”Kiddo Labs” Child-Friendly Reading and Comprehension Coach

Senavirathna W.H.D.A
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
it21357930@my.sliit.lk

Y.M.Senevirathna
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
it21381768@my.sliit.lk

Hetti Hewa K.C.W.B
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
it21371622@my.sliit.lk

Karunarathna L.M.J.T.
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
it21172014@my.sliit.lk

Uditha Dharmakeerthi
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
uditha.d@sliit.lk

Suranjini Silva
Faculty of Computing
Sri Lanka Institute of Information Technology
Malabe, Sri Lanka
suranjini.s@sliit.lk

***Abstract*—[1] The Understanding Vocabulary project is designed to offer children an engaging and enjoyable way to expand their vocabulary. By integrating adaptive games, contextual learning tools, and interactive exercises, the project caters to the individual learning needs of every child. Its primary goal is to create a dynamic learning environment where challenges are personalized to a child's progress, ensuring an optimal level of difficulty at every stage.[2] A standout feature of the project is its adaptive vocabulary games, which focus on word recognition and phonics. As children advance through the game, they encounter progressively complex tasks, supported by helpful guidance when necessary. Another key component is contextual word learning, where children derive the meanings of words from sentences, stories, or scenarios. This approach is further enhanced by interactive activities and visual aids, fostering better comprehension and retention of new vocabulary.[3] Overall, Understanding Vocabulary seeks to transform vocabulary building into a fun, personalized, and effective experience for children. By emphasizing adaptive challenges and context-based learning, the project nurtures a deeper understanding of language, laying a strong foundation for lifelong education and communication skills.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

Language forms the foundation of all human learning, making it imperative for children to develop a robust vocabulary during their formative years. Vocabulary is not merely a list of words; it serves as a gateway to comprehension, expression, and deeper cognitive abilities. Recognizing the importance of vocabulary, the Understanding Vocabulary project has been developed to equip children with tools and techniques that make learning words meaningful, engaging, and effective [1][2].

Identify applicable funding agency here. If none, delete this.

[5] The project combines modern educational methodologies with innovative digital tools to create an enriched learning environment. By employing adaptive games and contextual learning approaches, it ensures that children are not only exposed to new words but also gain the ability to use these words in practical, meaningful contexts. This is achieved through carefully crafted activities that focus on comprehension, application, and retention, rather than rote memorization [3]. The integration of contextual meaning analysis tools allows children to derive word meanings naturally, enhancing their understanding through exposure to sentences, stories, and real-life scenarios.

[6] In the field of early education, a child's ability to read and develop language skills depends on having a strong vocabulary. However, young learners find it challenging to be engaged by traditional methods of vocabulary instruction, which makes it harder for them to remember and use new words effectively. The Understanding Vocabulary project seeks to close this gap by combining cutting-edge teaching resources with flexible, kid-centered learning techniques [4][5].

[7] The goal of this project is to create a thorough set of vocabulary exercises that will aid kids in learning new words and comprehending their meanings in context. We can provide kids with a more engaging education where words are not only learned in isolation but also within engaging stories and sentences by incorporating contextual meaning analysis tools. Furthermore, by adapting to the child's reading level and progress, our adaptive vocabulary games will make sure that learning stays enjoyable and challenging while reiterating important concepts like phonics and sight word recognition [6].

[8] A unique feature of the project lies in its adaptive vocabulary games, which are designed to evolve based on the

individual learning pace of each child. These games prioritize essential language skills, such as phonics and sight word recognition, and dynamically adjust difficulty levels to match the learner's progress. This personalized approach not only enhances learning outcomes but also keeps children motivated and engaged throughout the process [7][8]. [9] With the help of this project, we want to establish a stimulating learning environment where kids can gain a solid vocabulary foundation that will help them succeed academically and in language development as a whole. Beyond vocabulary acquisition, this initiative aims to instill a lifelong passion for language and learning in children. By creating a foundation built on understanding and application, the project empowers children to become confident communicators and critical thinkers [9][10]. [10] In the modern era, where digital technologies are transforming education, it is vital to create solutions that cater to the dynamic needs of learners. The Understanding Vocabulary project aspires to bridge the gap between traditional teaching methods and the demands of today's digital learners. By leveraging digital platforms and research-based practices, the project ensures that children receive a holistic, well-rounded education that prepares them for the challenges of the future

