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SAMUDERA®: A SIMULATION BLUEPRINT FOR SUSTAINABILITY ACTION-EXPERIENTIAL LEARNING ACROSS DISCIPLINES

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ABSTRACT

Simulation games are increasingly recognised as versatile tools for promoting sustainability education across disciplines. This paper reviews SAMUDERA®, a sustainability simulation game adapted from the Fish Banks game by the System Dynamics Society, tailored to local Malaysian contexts. SAMUDERA® has been implemented with university students, government agencies, private companies, and community groups. This paper discusses its development, integration with action-experiential learning pedagogy, and application across diverse fields. It also reflects on the simulation's challenges, strengths, and potential to enhance decision-making and sustainability practices. Insights into the game highlight the importance of strategic preparation by facilitators, including the use of engaging physical setups and clear instructions. The paper also highlights the significance of collaboration, active participation, and post-game discussions in achieving impactful learning outcomes and catalysing behaviour change. Furthermore, the study reflects on SAMUDERA®'s adaptability across management, business, policymaking, social sciences, and fisheries education. Future directions for improving the simulation's content include exploring advanced topics like climate change impacts, fisheries certification, and the role of marine protected areas. Overall, SAMUDERA® demonstrates its potential as an effective educational tool for sustainability education across disciplines and diverse participant groups.

Keywords: *SAMUDERA®, sustainability, simulation, game, action-experiential learning*

INTRODUCTION

This paper is positioned at the intersection of five selected synergistic elements that have assisted the achievement of learning outcomes and the action orientation associated with sustainability education, both in academic and non-academic settings. The synergistic elements in the discussion are: (i) the active, experiential, project-based and problem-based learning, or branded as the Action-Experiential Learning (AxL) by the researcher; (ii) system thinking and system dynamics inspired by the Massachusetts Institute of Technology (MIT) Sloan School of Management's System Dynamics Group (MIT Sloan School of Management, n.d.); and (iii) the System Dynamics Society's Fish Banks game. These elements are aligned to simulate real-life management, operational and leadership and decision-based critical situations involving (iv) resource management and (v) sustainability initiatives.

This study reflects the researcher's experiences running the sustainability action-education course, SAMUDERA®, designed to simulate real-life management, operational, and leadership challenges involving sustainability initiatives. It details the learning outcomes, preparation, adaptation, and development of the simulation, along with the physical and digital setups, participant experiences, feedback, and overall successes of the programme. The importance of experiential learning, systems thinking, and sustainability initiatives in shaping participants' decision-making, critical thinking, and problem-solving skills is highlighted. Incorporating these elements into sustainability education programmes can lead to more action-oriented and effective outcomes.

Sustainability in Action-Education

Sustainability in action education emphasises hands-on, experiential learning, encouraging students and

course participants to actively design and implement sustainable solutions in their roles, workplace, future and communities. This education style can take many forms, such as hybrid, active, experiential, problem-based and/or project-based learning. Additionally, sustainability in action education is an important approach to teaching, training, and facilitating knowledge, concepts, and theories on sustainability. It involves active involvement through role-play, simulation, game, case study, presentation or even real-life consultation. It allows students and participants to understand the interconnectedness of social, economic, and environmental systems and develop the skills and knowledge needed to address these challenges.

Existing literature has a plethora of systematic reviews and evidence of the importance of sustainability education through active, experiential and simulated learning. The study "The Sustainability Manager: A Tool for Education and Training on Sustainability Management" by Baumgartner and Winter (2014) explored the use of a sustainability manager tool as an effective means of educating and training individuals on sustainability management. Their sustainability manager tool is a computer-based simulation tool that allows users to simulate and manage various sustainability scenarios within a virtual company. The tool is designed to be used in education and training settings to teach students and professionals about sustainability management concepts, including resource management, energy efficiency, and waste reduction. They argued that the sustainability manager tool provides a valuable learning experience because it allows users to experiment with different sustainability strategies and see the results of their decisions in a safe, risk-free environment. This type of hands-on, experiential learning is particularly effective in engaging learners and helping them develop a deep understanding of sustainability management principles. Overall, the article highlights the potential of the sustainability manager tool as an innovative and effective approach to sustainability education and training.

