game to encourage metacognition, allowing students to assess their own learning and problem-solving strategies.

D. Spiral approach

A spiral approach in education involves revisiting and building upon previously learned concepts in a cyclical manner, allowing students to deepen their understanding over time.

Designing a progressive learning path within the educational games, guiding students through increasingly complex coding challenges aligned with Bloom's Taxonomy.

Ensuring that each level builds upon the skills acquired in the previous stages.

Introducing new Competence Approach elements as students advance through the game, requiring them to apply coding skills in varied and realistic contexts.

E. Assessment Strategies

Developing assessment strategies that align with both Bloom's Taxonomy and the Competence Approach.

Using a combination of formative and summative assessments to evaluate students' understanding, application, and proficiency in coding.

Implementing assessments within the game environment to provide immediate feedback and facilitate continuous learning.

IV. Combining Bloom's Digital Taxonomy with a Competence Approach for Learning Coding through Educational Game Design

Combining Bloom's Digital Taxonomy with a Competence Approach provides a comprehensive framework for students learning coding through educational game design. This approach focuses on developing not only knowledge and skills but also the ability to apply them in authentic contexts.

Here's how the methodology can align with both frameworks:

A. Remembering

Objective: Recall fundamental coding concepts.

Competence Approach: Memorize coding syntax and basic algorithms.

Bloom's Digital Taxonomy:

- Use online quizzes or interactive digital assessments to recall coding syntax.
- Create digital flashcards or mind maps for quick recall.

B. Understanding

Objective: Comprehend the relationship between coding concepts and game design.

Competence Approach: Understand the principles of coding in the context of game design.

Bloom's Digital Taxonomy:

- Engage in collaborative online discussions to deepen understanding.
- Watch instructional videos or online tutorials on coding and game design.

C. Applying

Objective: Apply coding concepts to design simple game elements.

Competence Approach: Implement coding knowledge to create basic game elements.

Bloom's Digital Taxonomy:

- Collaboratively code using online platforms or Integrated Development Environments (IDEs).
- Participate in coding challenges on digital platforms.

D. Analyzing

Objective: Evaluate the effectiveness of coding in game design.

Competence Approach: Analyze and critique the coding structure of existing games.

Bloom's Digital Taxonomy:

- Use digital tools to compare and contrast different coding approaches.
- Participate in virtual coding peer reviews, providing constructive feedback.

E. Evaluating

Objective: Assess the suitability of educational games for specific learning objectives.

Competence Approach: Evaluate the effectiveness of game-based learning in achieving educational goals.

Bloom's Digital Taxonomy:

- Administer online surveys to gather feedback on educational game prototypes.
- Collaboratively assess existing educational games using digital rubrics.

F. Creating

Objective: Design and implement educational games integrating coding principles.

Competence Approach: Create complete educational game prototypes demonstrating coding proficiency.

Bloom's Digital Taxonomy:

- Develop game prototypes using digital game design tools and coding platforms.
- Collaboratively code, share projects through version control platforms, and create digital lesson plans.

G. Reflecting

Objective: Reflect on the pedagogical implications of using coding in education.

Competence Approach: Reflect on personal growth in coding and its application to teaching.

Bloom's Digital Taxonomy:

- Blog or journal reflections on digital platforms.
- Participate in asynchronous online discussions about coding challenges and successes.

H. Sharing

Objective: Share completed educational games with peers and educators.

Competence Approach: Demonstrate the ability to effectively communicate the educational value of coding-based games.

Bloom's Digital Taxonomy:

- Show games through online platforms or virtual exhibitions.
- Create digital presentations or webinars to share experiences with a wider audience.

V. Case Studies

Our integrated methodology, seamlessly combining Bloom's Digital Taxonomy with a Competence Approach within the realm of coding education through educational game design, has proven to be a resounding success. In this section, we proudly present a collection of case studies meticulously curated to spotlight instances where this innovative approach has led to exceptional outcomes in coding skill development. These case studies serve as compelling narratives, offering concrete examples of how the fusion of cognitive depth, practical application, and gamified learning can foster remarkable advancements in students' coding proficiency. Each case study provides a vivid illustration of the successful implementation of our methodology, offering a closer look at the transformative impact on students' learning experiences.