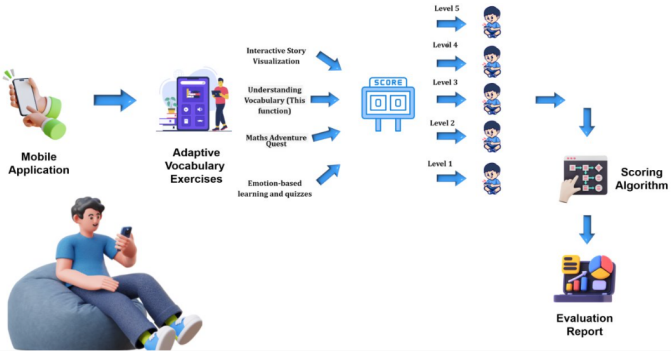

Fig. 1. System architecture of the vocabulary learning system.

II. LITERATURE REVIEW

[11] Extensive research in the field of vocabulary acquisition and language development underscores the importance of teaching vocabulary in meaningful contexts. Nation [1] emphasizes that learning vocabulary is fundamental to language acquisition, advocating for methods that integrate new words into real-life situations. Similarly, Schmitt [2] highlights the need for repetition and contextual engagement to improve retention and comprehension. These principles are core to the Understanding Vocabulary project, which utilizes contextual tools and interactive exercises to reinforce learning.

[12] Research by Stahl and Nagy [3] identifies the limitations of traditional rote memorization techniques, suggesting that children learn better when they actively engage with words in diverse scenarios. This finding supports the project's emphasis on adaptive games, which not only make learning fun but also tailor challenges to the child's progress. Gee [6] and Squire [7] further explore the role of games in learning, noting that gamified approaches can enhance motivation and deepen understanding. By incorporating these insights, the project creates an engaging environment where children are motivated to learn.

Vygotsky's theory of scaffolding [5] provides a theoretical foundation for the adaptive learning model employed in this project. By adjusting the level of challenge based on a child's abilities, the project ensures that learners are consistently supported while being encouraged to stretch their skills. This approach aligns with Rosenshine's [9] principles of instruction, which advocate for guided practice and active participation as key elements of effective teaching.

The significance of phonics and sight word recognition in early literacy development has been well-documented. Research by Clark and Mayer [10] emphasizes the role of multimedia learning tools in enhancing phonics instruction. By integrating visual aids and interactive exercises, the project capitalizes on the benefits of multimedia to improve children's language skills. Kuhl's [11] work on early language acquisition also highlights the importance of engaging, multisensory experiences in fostering linguistic development, further validating the project's methodology.

Overall, the Understanding Vocabulary project draws on a robust body of research to inform its design and implementation. By combining insights from educational psychology, game-based learning, and language pedagogy, it offers a comprehensive solution to the challenges of vocabulary instruction. The project not only addresses the limitations of traditional methods but also leverages innovative technologies to create a dynamic, child-centered learning experience.

A. Motivational Systems in Educational Technology

For any educational intervention to be successful, motivation is essential, especially for kids with learning difficulties. Deci and Ryan's Self-Determination Theory [12] states that activities that provide people a sense of competence, autonomy, and relatedness might help them become more intrinsically motivated. Learner engagement and results have been shown to significantly improve when educational technology is included with these principles. In recent years, gamification has been thoroughly researched as a motivational strategy. According to Deterding et al. [13], game-like features like leaderboards, badges, and levels can maintain long-term engagement. These characteristics can turn otherwise annoying chores into fun challenges for kids. A "flow state" that is favorable to learning is maintained by integrating adaptive feedback mechanisms, which also guarantees that students are neither overburdened nor underchallenged.

B. Adaptive Vocabulary Games:

Adaptive vocabulary games play a central role in engaging children while tailoring learning challenges to their individual levels. These games focus on phonics, sight word recognition, and overall vocabulary development. This gamified approach is informed by the work of Gee [6] and Squire [7], who explore how video games can enhance motivation and learning by

providing a fun, interactive environment that encourages active participation. By utilizing this method, the project ensures that learning is both enjoyable and effective.

