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GAMIFIED LEARNING PATHS: INTEGRATING CAMPUS WALKS INTO SUSTAINABILITY EDUCATION

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ABSTRACT

Education for sustainable development (ESD) provides a strong basis for the implementation of sustainability in universities. Using Bryant's rationale for space agnostic learning (SAL) and Carman's blended learning elements, a team at a Finnish higher education institution (HEI) developed the idea of a Sustainability Campus Walk, a blended learning approach combining elements of a physical walk with online learning materials. The aim was to introduce the HEI's work on sustainability to students of bachelor's and master's programs. The project was completed using the novel approach of a multi-stakeholder planning group, which enabled the enrichment of the study materials with practical examples. Gamification elements were used to create checkpoints on the walk and make it more engaging for the participating students. The methodology used to record the progress and results of the project was Kananen's observation diary model, which allowed meticulous recording of activities. An analysis of the records of the coordinating member of the creation team and the notes of managerial members provided the answers to two research questions about the involvement of stakeholders in the planning process of gamified blended learning projects. We found that stakeholders play a key role in planning learning projects, therefore multi-stakeholder teams are recommended for further iterations of future courses.

KEYWORDS

Blended Learning, Gamification, Sustainability Learning

1. INTRODUCTION

1.1 Background and Rationale

Lozano (2010, p. 643) noted that if sustainability were integrated as a concept among the different disciplines and tailored to their specific nature, universities could become more balanced, synergetic, trans-disciplinary, and holistic. This would enable students to become

more proficient in sustainability. This idea is supported by Fischer and Isenmann (2023, p. 147), who underline that education for sustainable development (ESD) is undeniably key to implementing sustainability at universities. In their research, Hueske et al. (2022, p. 202) found several e-learning opportunities which can support education for sustainability development (ESD), and reported that in terms of blended learning types, each HEI in their research applied several different formats.

1.1.1 Learning Design

Bryant (2021) introduced the space agnostic learning (SAL) concept, in which mixed modes of participation allow students to undertake learning activities either face-to-face or online, for the duration of the teaching period and other times varying across it. SAL involves designing teaching and learning activities so that *where* they occur does not limit the engagement and participation of students. SAL involves the design of teaching activities for implementation in different spaces that can be shared to enhance learning between students.

1 PURPOSEFUL	2 WIRED	3 LEVERAGED	4 BALANCED	5 CONNECTED
Design specifically for mixed modes of participation. Break down and rethink teaching and learning activities. Design for the affordances of space, not around them.	Design for equal opportunities and capabilities for all students to participate. Balance the connection of the online students to the physical students in the spaces they are both occupying.	Design ensures that the unique capabilities of physical interaction can be leveraged to better support the learning of those studying online (and vice versa).	Design for the different modes of participation by balancing between and within the cohort in terms of access, engagement, group work, and assessment.	Design that identifies multiple ways for students to engage. Design that values asynchronous connection as much as it values synchronous discussion.

Figure 1. Diagram of space agnostic learning design principles (applied from Bryant, 2021)

Bryant underlines important planning principles within SAL. The main idea is for planners to put themselves in the position of the student, feeling empathy, and design learning activities by making the most of the spaces that are available for learning. To make it work, teachers must also 1) communicate clearly with students, thinking through the activity and how it will work for the entire learning process, 2) keep technical solutions simple because overly complex solutions easily lead to failure, 3) support ways to participate collectively and ensure the equivalence of experience, and 4) design a framework of evaluation, because this is critical to improving the educational experience.

1.1.2 Blended Learning

There are many frameworks available which conceptualize the relationships of blended learning elements. Carman's (2002, p. 2) framework has five key elements: live events, online content, collaboration, assessment, and reference materials. In addition, if we adopt a learner-centered approach, focusing on the relationship between the design of blended learning environments and factors within the learner, empirical blended learning research might identify core attributes that influence learning, which can then be tested and better understood. Additionally, blended teaching and learning are central to enabling us to better manage complex contemporary information flows and integrate these flows into effective teaching (Ololube et al., 2015, p. 233). Blended learning environments nowadays differ widely in terms of the technologies and methods used, and learning takes places in various physical environments; blended learning is no longer simply learning that happens in an instructional context characterized by a deliberate combination of online and classroom-based interventions.