Game 1. The aim of the game is to follow the instructions which will help students to solve problems and learn about healthy eating.

Sprites

Annie (main character). Annie is a little girl who appears throughout the entire game. She provides various instructions during the gameplay. Based on these instructions, the player performs tasks to master new content and reach the goal - the end of the game.

Grandma Maria (additional character). Grandma is a character who appears in the game to provide guidance. She works at the market. Annie goes to the market to buy healthy food products.

Description of the activities

The game is initiated by pressing the 'n' key. Annie urges the player to help her choose healthy foods. She goes to the store, where Grandma Maria appears, providing instructions for the first mini-game.

Mini-Game 1: The game starts with pressing the '1' key. The player must use the left and right arrow keys to move and collect 20 healthy products in their basket. The player has 30 seconds to gather the groceries. If the player doesn't collect enough healthy foods, the game restarts.

Fig. 1. Screen from Mini-Game 1 (Annie)

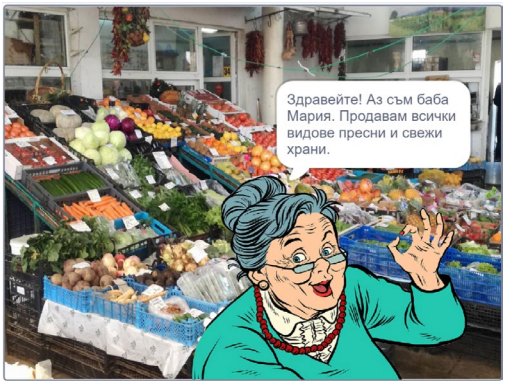

Fig. 2. Screen from Mini-Game 1 (Grandma Maria)

Mini-Game 2: The next game is activated with the '2' key. The player must guide Annie through the maze to find grain-based foods.

Fig. 3. Screen from Mini-Game 2

Mini-Game 3: After successfully navigating the maze, the girl returns home. On her way, she encounters a wall. To see the next task, the player must press the '3' key. The task is to arrange the words in a phrase related to healthy eating in the correct order.

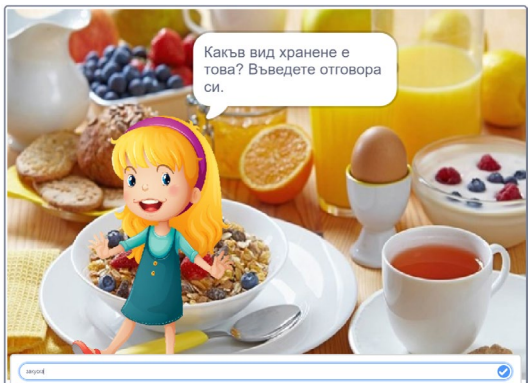

Fig. 4. Screen from Mini-Game 3

Mini-Game 4: The player must write the name of the dish shown in the picture. If the player answers correctly, Annie is ready for lunch. Pressing the '4' key activates the final mini-game, where the player must set the table.

Fig. 5. Screen from Mini-Game 4

Game 2. The goal of the game is for the main character to dress appropriately for the season to gather fruits typical for that time of the year

Sprites

A girl (main character).

Family (mother, father, 2 sisters, 1 brother) (additional characters).

Description of the activities

The main character introduces the player to the story. The girl, Aria, comes from Australia to Bulgaria to learn more about the seasons specific to the Bulgarian climate. For each season, Aria needs to dress appropriately, which is also a condition for continuing the game. Successful dressing is followed by the second part of the game, where fruits specific to a particular season are collected. This way, the main character goes through the four seasons.

By collecting the correct fruit, the player earns 1 point, and making an incorrect choice result in losing 1 point. By gathering seasonal fruits throughout all seasons, the player can accumulate a total of 36 points, of which a minimum of 20 points is required for the successful completion of the game.