By providing a realistic, interactive learning experience, the tool can help learners develop the knowledge and skills needed to create a more sustainable future. Similar arguments were made by Dahlin et al. (2015) in their paper "Critical Evaluation of Simulations and Games as Tools for Expanding Student Perspectives on Sustainability". The team evaluated the effectiveness of simulations and games as tools for expanding student perspectives on sustainability. Their paper argued that sustainability education requires a multidisciplinary, interdisciplinary approach incorporating experiential learning, critical thinking, and problem-solving skills. They provided an overview of various simulations and games that have been used in sustainability education, including the Ecological Footprint Game, the Fish Banks Game, and the World Climate Simulation, and the paper identified key challenges in using simulations and games for sustainability education, such as limited access to technology, cultural and linguistic barriers, and the need for long-term and systemic change. Their analysis suggested that the effective use of simulations and games requires careful consideration of the learning objectives, target audience, and assessment methods.

A more direct game-based approach also exists, like what Emblen-Perry (2017) promoted in "Promoting Education for Sustainability Through Game-Based Learning: Using the Sustainable Strategies Game to Improve Students' Knowledge and Skills of Sustainable Business Practices". Emblen-Perry argued that game-based learning can effectively overcome these challenges, as it engages students in a fun and interactive way and provides them with opportunities to apply sustainability concepts in a realistic and practical context. The paper describes a finding that students who played the Sustainable Strategies Game (SSG) showed significant improvements in their knowledge and skills of sustainable business practices. Therefore, it is suggested that game-based learning can be an effective tool for promoting education for sustainability. This claim by Emblen-Perry can be supported by experimental studies run by Jääskä et al. (2021), who explored the use of game-based learning in project sustainability management education. The paper developed a simulation game called the Project Sustainability Management Game (PSMG), which was designed to teach students about project sustainability management practices and evaluate the PSMG's effectiveness in improving students' understanding and application of sustainable practices in project management. Their experimental study grouped 80 students into two groups: a game-based learning group and a traditional lecture-based learning group. Both groups received the same course material, but the game-based learning group played the PSMG while the

other did not. The results of the full-scale study showed that the game-based learning group performed significantly better than the lecture-based learning group in terms of their understanding and application of sustainable practices in project management.

Extensive evidence supports action-based education and game-based learning toward sustainable teaching and learning. Another study by Koenigstein et al. (2020) proposed a game-based education approach to promote sustainable ocean development. Much like Jääskä et al. (2021), Koenigstein et al. argued that traditional education methods are often insufficient and that experiential learning through games can offer a more effective and engaging approach. The author developed a board game focusing on sustainable ocean development, including topics related to renewable energy, shipping, and fisheries management. The game is designed for university students, professionals, and policymakers. The paper found that the game-based approach improved students' knowledge and understanding of sustainable ocean development and their critical thinking, decision-making, and collaboration skills. Students reported high levels of engagement and enjoyment with the game, and many expressed a desire to play similar games in the future. More significant than just efficient learning and high engagement, gamification and active learning in sustainability can promote behavioural change and, in the long run, help with a sustainable mindset, culture and lifestyle. This notion is argued by a recent study by Rao et al. (2022) and by older literature (Kibert et al., 2011). Rao and friends made a bold argument that gamification has the potential to enhance the effectiveness of ESD and encourage students to become active agents of change towards sustainability. This and more literature substantiate the current paper that among the ways for efficient and impactful sustainability education, training and/or teaching-learning is through action-education, which includes action-experiential learning such as simulations, games, and role plays.

Action-Experiential AxL Pedagogy

Action-Experiential Learning (AxL) is an educational approach that goes beyond classroom theory and involves students in fieldwork and the practical application of tools and frameworks. This student-centred approach is based on inquiry, problem-solving, and project-based learning. AxL aims to develop real-world technical and social skills, including complex problem-solving, evidence-based management, effective communication, and cooperative work. It is designed to prepare students to face the challenges of real business settings by engaging them in short- or long-term projects, internships, simulations, field visits, case studies, and other live projects. Additionally, AxL aims to engage students in real-world situations that require critical thinking, collaboration, and decision-making and provides them with opportunities to reflect on their experiences and identify areas for improvement. This pedagogy is often used in sustainability education, where students are encouraged to explore complex environmental, social, and economic issues and to develop strategies for addressing them (Sharma, 2017). Sharma argued the importance of integrating experiential learning into management education to promote sustainability and prepare students for careers in a rapidly changing world. AxL pedagogy integrates diverse teaching methods such as case studies, simulations, games, field trips and service-learning projects and strongly emphasises experiential learning or learning by doing.

