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A model for integrating microgames in teaching primary education for sustainable development

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Abstract

Purpose – The purpose of this study is to propose a model for integrating microgames in teaching primary Education for Sustainable Development (ESD) and illustrate the application of the proposed model in teaching integrated mathematics, arts, technology and language in primary ESD.

Design/methodology/approach – The model was based on conceptual mapping from the reviewed literature and reflection from their teaching experience.

Findings – The model and the related teaching-learning activities have been proposed.

Originality/value – The proposed model enhances the use of microgames in an interdisciplinary teaching framework.

Keywords Microgames, Education for sustainable development, STEAM education, Project-based learning, Model for integrating microgames

Paper type Research paper

1. Introduction

Microgames are becoming popular teaching resources for facilitating learners' engagement as they develop skills, knowledge and attitude for dealing with complex problems. As Lukosch *et al.* (2016, p. 347) state "… by providing engaging learning experiences, simulation games can support the whole learning process, because they provide a situation where the learner can directly acquire new knowledge and skills." Moreover, studies have revealed that mathematics (Rahmadi *et al.*, 2022; Wijaya *et al.*, 2022) and language (Seidler, 2021) are among the subjects whose teaching and learning could benefit from the use of microgames in the classroom. Therefore, this call for educators to consider microgames as one of the useful teaching resources.

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However, teachers need to know how to use microgames to transform their teaching practices. In this study, the focus is on using microgames within an Education for Sustainable Development (ESD) framework to create a learning environment for learners to engage in exploring, understanding and developing solutions for sustainability issues using skills from different disciplines.

In the pursuit of a sustainable world, the ESD approach has been introduced to all levels of education globally. The ESD defines a number of Goals and Consequences: The overall goal of ESD is to develop learners' ability to understand and act on issues that threaten sustainability (interconnectivity among social, economic and environment) through adopting learner-centered, action-oriented and interdisciplinary teaching approaches (UNESCO, 2017a, b, 2020). The main sustainability issues to be addressed in the classroom are those related to 17 Goals, namely, GOAL 1: No Poverty, GOAL 2: Zero Hunger, GOAL 3: Good Health and Well-being, GOAL 4: Quality Education, GOAL 5: Gender Equality, GOAL 6: Clean Water and Sanitation, GOAL 7: Affordable and Clean Energy, GOAL 8: Decent Work and Economic Growth, GOAL 9: Industry, Innovation and Infrastructure, GOAL 10: Reduced Inequality, GOAL 11: Sustainable Cities and Communities, GOAL 12: Responsible Consumption and Production, GOAL 13: Climate Action, GOAL 14: Life, Below Water, GOAL 15: Life on Land, GOAL 16: Peace and Justice Strong Institutions and GOAL 17: Partnerships to Achieve the Goal (UNESCO, 2017a). The ESD framework outlines six key competencies that learners should develop:

(1) Systems thinking competency: the abilities to recognize and understand relationships; to analyze complex systems; to think of how systems are embedded within different domains and different scales; and to deal with uncertainty.

(2) Anticipatory competency: the ability to understand and evaluate multiple futures – possible, probable and desirable; to create one's own visions for the future; to apply the precautionary principle; to assess the consequences of actions; and to deal with risks and changes.

(3) Normative competency: the ability to understand and reflect on the norms and values that underlie one's actions; and to negotiate sustainability values, principles, goals and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions.

Strategic competency: the ability to collectively develop and implement innovative actions that further sustainability at the local level and further afield.

(4) Collaboration competency: the abilities to learn from others; to understand and respect the needs, perspectives and actions of others (empathy); to understand, relate to and be sensitive to others (empathic leadership); to deal with conflicts in a group, and to facilitate collaborative and participatory problem-solving.

(5) Critical thinking competency: the ability to question norms, practices and opinions; to reflect on one's values, perceptions and actions; and to take a position in the sustainability discourse.

Self-awareness competency: the ability to reflect on one's own role in the local community and (global) society; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

(6) Integrated problem-solving competency: the overarching ability to apply different problem-solving frameworks to complex sustainability problems and develop viable,

inclusive and equitable solution options that promote sustainable development, integrating the above-mentioned competencies (UNESCO, 2017a, p. 10).