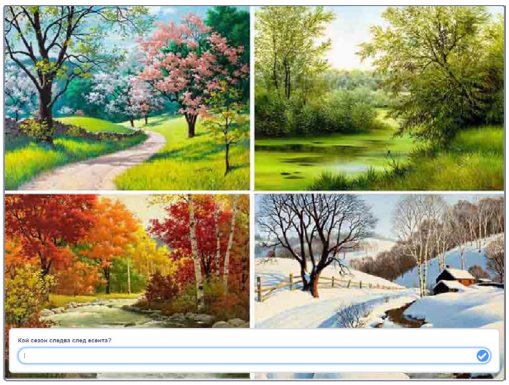

Fig. 6. Screen from Game 2 – four seasons

First Part of the Game for Each Season.

Selecting appropriate clothing for the main character according to the current season. A condition for continuing the game – collecting points."

Fig. 7. Screen from Game 2 – selecting appropriate clothing for summer

Second Part of the Game for Each Season.

Collecting fruits specific to a particular season. By gathering fruits, a maximum of 9 points can be earned in each season.

Fig. 8. Screen from Game 2 – selecting summer fruits

Fig. 9. Screen from Game 2 – selecting appropriate clothing for autumn

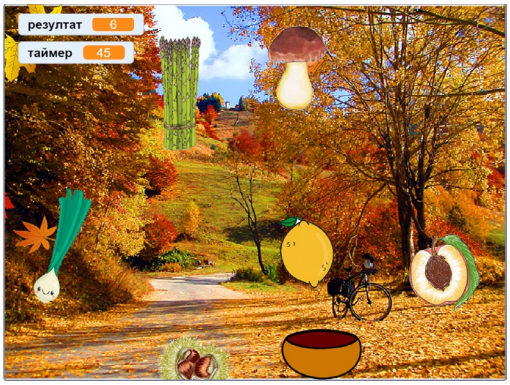

Fig. 10. Screen from Game 2 – selecting autumn fruits

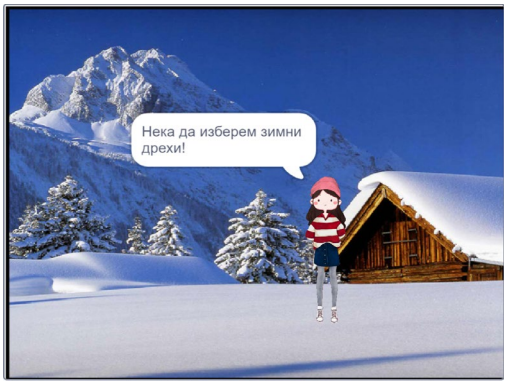

Fig. 11. Screen from Game 2 – selecting appropriate clothing for winter

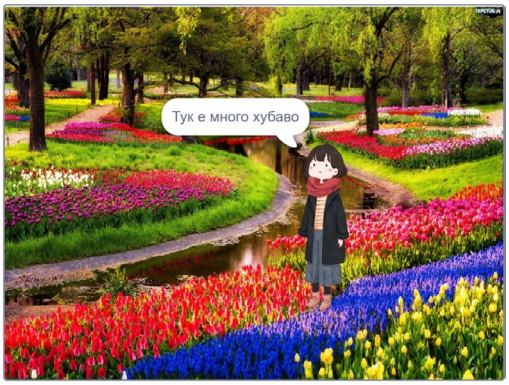

Fig. 12. Screen from Game 2 – selecting appropriate clothing for spring

VI. CONCLUSION

In conclusion, the integration of Bloom's Digital Taxonomy with a Competence Approach in coding education through educational game design presents a promising and innovative way for develop holistic learning experiences. Through the exploration of this approach, we have identified its transformative potential in enhancing students' coding skills while fostering critical thinking, problem-solving, and practical application.

The presented case studies reveal the successful implementation of the integrated methodology, demonstrating its effectiveness in engaging students and promoting a deeper understanding of coding concepts. These real-world examples underscore the positive impact of aligning educational games with Bloom's Taxonomy and the Competence Approach, providing valuable insights for educators.

As the education continues to evolve, the integration of pedagogical frameworks and innovative technologies remains essential. The combined strength of Bloom' Digital Taxonomy, the Competence Approach, and educational game design holds great promise in preparing students for the multifaceted demands of the digital age.

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