This approach is particularly relevant for responsible management education, emphasising sustainability issues. Several studies have shown that AxL increases students' interest and perceived relevance of the course materials and prepares them to apply various subject matters to professional practice (Salinas-Navarro et al., 2022; Rao et al., 2022). The researcher developed AxL for sustainability education as an approach to education for sustainable contexts that emphasises hands-on, experiential learning through simulated sustainability scenarios. These scenarios involve complex sustainability challenges, such as resource management or sustainable supply chain management, and require participants to take on the role of decision-makers in a realistic setting. Through playing the AxL simulation game SAMUDERA®, participants can develop their critical thinking and problem-solving skills while also gaining a deeper understanding of the interconnectedness of social, economic, and environmental systems. Additionally, action-based learning in sustainability simulation games can foster collaboration and teamwork among participants to address sustainability challenges and develop sustainable solutions. This AxL is not a stand-alone approach, but rather, it involves the integration of applied modules with project-based coursework, course readings and references, classes, fieldwork,

live consulting projects, interdisciplinary inputs, social and corporate responsibility angles, structured experience and reflection, stakeholder and expectation management, assessment of project outputs, and converging global vision to local actions.

The MIT-Inspired System Dynamics Board Game

The MIT System Dynamics Fish Banks is a simulation game that teaches players about the challenges of managing resources, especially in the midst of competition, survival and self-interest. The game was designed to demonstrate the principles of system dynamics, which is the study of how complex systems change over time. In the Fish Banks game, players manage a fishery and try to balance the needs of the fish population with the needs of the fishing industry (Morris, 2012). The game is based on a model developed by the System Dynamics Group at MIT's Sloan School of Management, and it has been used in classrooms and workshops around the world to teach about sustainability, environmental management, and systems thinking. The game lets players simulate running their own fishing companies. In this game, players take on the roles of captains and crew members and compete against other fishing companies.

At the beginning of the game, all fishing companies have equal resources, including cash, fishing boats, and technology. Throughout the game, players must strategise about purchasing and selling ships, choosing fishing locations, and managing fleets without depleting fish stocks, all while competing against neighbouring teams (System Dynamics Society, n.d.). The game aims to provide participants with an experiential learning experience, teaching them about the careful and efficient use of natural resources. Participants must manage a fleet of fishing boats, decide where to fish (deep sea or coastal waters), and buy or sell boats to maintain profitability and ensure the longevity of their fishing enterprise (Ruiz-Pérez et al., 2023). The game takes place in an uncertain environment, where weather, fish catch, and competitors' decisions can vary from year to year. Fish Banks has multiple learning objectives, including providing historical data on fisheries worldwide and demonstrating the interactions involved in real-world systems. The game is followed by a debriefing that includes a causal loop diagram, which captures the main interactions in the game and relates them to the real-world system on which the game is based. This debriefing leads to a discussion of sustainability and Hardin's (1968) "Tragedy of the Commons".

The research team took on the learning, objectives, intended outcomes, pedagogy, vision and simulated environment of the Fish Banks game. It adapted each inspiration into its own version of Sustainability simulation, fishery and ocean-based SAMUDERA®.

The Tragedy of the Commons and Sustainability Education

The "Tragedy of the Commons," a concept introduced by Hardin (1968), describes how individuals acting in their own self-interest can overexploit shared resources, leading to long-term collective loss. This results in a "tragedy" because the resource becomes scarce or extinct, ultimately harming everyone who depends on it. The concept of "The Tragedy of the Commons" is often used in sustainability education to teach the importance of managing shared resources responsibly. Fish Banks, the board game described earlier, is one example of a sustainability education tool that incorporates this concept. By playing the game, participants experience the challenges of managing a shared resource in a competitive environment and learn about the importance of sustainable practices.

