Leveraging Serious Play to Foster Learning and Action on Sustainable Development Goals

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***Abstract*—This paper presents the development and early validation of an innovative Games for Change platform aligned with the Sustainable Development Goals (SDGs). Designed to engage players in tackling socio-environmental and health challenges, the platform integrates interactive, challenge-based learning and gamified mechanics to promote sustainable practices. Developed in Unity, the platform combines 3D and 2D assets with a scalable backend powered by MySQL, PHP, Firebase, and Azure Database for MySQL. It supports real-time feedback and runs on PC, web, and mobile devices. Early validation through comprehensive testing has confirmed core functionalities such as authentication, interface navigation, and in-game interactions. Initial evaluations with educational institutions and industry partners suggest that the platform effectively fosters critical thinking, collaboration, and behavior change towards sustainability. These findings highlight its potential as a valuable tool for academic and corporate training in the context of Games for Change.**

***Index Terms*—games for change, learning, collaboration, SDG**

I. Introduction

Serious games have emerged as a powerful tool for social change and sustainability, merging education with interactive engagement to drive real-world impact. By transforming traditional learning into immersive problem-solving experiences, they empower players to tackle complex global challenges, including climate change, social justice, sustainable development, and public health [1], [2]. Research suggests that serious games not only enhance critical thinking and collaboration but also foster environmental awareness and social responsibility [3]. By integrating game mechanics with sustainability principles, these platforms engage players in problem-solving, allowing them to explore innovative solutions and actively participate in shaping a more sustainable future.

Among serious games, the Games for Change (G4C) movement has gained traction, leveraging the immersive power of games to address critical social and environmental challenges [4]. Since its inception in 2004, G4C has enabled developers, educators, and social innovators to design interactive experiences with real-world impact [5]. Games uniquely foster social change by providing a risk-free environment where players can experiment with solutions, develop empathy, and build critical thinking skills [6]. For instance, *Half the Sky*, a game-based adventure that aims to reach mainstream audiences to raise awareness and donations to empower women and girls around the world—inspired by the book of the same name—translates virtual achievements into real-world outcomes, such as funding surgeries and donating books through partnerships with NGOs [7]. Other impactful games include *Alba: A Wildlife Adventure* [8], which uses interactive storytelling to raise awareness and inspire action on global issues like environmental sustainability and social justice, and *Endling: Extinction is Forever* [9], about environmental conservation and biodiversity, which positions players as the last fox mother on Earth, creating an emotional connection to the consequences of biodiversity loss. Games are increasingly contributing to the SDGs, driving scalable sustainability solutions across industries, education, and environmental initiatives. As their influence grows, there is a rising demand for innovative approaches that integrate sustainability into various sectors [10], [11].

Despite growing awareness of the 17 Sustainable Development Goals (SDGs)—which aim to address key global challenges by 2030—many organizations struggle to translate knowledge into action. The SDGs cover poverty (1), hunger (2), health (3), education (4), gender equality (5), clean water (6), and clean energy (7), as well as economic growth (8–10), sustainable living (11–13), environmental protection (14–15), and global stability (16–17). However, sustainability education often remains theoretical, limiting its impact on behavior change and real-world problem-solving [12], [13]. Innovative approaches—such as technology-enhanced active learning—have shown potential to bridge this gap, increasing engagement and effectiveness in sustainability initiatives [14].

This work introduces *SIB Game*, a game for change platform designed to connect sustainability knowledge with real-world action. By combining interactive storytelling, problem-

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solving, and collaboration, it creates an experiential learning environment where players actively engage with sustainability challenges. The platform enhances engagement and learning outcomes by providing adaptive, hands-on challenges, addressing key barriers such as the following: Lack of engagement in sustainability initiatives, limited hands-on applications for theoretical knowledge, and scarcity of scalable tools for training and innovation across sectors.

Furthermore, *SIB Game* connects users with organizations seeking innovative sustainability solutions, fostering collaboration and real-world impact. This aligns with ongoing research emphasizing the importance of active, experiential learning in driving practical solutions to global challenges.