Despite the potential of microgames to facilitate ESD, teachers rarely integrate microgames in implementing ESD, as they lack knowledge and skills. Therefore, in the present study, we propose a model for integrating microgames in teaching primary ESD and illustrate the application of the proposed model in teaching integrated mathematics, arts, technology and language in primary ESD.

We have organized the article as follows: Section 2 covers the conceptualization of microgames. In Section 3, we present considerations for integrating microgames in classrooms. In Section 4, we present the proposed model for integrating microgames in primary ESD. Section 5 covers the illustration of the applicability of the proposed model in teaching integrated mathematics, language, arts and technology. Section 6 covers the discussion of findings and Section 7 covers the conclusions and recommendations.

2. Conceptualization of microgames

According to Rahmadi *et al.* (2021a), the definition of microgames has been constantly changing and hence defining them is significant for avoiding misconception. Having reviewed the literature on microgames, Rahmadi *et al.* (2021a, b, p. 9) concluded "Microgames are very small and short games that provide brief engagement and meaningful experience for players, support learning and instruction toward specific objectives, and integrate with existing resources." This definition reveals the advantages and principles of integrating microgames in the classroom. Being small and short implies their compatibility with limited classroom time and less sophisticated technological resources (Rahmadi *et al.*, 2021a). Being used for specific objectives entails that teachers should identify specific objectives that microgame games should facilitate to achieve at the end of the lesson. This may help in evaluating the usefulness of microgames and the employed teaching strategies. Another principle comes from the microgame characteristic of being used with existing resources. This means that teachers should not substitute microgames for teaching resources such as curriculums and syllabi (Rahmadi *et al.*, 2021a).

2.1 Commercial off-the-shelf microgame digital-based learning

Commercial off-the-shelf microgame digital-based learning (COSTS MDBL) may be for teaching-learning purposes even if they are not necessarily developed for learning purposes. The term (COSTS MDBL) has been coined by Van Eck (2006) who used it for approaches to using all existing games to support learning regardless of their primary development goals. However, in the present study, we confine the approach to the use of existing microgames to align with the purpose of the study. COSTS MDBL is widely accepted as cost-effective because there are no financial resources or time to be used for developing the game. Nevertheless, failing to accommodate all learning requirements is the biggest drawback of this approach. This implies that this approach should not be expected to realize learning goals in all teaching contexts. Therefore, it is important for teachers to make a thorough analysis of the teaching contexts in which this approach is being adopted (McFarlane *et al.*, 2002).

3. Considerations for integrating microgames in the classroom

Successful integration of microgames in the classroom for ESD requires teachers to consider a number of issues such as the suitability of the microgame, the alignment of the microgame with the curriculum and pedagogical aspects, designing and evaluating of the game and making decisions. The majority of these considerations have been associated with COSTS DGBL (Van Eck, 2006) in general, but they are also relevant to microgames. The question of microgame suitability is based on the fact that not every microgame can be useful in all learning context (Van Eck, 2006; Vandercruysse *et al.*, 2012; Rahmadi *et al.*, 2021b). Van Eck (2006) argues that the content of the game sometimes can be irrelevant to the learning objectives and level of students. Furthermore, Rahmadi *et al.* (2021b) noted pedagogical relevance, meaningful aesthetics, brief story, simple mechanics and integrated technology as key qualities of microgames that can facilitate learning. This means that in analyzing the suitability of the microgame, the teacher has to consider these aspects. Van Eck (2006) argues that teachers should think of how to fill gaps for the missing features of games rather than abandoning them. Therefore, teachers should not expect microgames to have all qualities needed for facilitating teaching and learning.

Moreover, the alignment of the microgame with the curriculum involves the assessment of how the features of the microgames resonate with curriculum content, objectives and contexts. When discussing integrating games, Van Eck (2006) argues that teachers need a balance between the game and the curriculum in a way that neither compromises the other. This calls for teachers to avoid trying to maximize learning while obscuring the pleasure that learners can get from playing the game and vice versa. This implies the need for teachers to develop learning activities that can make students enjoy the game while at the same time engaged in developing target knowledge, attitude and skills.