Sivapalan's (2017, p. 10, 21) findings combine blended learning and sustainability learning needs and possibilities. Some indicators have been found for higher educational institutions (HEIs) and sustainability educators planning to use blended learning to develop sustainability literacy and sustainability communication skills amongst undergraduate engineering students. In addition, blended learning provides flexible teaching and learning options for teachers and students in comparison to conventional face-to-face studies.

1.1.3 Learning by Gamification

Gamification means to apply game elements to non-game contexts (Nair & Jain, 2021, p. 751). Around a decade ago, gamification took off in education (Dominguez et al., 2013, p. 382). Games help to reframe failure and create resilience through rapid and frequent feedback and transform learning goals to be more appealing and achievable (Denmeade, 2015). Dieleman and Huisingh (2005, pp. 837-847) combine games with experiential learning for sustainability based on the theory of experiential learning, developed by David Kolb in the 1980s. According to this theory, the experience grasped through apprehension relies on the tangible and felt qualities of immediate experiences. This refers to the kind of learning processes one goes through while exploring things and looking at them. Dieleman and Huisingh see that the beauty of playing games involves 'learning by doing' and 'learning by failing', but without negative consequences in the real world. The rationale for usage of game elements in educational contexts is that various video and smartphone games have captured the attention of young people all over the world (Alsawaier, 2018). They emphasize that the theory of experiential learning provides numerous opportunities for teachers and learners to obtain valuable insights in learning processes and games could and should be added to ESD curricula.

Landers (2019, p. 137) has noted that researchers have offered gamification as a solution to improve engagement and motivation, and influence learner attitude and behaviors, which all leads to improved learning outcomes. He warns, however, about the decoration of existing organizational processes with game elements but with a lack of psychological processes, as this would not lead to full use of gamification potential. In research in organizational contexts, gamification has been found to improve learning in several studies; for example, Andriamiarisoa (2018, p. 69) discusses the scope of improved engagement for learning, and MacKinnon et al. (2015, p. 74) underline that gamification can increase the perceived value of the knowledge or skill to be gained. They used a pre-test, post-test control group design to explore how gamification improved learning and learner motivation. Research by O'Neill et al. (2018) on

project outcomes demonstrated enhanced knowledge and staff engagement. In research, gamification is connected to motivation and thus leads to enhanced learning processes and outcomes. Overall, most of the reviewed gamification studies reported positive effects and benefits, but that is caused by the novelty effect, and they may not be long-term results (Hamari et al., 2014, p. 3028).

1.1.4 Gamified Learning Paths

As most of the content of e-learning is fragmented, learners are not able to systematically and efficiently absorb multiple knowledge objects in a specific field – this has always been a problem for e-learning. Research shows that high-quality learning helps increase learners' understanding of the learning content. That is why high-quality learning paths are an issue of concern for academia (Shi et al., 2020, p. 1). This challenge, of course, concerns blended learning as well - and more so, as traditional and digitalized e-learning with gamification is integrated.

There have been two research directions in digital learning so far. The first is concerned with how to generate high-quality customized learning paths to satisfy learners. This is called the clustering-based method, and its challenges include that it often collects redundant or irrelevant learning objects because it ignores potential dependencies between learning objects, and it shows only the simplest relationship and does not explore more complex semantics in the relationship (Shi et al., 2020, p. 1; Tang & McCalla, 2010, p. 257; Su, 2017, p. 2289).

Tam et al. (2014, p. 350) noted that it would be very important and meaningful to conduct a thorough investigation on pedagogic theory to support their proposed e-learning system framework for learning path optimization. This is a good example of adding new learning channels like e-learning; in such situations, it is necessary to check various theoretical aspects, starting from pedagogic theory.

A new concept called precision education focuses on individual learning and provides personalized and timely intervention for different learners. It is regarded as a new perspective on game-based learning and, accordingly, the order of knowledge acquisition in the learning environment is viewed as a kind of learning path. In an open-ended learning environment, which gamified learning and games are, control over interactions within the learning environment shifts from teacher to learner, so the learning paths of each learner vary. In any case, learning paths are a factor that should be analyzed in precision education. Furthermore, learning material related to in-game interaction is one form of context data constituting the learning path as well (Feng & Yamada, 2021, pp. 176-177). Ruipérez-Valiente et al. (2019, p. 8) added a new aspect by proposing a visualization approach showing the path to completing tasks in the game, as they assumed that the results can only provide insight into students' behaviors, and teachers cannot assess the performance directly.