II. Related Work

The use of gamification and digital platforms for sustainability education has gained traction as a means of bridging the gap between knowledge and practical action [15]. Various initiatives and platforms have been developed to promote sustainability through interactive learning experiences, each with a unique approach to engaging users and integrating educational content.

Sulitest is a recognized online platform designed to assess and promote sustainability literacy [16]. Although it is not a game platform per se, it incorporates gamified elements like a real-time quiz aligned with the SDGs to measure users' knowledge and awareness of sustainability issues to make learning more engaging and interactive. Serving as a hub for various projects—such as *Half the Sky* and *Alba: A Wildlife Adventure*—G4C initiative promotes the use of immersive narratives and interactive experiences to raise awareness of global challenges, although it does not focus exclusively on sustainability education.

Several games have been specifically designed to address different aspects of the SDGs through varied gameplay approaches. *World Rescue* [17] stands out as a comprehensive mobile game that addresses multiple SDGs simultaneously, challenging players to solve interconnected issues of poverty, education, public health, gender equality, and climate action across global contexts. *Minecraft Education Edition* [18] offers a highly immersive and flexible learning environment for younger audiences where educators can design custom game scenarios to explore sustainability issues.

For climate action specifically, *Fate of the World* [19] presents a simulation where players manage a global organization tasked with balancing ecological sustainability against economic development. Similarly, *ECO* [20] takes a different approach by requiring collaborative decision-making among players to build a civilization capable of preventing environmental collapse while stopping an impending meteor strike, providing an interactive virtual environment to explore ecological concepts.

Other games address specific SDGs in depth. *Food Force* [21] simulates humanitarian response to hunger crises while teaching players about sustainable food systems. For economic inequality, *Ayiti: The Cost of Life* [22] offers a simulation of a Haitian family facing intersecting challenges of poverty, health, and education access. Environmental conservation and biodiversity are powerfully represented in *Endling: Extinction is Forever* [9], which positions players as the last fox mother on Earth, creating an emotional connection to the consequences of biodiversity loss.

These games demonstrate the medium's capacity to foster experiential learning about complex global challenges, moving beyond educational content delivery to create systems that players can manipulate, explore, and learn from through direct engagement. The effectiveness of game-based approaches for sustainability education is supported by a growing body of research. Recent studies have examined both the pedagogical foundation and measurable impacts of these interventions. For instance, DeSmet et al. [23] conducted a meta-analysis demonstrating that digital games can effectively promote healthy lifestyles, an outcome that aligns with broader SDG goals related to health and well-being. In parallel, the work by Koivisto and Hamari [24] reviews the rise of motivational information systems and highlights how gamification can drive user engagement and behavior change, which is essential for sustainability initiatives.

The reviewed works exhibit varying degrees of SDG integration, engagement mechanisms, and scalability. In contrast to the previously discussed initiatives, our platform stands out by balancing practical engagement with structured SDG-aligned content, addressing both educational and corporate needs. It empowers users to tackle complex sustainability challenges through interactive, challenge-based learning that incorporates gamification elements such as points, missions, and rewards. The platform supports both individual and team-based engagements, facilitating the development of practical solutions to real-world problems through interactive, challenge-based learning. Its adaptability—including user feedback mechanisms and the potential for AI-driven customization—positions it as a scalable tool for sustainability training across diverse settings. This approach is consistent with research advocating for active, gamified learning strategies [14].

III. Game Platform Overview

Several key challenges—identified through literature on sustainability education, early testing of the board game version, and interviews with educators and organizational partners—guided the design and development of the *SIB Game* platform:

- **Low engagement with sustainability initiatives:** Traditional training methods often fail to motivate employees to adopt sustainable practices, as they are perceived as uninspiring and disconnected from real-life applications.
- **Theory-practice disconnect:** Educational institutions frequently struggle to offer practical opportunities for students to apply theoretical knowledge, hindering the development of critical problem-solving skills.

- **Limited capacity-building tools:** NGOs and governments face a lack of scalable tools to educate and empower teams and communities in sustainability practices.
- **Barriers to innovation:** Social entrepreneurs encounter difficulties in testing, validating, and scaling innovative sustainability solutions due to limited resources and restricted access to real-world experimentation.