Furthermore, the alignment of the microgame and the pedagogical aspects requires the teachers to determine ways in which the chosen microgame can meet the requirements for the adopted pedagogy (Van Eck, 2006; Rahmadi *et al.*, 2021b). For instance, employing a learner-centered approach requires students to engage in learning by discovery through collaboration (Bonk and King, 2012). Nevertheless, some microgames are meant for independent playing. This means that the teacher has to find a way to engage learners in collaborative learning if he has to use a game that involves only a single player. On the other hand, some games may be for simple understanding and practicing certain skills rather than developing new complex skills. This means that the teacher needs to find a way to use such microgames with pedagogies that are intended for developing complex problem-solving skills.

Overall, designing and evaluating the microgame involves assigning tasks to teachers and students and setting assessment tools. It involves developing teaching-learning activities, directions for teachers and students and assessment rubrics (Van Eck, 2006). It is suggested that the learning activities should strive to keep learners in flow with the game to make a balance between learning and gaming activities.

Above all, the implementation of the microgame design is an act of teaching using microgames. The attempt to use microgames should only be done if the analysis convinces that the games will potentially facilitate the realization of intended learning objectives.

4. ESD in primary schools

Implementing ESD in primary schools is as significant as in other levels of education. If young children understand the concepts of sustainability, they can easily change their behavior and participate in sustainable actions (Taylor, 2015; Mitchell and Forestieri, 2018; Summer, 2020) As Taylor (2015, p. 26) posits,

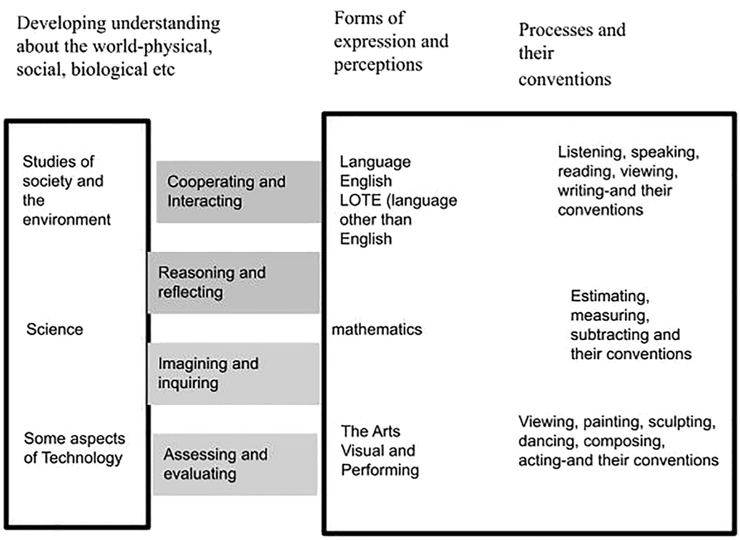
> We have seen children and teachers create biodiverse native ecosystems in place of degraded, eroding land. We have seen children researching, planning, fundraising and implementing initiatives such as water tanks, rooftop photovoltaic systems, energy conservation measures and waste-recycling systems in schools and beyond. We have heard children passionately argue for social and environmental justice, and weep at injustice

Therefore, developing strategies that can enhance the implementation of ESD in primary schools is imperative.

Mathematics, language, arts and technology are often prioritized subjects in primary education because they help learners to develop basic skills for future learning. Literature shows that mathematics, language, arts and technology can enhance learners' competence in dealing with sustainability issues (Jensen, 2002; Zygmunt, 2016; Armstrong, 2019; Rosman *et al.*, 2019; Bekteshi and Xhaferi, 2020; Lafuente-Lechuga *et al.*, 2020; Summer, 2020). Murdoch and Hornsby (1997, p. 14) in Jenkins (2015, p. 40) proposed an Integrated Curriculum Model in which the role of each subject in developing competence for sustainability is illustrated as shown in Figure 1. Therefore, it is important for teachers to engage students in using skills from these subjects in an integrated manner through engaging learning resources such as microgames to prepare them to deal with sustainability issues.