Yang (2021, p. 106) categorizes the research topics of precision education as governance, policy, technology, and practice. The effect of precision education can be seen in emerging pedagogical environments such as MOOCs (massive open online courses), e-books, coding, AR/VR, robotics, and games, all of which warrant exploration, in addition to examination of the critical factors that influence students' learning performance when guided by precision education.

Research into gamification learning contexts has mostly highlighted positive outcomes, for example, in terms of increased motivation and engagement in learning tasks, as well as enjoyment. However, research has also pointed out negative outcomes which need to be paid attention to, such as the effects of increased competition among learners, task evaluation

difficulties among teachers, and design features (Hamari et al., 2014, p. 3028). The goal of most previous research has been to find an optimal learning path. As AI can now offer a one-of-a-kind precise solution for everyone (Yang, 2021, p. 105), it will certainly have a role in this development.

1.2 Research Context

Research by Pretorius et al. (2021, p. 1318) involved a case study presented as a reflective narrative with a focus on links with sustainability learning, allowing a contextualized description and assessment of the selected pedagogies, with inclusion of critical reflection.

We designed a course titled The Sustainability Campus Walk according to SAL principles to promote sustainability literacy by immersing students in practical sustainability initiatives on campus and providing them with supplementary learning materials and reflections in a virtual environment. The course integrates physical and experiential learning with virtual, online components. This blended approach aims to enhance student engagement and understanding of sustainability concepts through real-world experiences. The following learning objectives were established for students:

- to improve identification of the possibilities and functions of sustainability on the LAB Lahti campus.
- to observe practical applications of sustainable development in the operational environment.
- to enhance understanding of him/herself as a part of the sustainable community and its different functions.

The research context also involves an educational approach whereby sustainability education is integrated into a course designed as a “hop on - hop off” experience, combining physical campus activities with virtual course components. In practice a student can enroll on the course at any time and when all the assignments are completed and their course result recorded as pass or fail, (s)he “hops off.” Students physically visit specific locations on campus, each representing a sustainability checkpoint, when their individual schedules permit. These checkpoints are real-world settings of the university, where sustainable practices or initiatives are displayed or implemented. Each checkpoint corresponds to an assignment or activity with gamification elements on the virtual course platform. Here, students access additional resources, instructions, or reflections related to the physical activities they have completed.

1.3 Purpose, Objectives, and Research Questions

1.3.1 Research Purpose

LAB University of Applied Sciences has set the ambitious goal of showing and developing practical capabilities in the key areas of sustainability education and sustainability change management. It aims to follow global learning needs, as defined by the OECD: a) to create self-directed learning options for the development of competencies, b) to apply transdisciplinary settings to make knowledge applicable and effective in real-life situations, and c) to consider overlapping the boundaries of academic versus nonacademic learning to achieve a holistic approach to lifelong learning (Tuomala 2022, p. 33). As a result, the purpose of this study is to investigate innovative approaches to sustainability education that empower individuals to

autonomously develop competencies, apply knowledge effectively in real-life contexts through transdisciplinary settings, and integrate academic and nonacademic learning into a holistic framework aimed at advancing sustainability education and change management.

1.3.2 Research Objectives

The first objective is to ensure the sustainability knowledge acquired through SAL has practical applications. It seeks to explore whether SAL is applicable to actionable forms of sustainability study. This objective is rooted in the idea that SAL can transcend traditional learning environments, allowing students to engage with sustainability concepts in a manner that is flexible and contextually relevant. By examining how SAL facilitates the acquisition and application of sustainability knowledge, the study aims to determine the effectiveness of this learning model in fostering real-world sustainability competencies. This involves analyzing student engagement, understanding, and ability to apply learned concepts in practical settings. The findings related to this objective will contribute to the broader discourse on innovative educational models that support the development of sustainability competencies in higher education.

The second objective is to evaluate whether gamification elements are efficient in promoting sustainability literacy and engagement. Gamification, which involves game design elements in non-game contexts, can make learning more interactive and enjoyable. This objective focuses on understanding how gamification can be integrated into sustainability education to enhance student motivation, participation, and retention of knowledge. By incorporating game-based activities into the curriculum, the study aims to determine the impact of these elements on students' sustainability literacy. This includes assessing the effectiveness of gamified assignments and activities in helping students grasp complex sustainability concepts, fostering deeper understanding, and encouraging proactive engagement with sustainability practices. The research will analyze the extent to which gamification can transform traditional educational approaches, making learning about sustainability more engaging and impactful.