The game (Fig. 1) addresses these challenges by leveraging adaptive, personalized learning experiences tailored to diverse user profiles. By integrating features such as dynamic problem-solving scenarios, the platform enhances engagement and promotes deeper learning. Additionally, it fosters collaboration by connecting organizations with participants who co-create and implement innovative solutions to sustainability challenges.

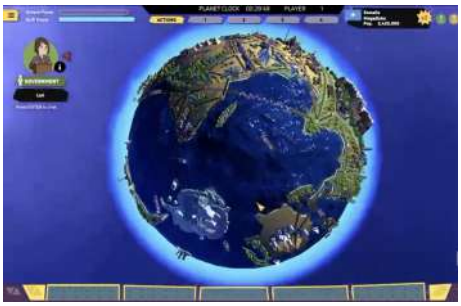


Fig. 1. Game home.

A. Concept Development

The original version was developed as a board game (Fig. 2), serving as the foundation for its digital evolution. This initial physical format allowed for hands-on testing, yielding valuable insights into gameplay mechanics, user engagement, and educational effectiveness. These insights, in turn, informed the development of the digital version. The results demonstrated that the game effectively engaged participants in sustainability training, leading to tangible outcomes in capacity-building and the development of innovative solutions.

B. Artistic Elements and Core Features

Educational content in the *SIB Game* includes over 130 sustainability solutions aligned with the 17 SDGs, 85 cities challenges all over the world, 26 world's news (luck/setback), 8 different players with a different role, co-developed with sustainability experts and educators. Each challenge has several real-world solutions to apply, problem-solving driving, and aligned with the SDG to foster applied learning. In addition to in-game learning, the SIB platform also supports external workshops and training programs designed to facilitate sustainability education in corporate, academic, and community settings. These structured experiences enable facilitators to use the game as part of broader engagement strategies, combining gameplay with real-world dialogue and collaborative planning. This capability positions SIB Game as a hybrid tool for both interactive play and professional development.

The game incorporates various artistic elements to enhance immersion. 3D assets include characters, buildings, rewards, vehicles, informational objects, and board details. 2D elements cover the game board, cards, buttons, achievements, and UI components. SFX provides auditory feedback, attention cues, global event triggers, ambient sound, lobby music, and achievement sounds. VFX enhances the experience with GIFs, particle effects, and virtual feedback. UX design ensures a thematic, intuitive, and accessible interface. Animation brings movement to the board and 3D elements. Typography prioritizes readability, maintaining a clean style with a maximum of two different fonts. The current **SIB Game 1.0**, available in digital format, includes the additional core features:

- **Simplified Interface:** This version provides a basic gamified experience to test critical functionalities, such as user interaction and engagement.
- **SGD-Focused Challenges:** The MVP features challenges that teach players about the SDGs and related global issues. This content was refined through testing with early users of the original board game, ensuring relevance and practical application.
- **Gamified Dynamics:** Players are engaged through a system of points, missions, and rewards. The platform fosters both collaborative and competitive gameplay to maintain interest and motivation.
- **Educational Integration:** The platform incorporates educational content and challenges developed by sustainability experts, emphasizing hands-on learning and the practical application of knowledge.
- **Digital Platform Capabilities:** The web version enables remote access, promoting scalability and player interaction. It supports solo and team play while collecting real-time feedback to continuously refine usability and challenge design.

Beyond these foundational features, *SIB Game* distinguishes itself by providing immersive, problem-solving experiences that encourage players to tackle complex challenges related to socio-environmental issues and health, such as climate change, social justice, and public health crises. The platform connects users with organizations seeking real-world sustainability solutions, fostering collaboration and driving tangible impact. By integrating customizable challenges, team-based learning, and gamified incentives, *SIB Game* offers a scalable and adaptable tool for education, professional training, and global sustainability initiatives.

C. Game Engine and Cloud Infrastructure

We used Unity to develop *SIB Game*, leveraging its advanced graphics engine and visual capabilities to create immersive environments and effects. Unity's cross-platform support allows us to compile our game for various platforms, including Windows, macOS, Linux, WebGL, mobile, PlayStation, and Xbox—with our primary build currently targeting WebGL. Additionally, we integrate Firebase to handle real-time data management, authentication, and analytics, ensuring a robust and scalable backend.