C. Data Collection Evaluation:

Data collection is integral to the project, with every interaction and learning progress tracked and stored in a secure database. This continuous evaluation helps in generating detailed reports that offer insights into each child's learning journey. This aspect of the project follows Rosenshine's [9] principles of instruction, which advocate for the use of feedback to guide and shape learning experiences. By continuously evaluating progress, the project can identify areas that need improvement and adjust the learning environment accordingly.

III. METHODOLOGY

The system will offer a range of interactive vocabulary exercises and adaptive games that help children learn new words and understand their meanings within sentences. It will track their progress through scoring algorithms, providing real-time feedback and personalized learning paths to ensure each child is appropriately challenged. Data on their performance will be collected, generating progress reports that highlight strengths and areas for improvement. This personalized approach helps keep children engaged and motivated while making the learning experience fun, effective, and easy to follow.

A. System Architecture

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

1) Vocabulary Exercises:(Vocabulary Handwriting System Interactive Word Recognition and Assessment) is designed to engage students in interactive and personalized learning while evaluating their vocabulary proficiency. This system leverages a Convolutional Neural Network (CNN) model for handwriting recognition, ensuring high accuracy and efficiency in interpreting students' written responses.

Students are presented with a series of new words displayed sequentially on a digital interface, requiring them to write the displayed words using a stylus or touch-sensitive device. The CNN model processes these handwritten inputs, identifying and evaluating the accuracy of the written words. When a student writes a word correctly, they are awarded full marks for that attempt. In cases of incorrect attempts, the system provides immediate, detailed feedback by highlighting errors and offering opportunities for correction. Subsequent attempts are scored incrementally lower based on the accuracy of the corrections, encouraging consistent engagement and iterative learning.

Each session consists of ten such interactive exercises. The scores from these activities, along with those from other complementary exercises, are combined to generate a cumulative score. This score is used to dynamically categorize students into appropriate learning levels, ensuring that subsequent instructional content aligns with their individual proficiency.

The primary objective of the system is twofold: (1) to provide an engaging and constructive learning experience that actively involves students in vocabulary development, and (2) to utilize performance data to dynamically adjust the learning path, fostering continuous improvement. The CNN model enhances the system's adaptability and precision by accurately interpreting handwriting across various styles, making it robust and scalable for diverse learners.

By integrating handwriting recognition through the CNN model, real-time feedback, and adaptive learning strategies, this system establishes a dynamic, personalized, and impactful educational environment for vocabulary development.

2) Snake Game Architecture: The Snake Game Architecture is an innovative and gamified learning mechanism integrated into the Vocabulary Handwriting System to reinforce vocabulary acquisition while engaging students in an interactive and enjoyable experience. This function serves as an adaptive extension of the learning process, where students are rewarded with an opportunity to play a level-specific snake game based on their performance in prior assessments. Once the Interactive Word Recognition and Assessment phase concludes, the system determines the student's proficiency level based on cumulative scores. The system categorizes learners into five distinct levels: Level One, Level Two, Level Three, Level Four, and Level Five. Each level corresponds to a progressively challenging version of the snake game, ensuring that the complexity aligns with the student's capabilities and developmental stage. At the assigned level, the student gains access to the corresponding version of the Snake Game, referred to as Snake Game 1 for the initial session. The complexity of the game is dynamically adjusted based on the assigned level. For example, in lower levels, such as Level One, the game design emphasizes simplicity, with slower snake movement, fewer obstacles, and more forgiving gameplay mechanics. This encourages engagement and boosts confidence in younger or less proficient learners. Conversely, in higher levels, such as Level Four or Five, the game becomes more intricate, featuring faster movement, complex mazes, and additional challenges that require quick thinking and enhanced motor coordination. The Snake Game is not merely a reward mechanism but also serves as a continuation of the educational process. Vocabulary elements can be integrated into the game's mechanics, such as requiring the student to collect letters in the correct sequence to form a word or associating game milestones with vocabulary prompts. This integration ensures that the game remains both entertaining and educational, reinforcing the student's learning in a contextually meaningful manner. By adapting the game's difficulty to match the student's proficiency, the Snake Game Architecture fosters a sense of achievement and progression. The system encourages learners to strive for improvement, as advancing to a higher level unlocks more complex and rewarding gameplay. This design not only sustains the student's interest but also contributes to building resilience,

problem-solving skills, and a deeper engagement with the learning process. The Snake Game Architecture exemplifies how gamification can be leveraged to complement educational objectives. By tailoring game complexity to individual performance and seamlessly integrating vocabulary reinforcement, it creates a holistic learning environment where students are motivated to excel academically while enjoying the process.