1.3.3 Research Questions

We formulated two research questions that address identified gaps in the literature on gamified blended ESD courses. Recent research by Bryant (2023) lacked an explanation of how co-design and co-generative dialogue could be supported when planning SAL in higher education institutions. Students required more diverse information to be included in the gamified process. A participatory approach involving multiple stakeholders could help to bring fresh perspectives to the quality of knowledge students would have after experiencing learning packages with SAL principles (Bakhanova et al., 2020).

To sum up, we noticed that there is a lack of information about stakeholders' participation in course ideation and planning, or involvement in general. We assume stakeholders' particular contexts could also give rise to new knowledge that may benefit the field beyond the context of practice in which the knowledge was generated. When establishing clear and concise research questions, the context of the stakeholders guided our investigation towards meaningful and beneficial findings for the future. The resulting research questions are:

- RQ1: How does the implementation of SAL with a stakeholder group impact students' understanding and application of sustainability concepts across diverse educational settings?

- RQ2: How could a collaborative approach to gamification strategies with stakeholder involvement be used to improve sustainability literacy and engagement among students?

These research questions serve as the foundation for our investigation, helping us to explore the research gaps identified. Clearly explain the nature of the problem, previous work, purpose, and contribution of the paper.

2. METHODOLOGY

We created an intervention that consisted of blended methods of action research and SAL design thinking concerning teaching and learning. The aim was to apply ideas from Wetzler's research (2013, p. 4), which concluded that a collaborative organizational innovation methodology - combining elements from action research and design thinking - has the potential to produce positive perceived outcomes related to novel solutions, personal commitment among organizational members, individual learning, and people's experience and relationship to the organization. The SAL concept of design thinking was introduced in Chapter 1.1.1 above.

Argyris summarized the main principles of Lewinian action research as five theses (Argyris et al., 1985, pp. 8-9):

1. Operations research looks for solutions to concrete operational problems of organizations.
2. The research progresses cyclically, from identifying problems to planning the activity, to the activity itself, and to evaluating the results of the activity.
3. In action research, priority is given to educational measures aimed at changing the behavior and ways of thinking of the participants.
4. Action research questions the existing status quo from the perspective of democratic values.
5. Operational research simultaneously aims to promote the theoretical understanding of the phenomena it studies and their practical management.

Operational research progresses in cycles where planning, implementation, observation of operations, and reflection are repeated. For this research, theory guided the search for new information and structured and systematized the process. The research progressed alternately as a dialogue between theory and empirics.

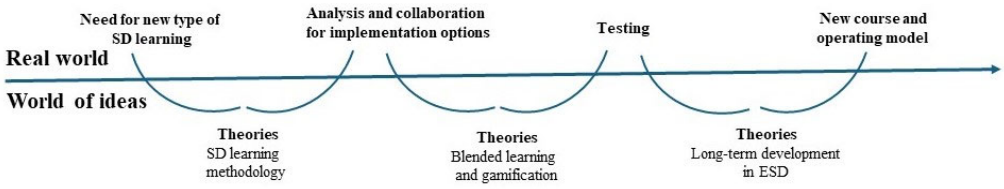

Figure 2. Stages of the dialogue cycle of the Sustainability Campus Walk between the real world and theory (applied from Saarinen, 2022)

In action research, the researcher's role is different from traditional research methods, because the researcher works as a group member throughout the research. The members participating in the activities agree on an equal basis throughout the research process. Action research fits with learning organizations, where the aim is both to train together and to develop

the organization's operations to better meet its goals (Suojanen, 2014). From a triangulation point of view, this research also included applying 1) direct observations in action by the researchers, and 2) an analysis of enrolments and assignments on an e-course platform and course management systems. A mixed-methods research approach was used to document the experiment. The documentation was carried out by the two action researchers/authors. Both researchers kept diaries independently. One kept a diary about the action in real life with the stakeholders and the other followed management issues as part of a larger RDI project. In the diary, the major steps and meetings with contributing stakeholders were documented. The reason for keeping the diary was two-fold: to record all the needs of the stakeholder group (which had to be highlighted on the Campus Walk), and to log activities for further analysis and presentation of the gamification method in sustainability education.