Fig. 2. The original board version of the *SIB Game* game.

The game platform deploys its application and database on Azure, using Azure Database for MySQL to store player data, game states, and other essential information. By leveraging Azure's managed services, *SIB Game* benefits from:

- **High Availability and Scalability:** Azure automatically handles replication and load balancing, allowing *SIB Game* to scale on demand without manual intervention.
- **Built-in Security:** Azure provides enterprise-level security features, including encryption at rest and in transit, as well as role-based access control, to protect sensitive game and user data.
- **Automatic Updates and Maintenance:** With Azure Database for MySQL, routine database management tasks—such as patching, backups, and performance monitoring—are handled automatically, letting the development team focus on game features.
- **Predictable Performance:** The managed service ensures consistent query response times, critical for delivering a seamless gaming experience.

Overall, this setup enables the game to concentrate on creating engaging gameplay while Azure manages the underlying infrastructure.

D. User Roles and Abilities

Each player can assume a specific role with unique abilities, influencing gameplay dynamics and strategic decision-making within the game, as follows:

- **Doctor**
  - **Role/Function:** Acts as the medical expert in the game, responsible for mitigating adverse events.
  - **Unique Ability:** When a setback occurs, a pop-up appears with the message: *"As a Doctor, you have the ability to remove all problems introduced by a setback in your current city. Would you like to use this ability now? (YES/NO)"*. Choosing YES reverses the setback. Bonus for SDGs (3) and (6). Power: Immunity.
- **Startup Founder**
  - **Role/Function:** Embodies innovation and entrepreneurship, representing the creative force behind new ventures.
  - **Unique Ability:** When located in a HUB, an action option called *"TELEPORT"* becomes available, allowing for strategic repositioning. Bonus for SDGs (8) and (9). Power: Super Hub with Teleportation.
- **CEO**
  - **Role/Function:** Oversees company operations and exercises strategic control over favorable events.
  - **Unique Ability:** At the end of their turn, a pop-up is displayed with the message: *"As a CEO, you can replay a lucky event that has already occurred. Would you like to use this ability now? (YES/NO)"*. If YES is selected, the event is triggered again. Bonus for SDGs (12) and (13). Power: Luck.
- **Community Representative**
  - **Role/Function:** Serves as the liaison for the community, maintaining stability across interconnected areas.
  - **Unique Ability:** When a setback affects the community, a pop-up appears with the message: *"You have the ability to remove one problem added by a setback in your city or connected cities. Would you like to use this ability now? (YES/NO)"*. This allows for targeted mitigation of problems. Bonus for SDGs (14) and (15). Power: Influence.
- **University Rector**
  - **Role/Function:** Represents academic leadership, capable of addressing issues beyond their own city.
  - **Unique Ability:** On their turn, if a problem exists in another player's city, a pop-up is shown with the message: *"As a University Rector, you can resolve a problem in another player's city. Would you like to use this ability now? (YES/NO)"*. Selecting YES initiates the problem-solving mechanism for that city. Bonus for SDGs (4) and (10). Power: Incentive.
- **Investor**
  - **Role/Function:** Focuses on financial strategy and influences game dynamics through strategic movement.
  - **Unique Ability:** On their turn, an *"Extra Movement"* option appears in the actions menu. Upon activation, the player is prompted to select another player to

move, and the chosen is moved according to standard game mechanics. Bonus for SDGs (1) and (2). Power: Control.

- **Government Official**
  - **Role/Function:** Holds regulatory authority, tasked with maintaining order by countering setbacks.
  - **Unique Ability:** If a setback occurs during the round, a pop-up is displayed with the message: *"You have the ability to nullify a setback that occurred this round. Would you like to use this ability now? (YES/NO)"*. Choosing YES cancels the setback and reverses its effects. Bonus for SDGs (16), (17), and (7). Power: Cancellation (cancels setbacks and reverses effects).
- **Civil Society Director**
  - **Role/Function:** Embodies civic leadership, driving proactive problem-solving via resource acquisition.
  - **Unique Ability:** When resolving a problem, this character gains a new card specifically tailored to address one of the city's issues, enhancing their capability to tackle future challenges. Bonus for SDGs (5) and (11). Power: Wild Card.