Sustainability education focuses on educating people about the need to live in a way that preserves the earth's resources for future generations. This type of education covers various topics, including environmental science, conservation, and sustainable development. Sustainability education aims to promote an understanding of the interconnectedness of social, economic, and environmental systems and equip people with the knowledge and skills to create a more sustainable future. The Tragedy of the Commons is one important concept within sustainability education, as it highlights the consequences of unsustainable resource use and the need for collective action to manage shared resources. Achieving sustainable economic growth requires a fundamental shift in business practices, such as reducing waste and pollution, investing in renewable energy sources, and prioritising stakeholder interests over shareholder interests. More importantly, there is an emphasis on the significance of government regulation, collective action, and international cooperation in promoting sustainable economic growth. Garrity's (2012)

"Tragedy of the Commons, Business Growth and the Fundamental Sustainability Problem" examines the relationship between "The Tragedy of the Commons" and the challenge of achieving sustainable economic growth. In the context of business growth, it is argued that "The Tragedy of the Commons" can manifest in the overuse of natural resources and the degradation of the environment. Garrity proposes that a new economic paradigm is needed, likely through an educational lens, one that prioritises sustainable development and recognises the finite nature of natural resources. He suggests that this new paradigm must involve a shift away from a consumption-based economy and towards a regenerative, circular economy that values natural capital and promotes social and environmental well-being.

In support of the game-based sustainability education to highlight the gravity of "The Tragedy of the Commons", is Morris' (2012) article, "The Tragedy of the Commons Fishing Game," which explores the use of the Fish Banks game in teaching the concept. Morris describes how the game can be used in educational settings to teach students about "The Tragedy of the Commons" and related concepts such as sustainability, resource management, and regulation. The game provides a hands-on, interactive way for students to experience the consequences of unregulated resource use and explore potential solutions. Morris suggests that the game can be adapted to different contexts and used to teach various age groups and subject areas. The article also notes that the game can be modified to include more complex variables, such as the introduction of external factors like weather or changes in market demand for fish, with which the current paper aligns. Overall, Morris' article demonstrates the value of game-based approaches for teaching complex concepts such as "The Tragedy of the Commons" and provides a practical tool for educators to engage students in learning about sustainable resource management.

SAMUDERA®, THE ACTION-EXPERIENTIAL LEARNING IN SUSTAINABILITY EDUCATION

After being conducted close to 30 times with different groups of participants, the principles of the Fish Banks Game from the Systems Dynamics Society were adapted to create a unique learning experience called SAMUDERA called SAMUDERA®. While rooted in the same foundational concepts, SAMUDERA® integrates local context and real-world relevance to deepen participants' engagement and understanding. The game was designed with various props to simulate the complexities of real-life fisheries while being adaptable to other fields such as management, policy-making, business, and social sciences. We incorporated actual case studies from local fisheries to ensure the scenarios were realistic and directly applicable to the participants' communities. This hands-on approach allowed players to experience the challenges and decisions faced by local fishers more tangibly, promoting a comprehensive understanding of resource management and sustainability issues beyond fisheries alone.

SAMUDERA® closely follows the structure of the Fish Banks Game, utilising a simulation-based format to engage participants in the intricacies of fishery management. However, what sets SAMUDERA® apart is its deep integration with local realities and potential applicability across disciplines. We incorporated a range of props designed to simulate various aspects of a fishery environment, as exhibited in Figure 1. These props were carefully chosen to reflect local fisheries' physical and operational elements, enhancing the realism of the scenarios presented during the game. One of the key features of SAMUDERA® was the inclusion of a printed map showcasing the actual fishery shores along the east coast of Malaysia. This map provided a geographical context to the game, helping participants to visualise the specific areas they were discussing and strategising about. It served as both a reference and a tool for decision-making, grounding the game's scenarios in real-life locations and issues.

This map was a decorative and functional tool that played a crucial role in the gameplay. Participants used the map to navigate different regions of the fishery, make strategic decisions, and visualise the impact of their choices on various geographical areas. This added a layer of authenticity to the game, making the scenarios more relatable and engaging. By blending these elements: dynamic game mechanics, local case studies, and geographic relevance, SAMUDERA® aimed to offer an immersive and educational experience. This approach enhanced participants' understanding of sustainability issues, fostered a deeper connection to their local environment, and encouraged critical