3) Level Design and Progression:

- Level 1 (Foundation Stage): This level introduces students to the game in a simple and stress-free way. Tasks have plenty of time, and the words are easy, helping students feel confident and get used to the game.
- Level 2(Slightly Increased Complexity): The difficulty goes up a little here. Students have less time to complete tasks, and the words are slightly harder. It helps them practice time management and build on what they learned in Level One.
- Level 3(Intermediate Challenge): This level is more challenging, with even less time and harder words. Students need to think faster and use the skills they've built so far.
- Level 4(Advanced Adaptive Engagement): Here, the game adjusts based on how well the student is doing. Time is tighter, and the words are more complex. The tasks are designed to match the student's abilities, keeping the challenges fun and interesting.
- Level 5 (Expert Mastery Stage): This is the toughest level, meant for students who have mastered earlier stages. The words are advanced, time is limited, and tasks require quick thinking and a strong vocabulary. The challenges keep changing to test their skills.

4) Performance Clustering System: The game implements a sophisticated clustering algorithm to categorize user performance, ensuring that learning interventions are targeted and effective:

- Low Performance Cluster: Score ¡ 50, completion time 120 seconds
- Medium Performance Cluster: Score 50-75, completion time 60-120 seconds
- High Performance Cluster: Score 75, completion time ¡ 60 seconds

5) Parent-Child Activity Framework: The approach addresses the observed gap of merging virtual and real-world learning experiences by suggesting real-world tasks based on performance clusters:

Cluster	Recommended Activities
Low	Game in a simple and stress-free way, Simple memory games
Medium	Interactive reading sessions, less time and harder words
High	Advanced cognitive tasks, Creative problem-solving activities

TABLE I
RECOMMENDED ACTIVITIES BASED ON CLUSTERS

6) Progress Analytics: This feature tracks and analyzes the student's performance throughout the game, providing detailed insights into their progress. It highlights strengths, identifies

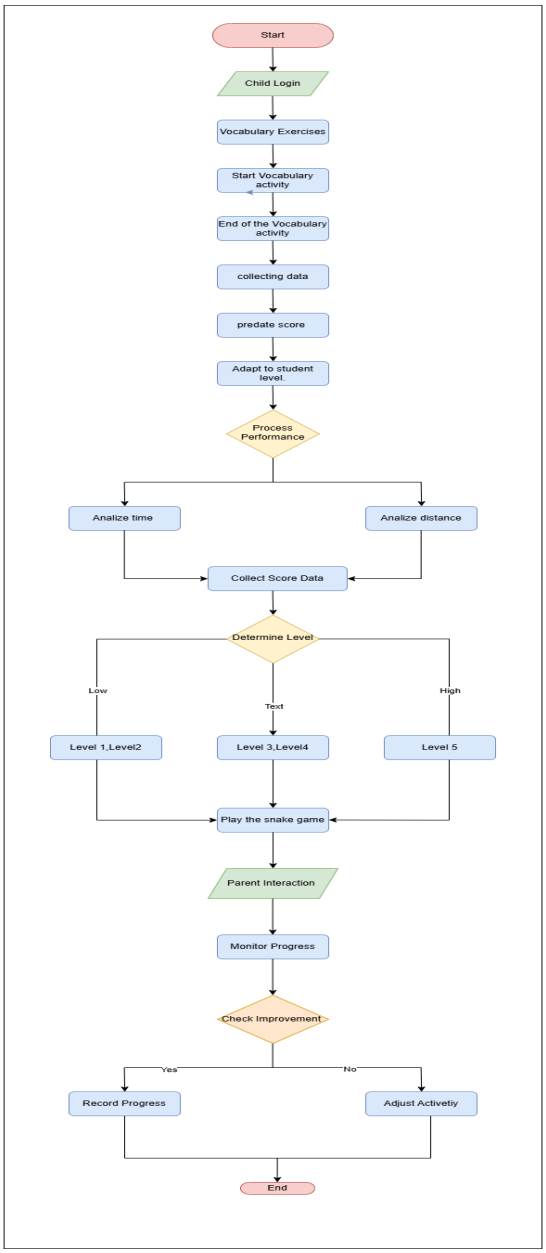

Fig. 2. Snake game level progression and difficulty scaling.