E. Mechanics

The *SIB Game* mechanics assign each city a set of problems based on its internal game system. Each problem is linked to specific SDGs and graded by severity—X_1, X_2, or X_3—depending on the city's population size, with higher populations increasing problem severity. Each city is defined by a set of attributes used as an internal game data structure (e.g., ID, coordinates, population size, SDGs, sprites, connected cities, city flags (e.g., "Allow Hub," "In Deck," "All Solved"), which are used to dynamically manage challenges and enable player interaction.

During gameplay, players perform core actions such as *Move* (travel between connected cities), *Solve* (address city problems using SDG-aligned cards), *Negotiate* (exchange cards with other players), *Pass* (end turn and trigger a global event), and *Build Hub* (establish infrastructure in strategic locations). These actions are central to collaboration and strategy within the game, and a clear understanding of them is essential before encountering advanced mechanics in later stages.

F. Game Data

Player progress and game metrics are saved in a database using JSON messages. When saving progress, the back-end receives data such as the room ID, total problems, discovered and saved cities, and detailed player information (e.g., unique ID, nickname, profession, number of solved problems, moves, built hubs, solved SGD details, mission IDs, and solution IDs). For example, a JSON payload is sent that contains all these elements. Conversely, the back-end responds with a JSON object summarizing each player's performance, including scores for solved problems, participation penalties, built hubs, and mission outcomes. This data exchange ensures that user progress is accurately tracked and updated in real time.

IV. Early Validation

The *SIB Game* platform has undergone preliminary testing of its core features through pilot workshops and prototype use with select users from academic and organizational settings. While this feedback has helped refine the platform's design and educational framing, claims of validation remain limited to functional testing and exploratory case-based engagement.

The game, in its board game and digital formats, has been used by companies, universities, and NGOs to train teams in sustainable practices. These initial interactions offered user impressions and suggestions, informing the refinement of both user interface and challenge framing. Further structured studies are planned to assess educational effectiveness more rigorously. Initial feedback from board game sessions informed the design and refinement of the first digital prototype, which served as a Minimum Viable Product (MVP). Key validation elements included:

- **Early adopters:** From corporate and educational environments have tested the MVP (*SIB Game* 1.0), providing continuous feedback. This input is guiding the development of version 2.0, which will be explored in future work.
- **Clear Value Proposition:** The platform addresses the growing need for sustainability-focused training aligned with Environmental, Social, and Governance (ESG) criteria and the SDGs [25]. By offering a gamified learning experience, the *SIB Game* responds to the increasing demand for interactive and practical employee training solutions.
- **Revenue Model Definition:** The business model includes multiple revenue streams, such as subscriptions, customized consulting services, intellectual property licensing, and commissions. This model supports flexibility and scalability, ensuring recurring revenue opportunities.
- **Scaling Preparation:** Development efforts are focused on transitioning to broaden access both nationally and internationally. By adopting a scalable subscription model and enhancing digital features, the platform will be positioned for growth.
- **Market Testing with Partner Institutions:** Collaborations with strategic partners, including educational institutions and corporate organizations, are underway to evaluate the platform's usability and effectiveness.

V. Validating Mechanics and SDG Integration via Test Cases

To ensure functional integrity and alignment with SDG-based learning goals, we implemented a targeted suite of test cases on the *SIB Game* platform. These validated key features such as login, interface navigation, and core mechanics (*Move*, *Solve*, *Negotiate*, *Pass*, *Build Hub*). All functions performed as expected, supporting usability and reinforcing the educational structure. While the tests confirmed technical reliability,

they did not assess user engagement or learning effectiveness, which would require structured feedback or comparative studies. Identified issues (e.g., movement bugs, UX delays) are informing ongoing improvements. Users performed the following gameplay tasks to validate core mechanics and flow consistency:

TC01 (Login Validation): Testers logged into the game website and successfully reached the initial screen with the PLAY button.