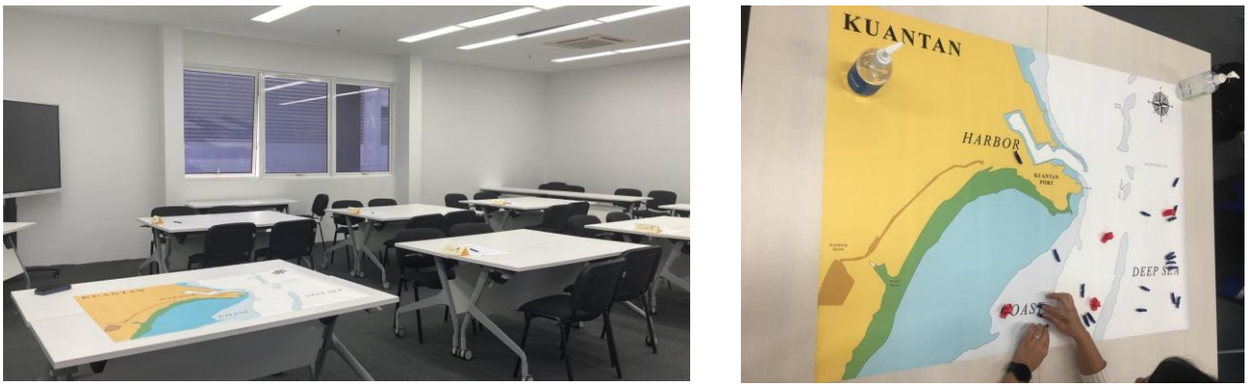


Figure 1 SAMUDERA®'s localised map of the Malaysian setting

thinking, which can be applied to other areas such as business and policy-making.

Additionally, to ground the game in a real-world context, local case studies were incorporated to highlight specific challenges and dynamics faced by fisheries on the east coast of Malaysia. As shown in Figure 2, these case studies were selected to illustrate various issues, from overfishing and resource management to the socio-economic impacts on fishing communities. By incorporating these real-life examples, the activity was designed to provide participants with a nuanced understanding of the issues at hand and to encourage critical thinking about potential solutions.

Through the use of these local props, case studies, and geographic references, SAMUDERA® provided an action-experiential learning environment. Participants