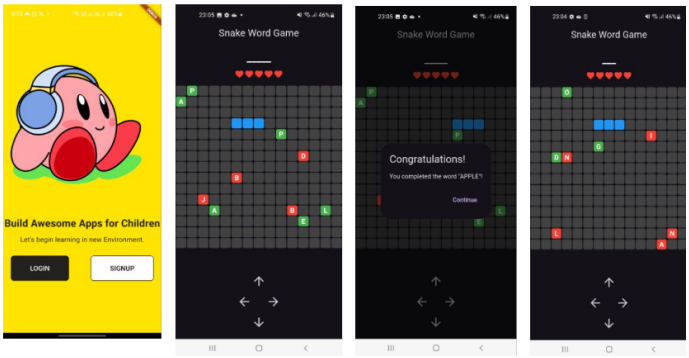

Fig. 3. Snake Game User Interface and Level Design.

areas for improvement, and offers tailored feedback to enhance learning. By monitoring metrics such as task completion time, accuracy, and vocabulary growth, the system ensures that students receive a personalized and effective learning experience.

Performance metrics
– Enhancements in reading speed
– Error reduction rates
– Points for comprehension

IV. RESULTS AND ANALYSIS

A. Data Collection and Evaluation

The system continuously tracks and records all interactions and learning progress, storing the data in a secure database. This enables the generation of detailed evaluation reports that provide valuable insights into each child's learning journey. These insights form the foundation for monitoring and improving the effectiveness of the learning experience.

B. Scoring Algorithms and Performance Metrics

The scoring system is designed to provide a fair and comprehensive evaluation of student performance, ensuring continuous engagement and motivation. In the Vocabulary Exercises, each student is presented with ten words, which they must write correctly. If a student writes a word correctly on the first attempt, they are awarded full marks for that word. However, if the initial attempt contains errors, the student is given a second chance. In this scenario, the marks for the second attempt are reduced to half of the original marks for that word. For example, if the full mark for a word in Exercise 1 is 4, the student will earn 2 marks for a correct response on the second attempt. This iterative approach ensures students are encouraged to learn from their mistakes while reinforcing correct spelling through practice. Participation in these exercises is mandatory, as they form the foundation for vocabulary assessment. Students cannot skip any exercise, ensuring a consistent evaluation process. Additionally, the scoring extends to the game-based learning component, where performance in the game is integrated into the overall score. Based on the student's assigned level (e.g., Level 1), marks earned from the game are added to their cumulative total. This gamified approach not only evaluates proficiency but also keeps students engaged by combining learning with entertainment. At the end of each session, the cumulative score reflects the student's overall performance, incorporating metrics from both the vocabulary exercises and the game. This comprehensive scoring mechanism supports the dynamic adaptation of future learning paths, ensuring that the student's educational experience is tailored to their progress and developmental needs.

C. Feedback System and Adaptive Learning Paths

The system offers real-time feedback based on performance metrics, providing constructive suggestions and encouragement. Simultaneously, it adjusts the learning path dynamically to maintain an optimal level of challenge. This adaptive approach ensures that children remain motivated while avoiding feelings of being overwhelmed, fostering continuous and effective learning.

D. Feedback System and Adaptive Learning Paths

Regularly generated progress reports highlight each child's achievements, strengths, and areas for improvement. These reports are instrumental in creating personalized learning experiences that are both effective and enjoyable, ensuring that the system evolves in alignment with each learner's development.

V. FUTURE SCOPE

The future scope of this research offers significant opportunities for enhancing educational technology and adaptive learning systems. As the foundation for this study integrates gamified vocabulary instruction and contextual analysis tools, several directions can be pursued to advance the current system's capabilities.