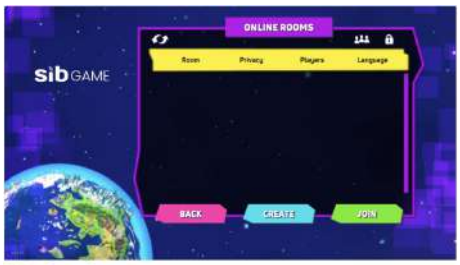
TC02 (Login Persistence): After completing **TC01**, testers restarted the browser. The login page reappeared, confirming secure authentication by preventing session cookie retention.

TC03 (Start Game): Testers verified proper game initialization by ensuring it maximized to the browser window and displayed the Play screen correctly.

TC04 (SDG Solutions Screen): Clicking SDG SOLUTIONS displayed the corresponding table, and clicking BACK was expected to return users to the same screen.

TC05 (Options Screen): Testers adjusted graphics, audio, and language settings, then clicked BACK, confirming all options worked as expected before returning to the Play screen.

TC06 (Create Online Rooms): Testers accessed the Online Rooms screen from two browser sessions, created a room named "TEST," and confirmed its correct appearance and disappearance across both windows.



Online Rooms Screen

Fig. 3. Create online rooms.

TC07 (Create a Single-Person Game): Testers created a room named "Test 01" with one player and 30-minute duration, confirming the SELECT CHARACTER screen was displayed.

Fig. 4. UI for creating a room and selecting a character.

TC08 (Select the Character): Testers chose an avatar (Fig. 5), confirmed their name, and clicked START, progressing through character selection to the Discovered City screen.

Fig. 5. UI for choosing a character.

For in-game interactions, **TC09** (Move Action), **TC10** (Solve Action), **TC11** (Change Card Action), and **TC12** (Pass Action) assessed player moves for alignment with educational goals and game balance.

TC09: Testers selected MOVE from the ACTIONS menu, clicked nearby cities until completing four moves, ending the turn, and revealing the next city with highlighted paths.

Fig. 6. Move screen.

TC10: The user selects SOLVE from the ACTIONS menu (Fig. 7), chooses a city problem, and selects a matching SDG card. The problem is highlighted, cards glow, and a "PROBLEM SOLVED" message appears, updating the SDG panel with one point.

Fig. 7. Solve option.

TC11: Testers used the NEGOTIATE option (Fig. 8) to

swap a card with another player's, with the updated deck reflecting the change.

Fig. 8. Negotiate option.

TC12: The user starts at the Game Screen and clicks the ACTIONS button, then selects the PASS option (Fig. 9). The expected result is a visual effect that zooms out and then zooms in on the planet, followed by the display of the News Around the World screen with the options: Luck or Setback. Once this sequence completes, the Discovered City screen should appear.

Fig. 9. Pass action and News Around the World screens with Luck or Setback options.

Further gameplay depth was evaluated in **TC13** (Create a HUB) and **TC14** (Check Bonus for SDG Solved).

TC13: Testers selected the GOVERNMENT character, moved to a blue-marked city, and chose BUILD HUB from the ACTIONS menu, verifying its correct display.

TC14: Testers selected the PHYSICIAN character and solved a problem in a city linked to SDG (3) or SDG (6). The SDG panel was expected to update with two filled dots, confirming the bonus mechanism.

TC15 (Undo a Setback): Testers using the GOVERNMENT character played until a setback occurred, then moved to the affected city, selected SPECIAL from the ACTIONS menu, and confirmed on the Special Result screen. The SDG panel was expected to reflect the undone setback with an updated SDG status.

All tests passed, verifying that each functionality performed as expected. These test cases confirm authentication, interface navigation, play modes, and core mechanics aligned with SDG learning objectives. This structured validation ensures the game remains engaging and effective in promoting sustainability awareness. In addition to these tests, users identified areas for improvement in the desktop version, including movement issues between territories, lack of feedback when waiting for another player's turn, and the need for more engaging gameplay to foster critical thinking over automatic problem-solving.