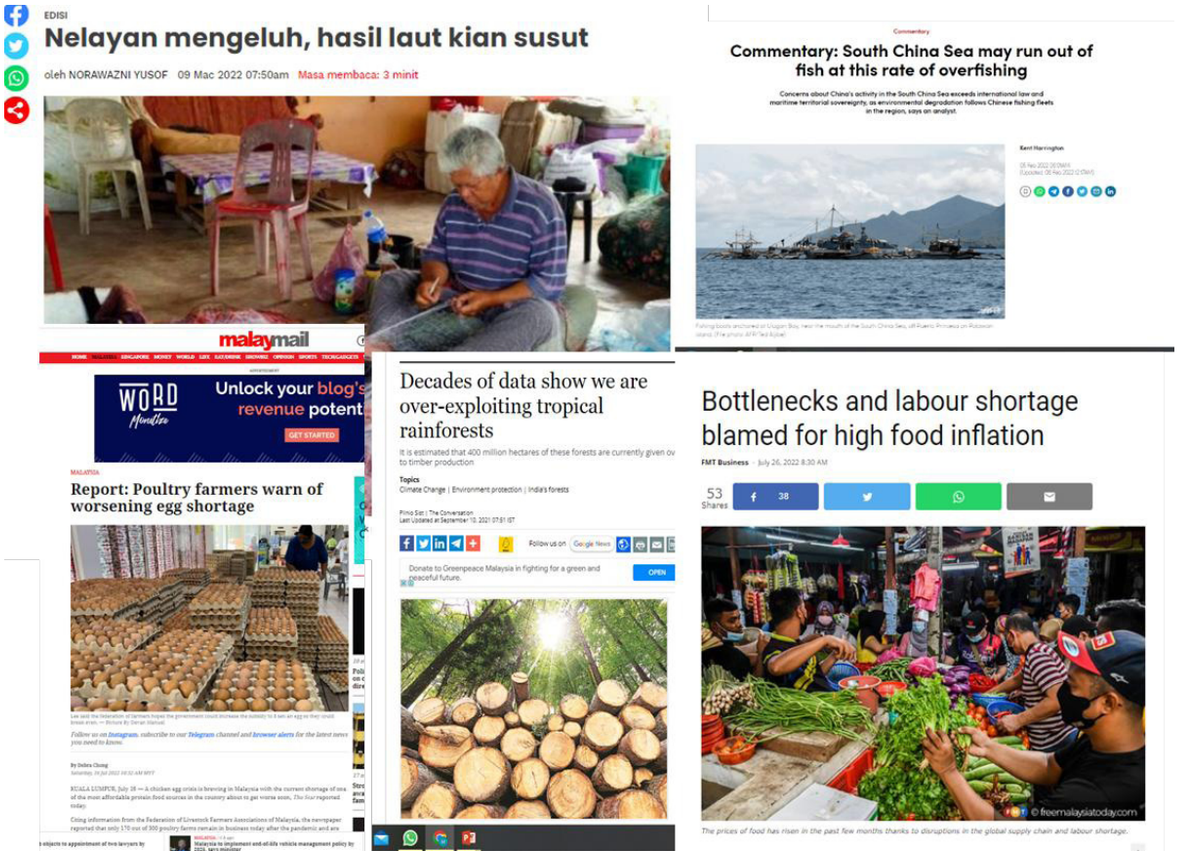


Figure 2 Selected SAMUDERA®'s localised case studies on sustainability, resource management and economic disparity

were not merely observers; they actively engaged with the game's dynamics, making decisions, facing consequences, and reflecting on their actions. This immersive approach deepened their understanding of sustainability issues and fostered a stronger connection to their local environment. In essence, SAMUDERA® was designed to bridge the gap between theoretical knowledge and practical application. The initiative aimed to create an educational and impactful learning experience by aligning the game's elements with local realities, equipping participants with the skills and insights needed to address sustainability challenges in their communities and other fields.

Pre-Simulation Briefing

Before diving into SAMUDERA®, participants were given a comprehensive pre-simulation briefing designed to set the stage for an effective and engaging learning experience. This briefing was crucial for ensuring that everyone understood the objectives, rules, and context of the game. The overarching goals of SAMUDERA® were introduced, emphasising its focus on sustainability and the management of fisheries while also highlighting its relevance to broader fields such as management, policy-making, and social sciences. As illustrated in Figure 3, participants were provided background information on the local fisheries, including key issues such as overfishing, resource depletion, and the socio-economic impact on coastal communities. This context was essential for helping participants appreciate the real-world relevance of the simulation and its applicability across disciplines.

The structure of the game was also explained, outlining how the different phases would unfold. This involved a thorough walkthrough of the game mechanics, roles, and responsibilities. Participants were given an overview of the props, maps, and case studies they would interact with, ensuring they were familiar with all the materials before the game began, as illustrated in Figure 4. The use of a printed map showing the east coast of Malaysia and case studies featuring local fisheries provided a more comprehensive grounding in real-world scenarios, enhancing participants' understanding of sustainability challenges and encouraging them to think critically about their decisions. To create a productive learning environment, expectations for participation and collaboration were clearly set. Emphasis was placed on teamwork, critical thinking, and reflective discussion. Participants were encouraged to approach the simulation with an open mind and a willingness to explore the complexities of fishery management, which could also be applied to similar challenges in other fields. Finally, we addressed any questions or concerns from the participants, ensuring that everyone felt prepared and confident before starting the simulation. This pre-simulation briefing was designed to maximise engagement and learning outcomes, laying a solid foundation for the game experience and promoting an inclusive, multi-disciplinary approach to sustainability education.

The Game

The core of SAMUDERA® centred around an interactive simulation where participants took on the roles of