A. Integration with Advanced

Future iterations of the system can incorporate cutting-edge AI techniques, such as Natural Language Processing (NLP) and machine learning, to refine contextual understanding and vocabulary recommendations further. AI-driven insights can also enable predictive analytics, allowing the system to anticipate learning challenges and proactively adjust content delivery.

B. Personalized Learning Ecosystems

Expanding the platform to include a comprehensive personalized learning ecosystem can revolutionize how children interact with vocabulary-building tools. By integrating multimodal inputs such as voice recognition and handwriting analysis, the system could cater to diverse learning preferences and cognitive abilities.

C. Scalability for Broader Demographics

Currently targeted at a specific age group, the system could be adapted to serve broader demographics, including adults seeking language acquisition or professional vocabulary enhancement. This scalability would position the platform as a versatile solution across different educational and professional domains.

D. Cross-Language Support

Future developments could include support for multiple languages, enabling bilingual and multilingual learners to expand their vocabulary in various linguistic contexts. This feature would promote global accessibility and cultural inclusivity, catering to diverse linguistic backgrounds.

E. Cross-Language Support

Incorporating VR and AR technologies can create immersive learning environments where users interact with vocabulary in real-life scenarios. This approach would deepen contextual understanding and make the learning process more engaging and experiential.

VI. FUTURE SCOPE

Throughout this research, my supervisor, Mr. Uditha Dharmakeerthi, provided essential direction, support, and encouragement, for which I am really grateful. This study would not have been possible without his shrewd criticism and unflinching faith in my work. My profound gratitude also goes out to my co-supervisor, Mrs. Suranjini Silva, for his unwavering encouragement, knowledgeable counsel, and helpful critique, all of which significantly improved the quality of this study. We extend our sincere appreciation to all the participating schools, children, and their parents for their valuable cooperation and commitment throughout this research project. Your participation and support were instrumental in making this study possible. We would like to sincerely thank all of the participating schools, kids, and parents for their invaluable collaboration and dedication during this research endeavor. Your assistance and involvement were crucial in enabling this research. Additionally, the authors express their gratitude to the academic experts from the Faculty of Computing, and *colleagues at the Sri Lanka Institute of Information Technology for their support, feedback, and counsel. Additionally acknowledged is the assistance that was provided by all other parties.

REFERENCES

[1] I. S. P. Nation, Learning Vocabulary in Another Language. Cambridge, U.K.: Cambridge Univ. Press, 2001.
[2] N. Schmitt, Vocabulary in Language Teaching. Cambridge, U.K.: Cambridge Univ. Press, 2000.
[3] S. A. Stahl and W. E. Nagy, Teaching Word Meanings. Mahwah, NJ, USA: Lawrence Erlbaum Assoc., 2006.
[4] A. Collins and R. Halverson, Rethinking Education in the Age of Technology: The Digital Revolution and Schooling in America. New York, NY, USA: Teachers College Press, 2018.
[5] L. S. Vygotsky, Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA, USA: Harvard Univ. Press, 1978.
[6] J. P. Gee, What Video Games Have to Teach Us About Learning and Literacy. New York, NY, USA: Palgrave Macmillan, 2003.
[7] K. D. Squire, Video Games and Learning: Teaching and Participatory Culture in the Digital Age. New York, NY, USA: Teachers College Press, 2011.
[8] J. Piaget, "Development and learning," J. Res. Sci. Teaching, vol. 2, no. 3, pp. 176–186, 1964.
[9] B. Rosenshine, "Principles of instruction: Research-based strategies that all teachers should know," Amer. Educator, vol. 36, no. 1, pp. 12–39, 2012.
[10] R. E. Clark and R. E. Mayer, E-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning, 4th ed. Hoboken, NJ, USA: Wiley, 2016.
[11] P. K. Kuhl, "Brain mechanisms in early language acquisition," Neuron, vol. 67, no. 5, pp. 713–727, 2010.
[12] "E. L. Deci and R. M. Ryan", Intrinsic Motivation and Self-Determination in Human Behavior. New York, NY, USA: Springer, 1985.
[13] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining 'gamification'," in Proc. 15th Int. Academic MindTrek Conf.: Envisioning Future Media Environments, 2011, pp. 9-15.