VI. User Testimonials

During initial pilot sessions, user feedback highlighted strengths in educational design, thematic engagement, and platform accessibility. While most comments were positive, users also pointed out opportunities for improving interactivity, refining turn-based pacing, and enhancing collaborative gameplay. These statements were shared freely, representing personal perceptions of the experience and the educational potential of the game developed:

Participant A – Sustainability Data Analyst, U.S. University: *"This is an absolutely fantastic learning tool, and the course offered in the game is very engaging!"*

Participant B – Sustainability Analyst, Brazil: *"I was impressed by the SIB Game's approach, which actively supports SDGs and serves as a significant resource for project managers worldwide. It is amazing to see how the platform opens new horizons for education, skill development, and the improvement of living and environmental conditions across diverse regions. The social, environmental, and economic engagement is extraordinary!"*

Participant C – General Postgraduate Advisor, Brazilian University: *"During a professional event organized to showcase the SIB Game it was incredible to witness its potential in developing skills and competencies, as well as its impact on the local community. The SIB Game is a highly effective tool for social and sustainable development."*

These testimonials highlight the game's potential for engagement, practical application, and its contribution to promoting sustainable development, emphasizing its value as both an educational tool and an awareness-raising platform.

VII. Conclusion and Future Work

This paper presented the development and early validation of an innovative Games for Change platform aligned with the SDGs. Designed to engage players in tackling socio-environmental and health challenges, the platform leverages challenge-based learning and gamification to foster critical thinking, collaboration, and behavior change. Beyond gameplay, the platform supports workshops and training programs, engaging diverse stakeholders in addressing global challenges.

The platform has undergone multiple validation stages, including physical, desktop, and web-based iterations. Initial validation confirmed core functionalities, and evaluations with educational institutions and industry partners highlight its potential for academic and corporate training. According to the Technology Readiness Level (TRL) framework, it is currently at TRL 5—Prototype Validation in a Relevant Environment, reflecting significant progress in proof-of-concept development and user feedback integration. These advancements position the platform as a scalable educational tool for sustainability and innovation across key SDG domains.

The platform presents multiple possibilities for future work and research. Potential directions include integrating visibility culling algorithms for smoother rendering [26], applying machine learning for generative art [27], and using decision tree editors to support extensible and customizable gameplay [28]. A VR version with gesture-based control via computer vision is also envisioned [29]–[31]. Additionally, AI-driven customization and solution matchmaking could enhance personalized learning. These and other possibilities position the game as a rich testbed for interdisciplinary research in software engineering, AI, game design, and sustainability education.

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References

[1] K. Squire, *Video Games and Learning: Teaching and Participatory Culture in the Digital Age*. MIT Press, 2011.

[2] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: Defining gamification," in *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*. ACM, 2011, pp. 9–15.

[3] J. Hamari, J. Koivisto, and H. Sarsa, "Does gamification work?—a literature review of empirical studies on gamification," in *2014 47th Hawaii International Conference on System Sciences (HICSS)*. IEEE, 2014, pp. 3025–3034.

[4] K. S. Fjællingsdal and C. A. Klöckner, "Games for change: A systematic review of studies on social impact games," *Psychology of Popular Media*, vol. 11, no. 1, p. 54, 2022.

[5] G. for Change Organization, "Games for change: Empowering game creators & social innovators," 2024. [Online]. Available: https://www.gamesforchange.org/

[6] J. Doe and J. Smith, "The role of games in social change communication," *SSRN Electronic Journal*, 2023. [Online]. Available: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4401202

[7] Frima Studio, "Half the Sky Movement: The Game," 2013. [Online]. Available: https://www.gamesforchange.org/game/half-the-sky-movement-the-game/

[8] Ustwo Games, "Alba: A Wildlife Adventure," 2020, winner of the Games for Change Award for Most Significant Impact, 2021. [Online]. Available: https://www.ustwogames.co.uk/games/alba/

[9] Herobeat Studios, "Endling: Extinction is Forever," 2022. [Online]. Available: https://endling.es/

[10] M. Prensky, *Digital Game-Based Learning*. McGraw-Hill, 2001.

[11] L. A. Annetta, "Video games in education: Why they should be used and how they are being integrated into curricula," *Theory into Practice*, vol. 47, no. 3, pp. 229–239, 2008.