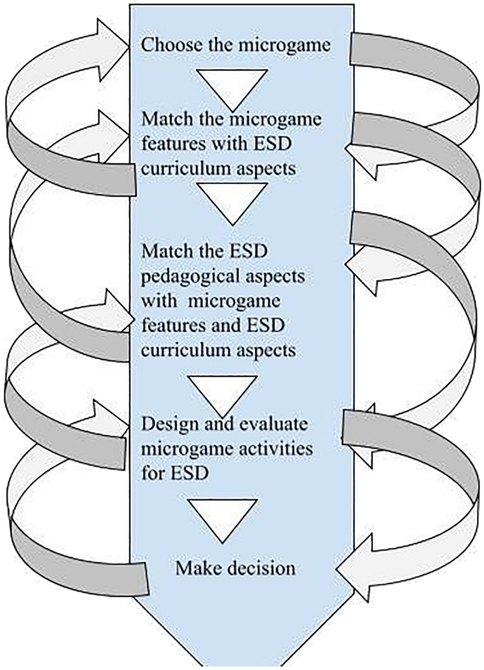
5. Proposed model for integrating microgames in teaching primary ESD

In this section, we propose a model for integrating microgames in teaching primary ESD based on the conceptual mapping from the reviewed literature and reflection from our teaching experience (see Figure 2). The model involves four phases, namely, choosing the microgames, matching the microgame with the curriculum aspects, matching the pedagogical aspects with both curriculum aspects and microgame features, designing and evaluating the microgame activities for ESD and implementing the microgame activities for ESD. The choice must adhere to the quality of the microgame features as highlighted by Rahmadi *et al.* (2021a). Having chosen the microgame, the teacher has to match the microgame features and the curriculum aspects (teaching objectives, content and students). After matching the curriculum aspects with the microgame features, the teacher must match the pedagogical aspects with both microgame features and curriculum aspects. Then, the teacher has to design and evaluate microgame activities for ESD. Finally, the teacher can make decisions on the microgame activities for ESD. In this phase, the teacher can decide to



Source(s): Figure by Murdoch and Hornsby (1997, p. 14) as cited in Jenkins (2015, p. 40)

Figure 1. Integrated curriculum model for implementing ESD in primary schools



Source(s): Figure by authors

Figure 2.
Model for integrating microgames in teaching primary education for sustainable development

use, improve or not use at all the designed microgames for ESD. However, teachers should consider these steps as iterative rather than linear in the sense that sometimes one can be forced to go back to the first step if there is a need to rework the step.

5.1 Applying the model to teach integrated mathematics, language, technology and arts in primary ESD

The model can be used for teaching integrated mathematics, language, technology and arts in primary ESD using various microgames for developing various ESD competencies. However, given the scope of the present study, we will illustrate the application of this model using a specific microgame.

5.1.1 Microgame choice. We chose Nature Guard Save Environment (NGSE) as our microgame for illustrating the application of the proposed model. NGSE is a free mobile-based application model that anyone can install on a smartphone from the play store. The game has three playing sections as shown in Figure 3. One of the sections involves cleaning the swinging playground. Another section involves growing flowers in the climatic conditions that support rains. The last section involves protecting basin water by preventing harmful objects from going into the in-stream water. Once any of the sections are opened, the player is directed by a finger icon on what to do and rewarded by word of mouth once he/she plays successfully.

5.1.2 Matching the microgame features and the ESD curriculum aspects. The features of the Nature Safeguard game align with the ESD curriculum aspects in various ways. The simple playing rules make the game relevant for primary school children and the nature of the game content is familiar to them. Also, the game is relevant to the ESD learning contents and

Source(s): Figure by authors

Figure 3. Sections of the NGSE

objectives because it involves practices for sustaining the environment. However, the game does not challenge learners to develop complex skills such as critical thinking and creativity. Besides, it does not explicate the interconnectedness among social, economic and environmental aspects. Therefore, we identified the need to think about how we could fill these gaps.