Figure 3 Participants in groups playing SAMUDERA®

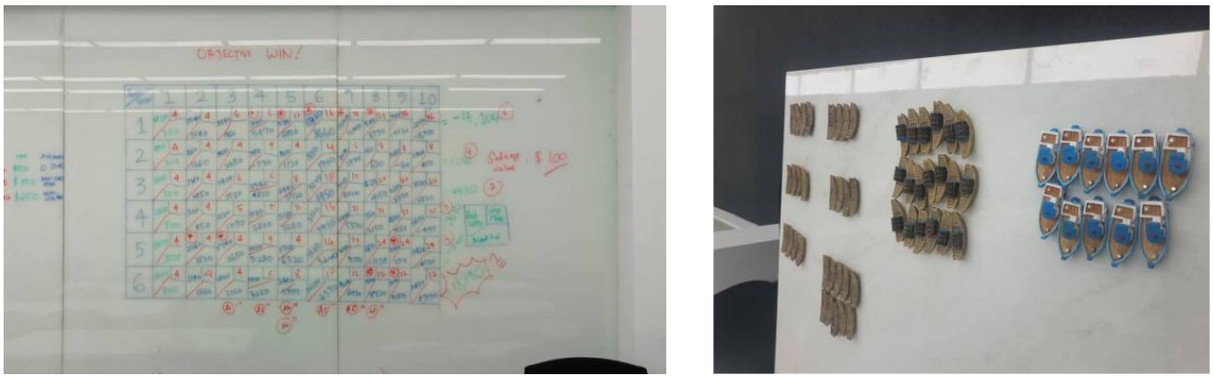


Figure 4 Props used in SAMUDERA®

stakeholders in a fishery management system. Each group was assigned a specific role, such as fishermen, policymakers, or environmentalists, and tasked with making decisions that would impact the sustainability of the fishery. The game utilised a range of props and materials to create an immersive environment. Participants used the printed map of the east coast of Malaysia to navigate different regions, make strategic choices, and visualise the consequences of their actions. This map was essential for helping participants understand the geographical and ecological dynamics of the fishery, providing context that deepened their grasp of sustainability challenges applicable to other fields such as business, policy-making, and social sciences.

As the game progressed, participants faced a series of scenarios and challenges based on real-life case studies. These scenarios were crafted to simulate the pressures and trade-offs involved in managing fishery resources, emphasising the balance between economic gains and environmental preservation. Participants had to adapt their strategies in response to changing conditions, reinforcing the importance of flexible decision-making and critical thinking. The gameplay was facilitated by a series of structured phases, including decision-making periods, reflection sessions, and feedback rounds. This approach enabled participants to experience the iterative nature of decision-making and see the immediate effects of their choices on the fishery ecosystem and community. Throughout the game, participants engaged in discussions, negotiated with other stakeholders, and made strategic decisions aimed at achieving sustainable outcomes. This dynamic format provided a hands-on learning experience that highlighted the complexities and interdependencies within fishery management, reinforcing the value of collaboration and engagement in addressing sustainability issues.

Post-Game Briefing

Following the conclusion of SAMUDERA®, a post-game briefing was conducted to reflect on the experience and consolidate learning outcomes. This debriefing session was crucial for helping participants connect their game experience with real-world applications and insights. We began by facilitating a group discussion where participants shared their experiences, observations, and reflections on the simulation. This discussion provided an opportunity to explore the key lessons learned and identify insights related to sustainability and resource management that extend to various disciplines, such as policy-making and business.

The facilitator then guided participants through a structured analysis of the game's scenarios and outcomes. We reviewed the decisions made, the challenges faced, and the impacts observed, helping participants understand the broader implications of their choices. This analysis was supported by feedback from the facilitators, who added context and perspectives based on the game's design, objectives, and real-world parallels. Participants were encouraged to reflect on how the lessons learned from the simulation could be applied to real-life situations. This included discussing strategies for addressing sustainability challenges within their communities and exploring how they could influence policy or practice in their respective fields. Participants were provided with resources and further reading materials related to fishery management, sustainability practices, and cross-disciplinary applications to conclude the post-game

briefing. This was intended to support their continued learning and engagement with the topic beyond the simulation. Overall, the post-game briefing was designed to reinforce the educational value of SAMUDERA®, ensuring that participants left with a deeper understanding of sustainability issues and practical insights applicable to their professional and personal contexts.

CONCLUSION

SAMUDERA® embodies the essence of AxL, advancing sustainability education. Inspired by the Fish Banks Game, SAMUDERA® has integrated local case studies and maps of Malaysia's east coast fisheries, making its simulation relevant and impactful across disciplines, including management, policy-making, and social sciences. SAMUDERA® employs The Tragedy of the Commons to illustrate the conflict between individual and collective interests in resource management, fostering critical thinking about sustainability. Pre-simulation briefings prepare participants for the complexities of fisheries management, ensuring they approach the game with clarity. Gameplay involves resource management challenges, balancing sustainability goals and economic pressures. Props and localised scenarios enrich the learning experience, presenting realistic environmental and economic conditions. Post-game briefings allow participants to reflect on strategies, enhancing theoretical insights with practical knowledge. SAMUDERA® demonstrates AxL's effectiveness in educational, professional, and business settings, engaging participants in decision-making and critical thinking. The game's future potential includes incorporating topics like climate change, marine protected areas, and fisheries certification and expanding to include diverse stakeholder roles and interdisciplinary scenarios. Continuous developments will bridge the gap between theory and practice, equipping participants with practical skills for real-world application. Overall, SAMUDERA® is a transformative educational tool that enriches learning through experiential methods, preparing participants to tackle sustainability challenges competently.

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