[12] L. Tikly and A. M. Barrett, "Implementing education for sustainable development: A review of progress, barriers and opportunities," *International Journal of Educational Development*, vol. 97, p. 102694, 2023.

[13] UNESCO, *Global Education Monitoring Report 2023: Technology in Education: A Tool on Whose Terms?* Paris: UNESCO Publishing, 2023. [Online]. Available: https://unesdoc.unesco.org/ark:/48223/pf0000384641

[14] M. Quintero-Angel, A. A. Duque-Nivia, and C. A. Molina-Gómez, "A teaching strategy based on active learning which promotes strong sustainability that empowers students to have a different type of relationship with the environment," *Environ. Education Research*, pp. 560–579, 2023.

[15] T. Connolly, E. Boyle, and E. MacArthur, "A systematic review of gamification for sustainability education," *Sustainability*, vol. 15, no. 2, p. 1458, 2023.

[16] Sulitest Organization, "Sulitest: Measuring Sustainability Literacy Worldwide," 2022. [Online]. Available: https://www.sulitest.org

[17] UNESCO MGIEP and ZU Digital, "World Rescue," 2017. [Online]. Available: https://mgiep.unesco.org/world-rescue

[18] Mojang Studios and Microsoft, "Minecraft: Education Edition," 2016. [Online]. Available: https://education.minecraft.net/

[19] Red Redemption, "Fate of the World," 2011. [Online]. Available: http://www.soothsayergames.com/

[20] Strange Loop Games, "ECO," 2018. [Online]. Available: https://play.eco/

[21] UN World Food Programme, "Food Force," 2005. [Online]. Available: https://www.wfp.org/

[22] Global Kids and GameLab, "Ayiti: The Cost of Life," 2006. [Online]. Available: https://ayiti.globalkids.org/

[23] A. DeSmet, I. De Bourdeaudhuij, C. Vandelanotte, W. Tang, J. Opdenacker, J. Brug, and G. Crombez, "A meta-analysis of serious digital games for healthy lifestyle promotion," *Preventive Medicine*, vol. 69, pp. 95–107, 2015.

[24] J. Koivisto and J. Hamari, "The rise of motivational information systems: A review of gamification research," *International Journal of Information Management*, vol. 45, pp. 191–210, 2019.

[25] B. Karatzoglou and J. Wu, "Education for sustainable development: Integrating ESG criteria and SDGs into higher education and professional training," *International Journal of Sustainability in Higher Education*, vol. 24, no. 8, pp. 1612–1631, 2023.

[26] Serpa, Yvens R. and Rodrigues, M.A.F., "A draw call-oriented approach for visibility of static and dynamic scenes with large number of triangles," *The Visual Computer*, vol. 35, pp. 549–563, 2019.

[27] Serpa, Ygor R. and Rodrigues, M.A.F., "Human and machine collaboration for painting game assets with deep learning," *Entertainment Computing*, vol. 43, p. 100497, 2022.

[28] R. G. Barbosa and M. A. F. Rodrigues, "An interchangeable editor to create generic and adaptable decision trees for versatile applications and game development scenarios," *Entertainment Computing*, vol. 52, p. 100864, 2025.

[29] J. H. Fonteles, Y. R. Serpa, R. G. Barbosa, M. A. F. Rodrigues, and M. S. P. L. Alves, "Gesture-controlled interactive musical game to practice hand therapy exercises and learn rhythm and melodic structures," in *2018 IEEE 6th International Conference on Serious Games and Applications for Health (SeGAH)*, 2018, pp. 1–8.

[30] É. S. Silva and M. A. F. Rodrigues, "Design and evaluation of a gesture-controlled system for interactive manipulation of medical images and 3d models," *Journal on Interactive Systems*, vol. 5, no. 3, 2014.

[31] M. A. F. Rodrigues, D. V. Macedo, H. P. Pontes, Y. R. Serpa, and Y. R. Serpa, "A serious game to improve posture and spinal health while having fun," in *2016 IEEE International Conference on Serious Games and Applications for Health (SeGAH)*. IEEE, 2016, pp. 1–8.