5.1.3 Matching the pedagogical aspects with microgame features and the ESD curriculum aspects. In this phase, our pedagogy of choice was STEAM-Project-Based Learning (PBL). STEAM-PBL requires learners to engage in collaborative planning and implementing projects of their interests using interdisciplinary skills while supported by their teachers. Although STEAM primarily entails connecting Science, Technology, Engineering, Arts and Mathematics disciplines, the approach can be applied beyond these disciplines (Mitchell and Forestieri, 2018; Armstrong, 2019; Khine and Areepattamannil, 2019). This is because the skills that students develop when learning from the perspectives of STEAM-PBL are universal to problem-solving in everyday life (Skowronek *et al.*, 2022). Therefore, this makes the approach relevant to teaching integrated mathematics, language, technology and arts for ESD. STEAM-PBL involves five stages, namely, reflection, research, discovery, application and communication (Laboy-Rush, 2011; Setyowati *et al.*, 2022). Reflection involves situating students in the problem and developing an interest to find solutions to solving problems. Research is the stage where students collect relevant information related to the problem. Discovery involves students synthesizing and analyzing the collected information related to the problem. The application involves modeling the solution to the problem. Communication involves students sharing their designs with the community.

In matching STEAM-PBL with the game features, we noticed that the game features can offer resources for students to visualize the sustainability issues during reflection. The game can also facilitate students' discovery and application of various models for solving sustainability issues in their real-life contexts. However, the game does not provide a space for students to create their own models for sustainability. This alerted us to rethink how to fill this gap. On the other hand, STEAM-PBL pedagogical aspects aligned with the proposed teaching approach for ESD (interdisciplinary and learner-centered) and learning objectives (competence oriented).

5.1.4 Designing and evaluating microgame activities for ESD. We designed microgame activities based on the nature of the microgames, the pedagogy and the curriculum aspects. We designed the learning activities that could be accommodated by the features of the game as well as complement the features of the game. This means that the activities were built on the ground of the game features and at the same time were meant to help students develop skills that cannot be realized by playing the game alone without these activities. This implies the need for creativity among teachers in developing activities that can strengthen the features of the game to realize learning objectives in a situation where the game lacks important features to match with all curriculum aspects. Studies show effective GMBL can only be realized if games are treated as teaching resources rather than replacements for teachers (Van Eck, 2006; Rahmadi *et al.*, 2021a). Therefore, this phase was conducted with consideration of the preliminary phases such as choosing the game and matching the game with the curriculum aspects.

5.2 Samples of microgame activities for ESD

Microgames activities for ESD that are presented in this subsection serve as samples of various teaching-learning activities that teachers can use in the integrated mathematics, language, arts and technology classroom. These activities can be aligned with various learning objectives and competencies as shown in Table 1.

Microgame activity for ESD	Learning objective to be achieved	Skills/concepts from integrated subjects	Competencies to be developed
Activity 1 Asking students to show ways in which adopting game practices strengthen sustainability (interconnectedness among social, economic and environmental aspects)	Students will be able to identify best practices for sustainability in various contexts	*Mathematics* Application of arithmetic, algebraic, probability and proportion concepts *Language* Application of reading, speaking, writing and listening skills *Technology* Application of mobile applications *Arts* Application of drawing and dramatizing skills	Critical thinking, normative and systems thinking competency
Activity 2 Asking students to choose any setting at the school or home compound and design a model of best practices for sustainability	Students will be able to develop best practices model for supporting sustainability in their local contexts	*Mathematics* Application of arithmetic, algebraic, probability and proportion concepts *Language* Application of reading, speaking, writing and listening skills *Technology* Application of mobile applications *Arts* Application of drawing and dramatizing skills	Critical thinking, normative, systems thinking, anticipatory and integrated problem-solving competency

Source(s): Table by authors

Table 1.
Samples of microgame activities for ESD and their relevant learning objectives and competencies

Our evaluation for Activities 1 and 2 involved peer-review which we shared among ourselves and other teachers. As shown in Table 1, the proposed activities have the potential to develop ESD competencies among learners in the integrated mathematics, language, arts, technology and language classroom. For instance, Activity 1 helps the learner to comprehend the broader concept of sustainability that connects the environment, economics and social aspects. Although the game does not show explicitly the concepts of sustainability, students can find the connection by reflecting the game features. For instance, the presence of the pieces of bread on the swing playground that has to be put in the dustbin can help the student realize that unwise consumption of bread can harm both the environment and human well-being. This illustrates the concept of sustainability. The ability to realize the potential effects of any practice on sustainability is associated with both critical thinking, normative and anticipatory competency.

Furthermore, it should be noted that students will also be developing mathematical, language, artistic and technological skills as they engage in the proposed learning activities. Extending the environmental protection picture to sustainability (environmental, social and economic protection) involves mathematical thinking such as algebraic equations, addition, subtraction and proportions. Responding to the activity involves aspects of language, technology and arts. Whether students provide the answer orally or in written form, he/she will be using language. However, it is expected that students will present their responses in different ways such as drawing, painting or role-playing. Furthermore, playing the NGSE game orients students to mobile applications, which may help them develop a positive attitude toward mobile technologies. Armstrong (2019) argues that arts and technology enhance students' comprehension and expressions of their thoughts. Therefore, it is imperative to design microgames activities that facilitate learners to employ arts and technology to comprehend and express mathematical and language concepts linking these concepts to sustainability issues.

6. Discussion

As shown in Figure 2, the proposed model requires the teacher to harmonize microgame's features with the ESD curriculum and pedagogical aspects. This implies that teachers can only adopt this model effectively if they are knowledgeable about microgames, sustainability issues and ESD teaching framework. This aligns with the notion that microgames facilitate students' learning if teachers match the microgames' features with the curriculum and pedagogical requirements (Van Eck, 2006; Rahmadi *et al.*, 2021b). Therefore, there should be efforts to support teachers to develop competence for using microgames in classroom in a way that meets the curriculum and pedagogical demands.

The proposed activities to be used in this model facilitate students to work in groups under the teacher's guidance to develop mathematical, artistic, language and technological skills simultaneously as shown in Table 1. This means that this model is relevant to ESD implementation framework. This is because ESD teaching framework is in favor of student-centered, collaborative, action-oriented and interdisciplinary teaching approach (UNESCO, 2017b, 2020). While studies that support the use of microgames have focused on a single-subject teaching approach (Seidler, 2021; Rahmadi *et al.*, 2022; Wijaya *et al.*, 2022), the present study went further to reveal the potential of microgames to facilitate interdisciplinary teaching approach. Therefore, there is a need to consider microgames as teaching resources in the implementation of ESD.

As shown in Table 1, the proposed model enhances learners' development of ESD competences through skills acquired from mathematics, language, technology and arts. This means that mathematics, language, arts and technology if taught as integrated subjects nurture the development of ESD competence among learners. This finding aligns with

Murdoch and Hornsby (1997, p. 14 in Jenkins (2015) p. 40)'s integrated curriculum for mathematics, language, arts and technology to support the development of ESD competencies (see Figure 1). It should be noted that the majority of the previous study noted the potential of integrated mathematics, language, arts and technology to developing learners' ESD competence (Rosman *et al.*, 2019; Bekteshi and Xhaferi, 2020; Lafuente-Lechuga *et al.*, 2020; Summer, 2020); however, guides teachers to teach these subjects in a way that capitalize their (subjects') potential to enhance the development of ESD competencies among learners. Therefore, the proposed model provides the roadmap for enhancing ESD competencies among students through teaching mathematics, language, arts and technology.

7. Conclusion and recommendations

The proposed model for integrating microgames in teaching primary ESD is based on researchers' teaching experience and conceptual mapping. The model requires the teacher to engage in reflective practices as he/she moves from one phase to another. To use this model successfully, the teacher needs to be knowledgeable of sustainable development issues, competent in interdisciplinary teaching approaches and knowledgeable of the microgames. The activities used to illustrate the application of the proposed model are to be regarded as samples rather than definite activities for the model.

Since the proposed model and its illustrating activities have not yet been tested in actual classroom settings, it is difficult to comment on its suitability to various classroom contexts. However, its contribution to the development of models for integrating microgames in implementing ESD cannot be underestimated. Therefore, the next step would be to test this model in different classroom contexts for suitability evidence or improvements.

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