Table 1. Observation diary model for the Sustainability Campus Walk (applied from Kananen 2014, p. 69).

Time	Place	Situation	Object	Activity	Description

3. RESEARCH IMPLEMENTATION

Lahti Science Park is seen as a platform for education, research, development, and cooperation. It is owned by the City of Lahti, LAB University of Applied Sciences, and the University of Helsinki, and its facilities and operating environments are suitable for hybrid work and studies. An expert from Lahti Science Park also participated in the planning of the Sustainability Campus Walk.

3.1 Pre-Walk Preparation

The preparation process started in spring 2023 when we contacted relevant stakeholders who would potentially be interested in contributing material for the walk. The idea was to identify points which would need to be highlighted as checkpoints on the campus walk. The relevant stakeholders who subsequently participated were Lahti Science Park, Lahti University Campus, chief research experts from LAB, the City of Lahti, and Compass Group. As the checkpoint material was collected and the places to locate them on campus were identified, the next step was to create a demo and pre-test it. Seven checkpoints were identified at different locations on campus.

The checkpoints covered themes such as: sustainability in food (hosted by the campus restaurant), sustainability in design (hosted by the Institute of Design), sustainability in mobility (hosted by Lahti City), the sustainable future of the campus area (hosted by Lahti Science Park and Lahti University Campus), the circular economy projects of LAB (hosted by the chief research expert), sustainable greening (hosted by university campus management), and

sustainable laboratories (hosted by the Faculty of Technology). We realized the campus walk should be offered in two languages, Finnish and English, so that it could be inclusive for both local and international degree students. This principle was kept in mind while the continuous planning process was carried out.

3.2 Creation of Demo Version

During Summer School 2023, students were given the task of using the collected materials to organize the checkpoints, create a story line, and run through the walk. Two groups of international bachelor's and master's students completed the task and made notes on relevant aspects like timing (they highlighted the average time spent at each checkpoint) and flexibility (the route should be designed so that it can be completed starting from any checkpoint and in any order), as well as the necessity for incentives (creation of a reward system to make the walk more engaging). One of the principal issues to consider when planning routes was to remember physical accessibility and to note the positions of elevators or special elevating devices. Another crucial task was to create a storyline for the campus walk, which would make it more engaging and connect all the checkpoints logically into one coherent storyline.

3.3 Building the Actual Walk

During August 2023, a cooperation team from LAB and the Lahti Science Park built an online environment on the Moodle platform as an engaging virtual course with tasks in the form of games. Because of the implementation of conditional activities, the Moodle platform has become a versatile gamification platform; with the help of simple labels and settings, the tutor can act as a game designer (Denmeade, 2015).

H5P plug-in solutions were used to create various playful activities such as memory games, crosswords, drag and drop cards, etc. As a practical example H5P plugins such as "Multiple Choice", "Fill the Blanks", "Drag the Words", "Image Hotspots", "Memory Game", "Find the Words" and "Crossword" were used. Also, the material the quizzes were based on was created in an engaging way using the Canva platform and hidden under QR codes at the seven checkpoints on the physical walk. In addition, visitors from outside the university were considered. Together with LUT Junior University, a Google game was created using interactive features from Google Forms, in which the participants could answer a short set of 12 questions related to all the checkpoints on campus. This was done to promote the visibility of the program and the sustainability efforts of the university as well as its research, development, and innovation activities.

An incentive program was implemented in cooperation with the Compass Group, which is a chain of campus restaurants located on the premises of the university campus. It was agreed that students who pass all the checkpoints would receive a badge with the project logo, which would entitle them to a 50% discount on filter coffee at the restaurant. In Finnish culture coffee is the foundation of our daily diet, which is why this incentive was chosen.

In addition, the virtual badge was offered via the Open Badge function of the Moodle platform, and students could save it for further use as sustainability experts of our university. The Open Badge Infrastructure is the technology that supports badge issuing, collection, and display. Achievement badges allow students to experience a feeling of recognition of their

efforts. They can motivate students by providing visual feedback in the form of the badge, and offer an opportunity to share achievements with peers (Denmeade, 2015).

One of the crucial issues acknowledged by the coordinating team member was the creation of a clear set of instructions connecting all the dots of the walk. This was a major step, as without the instructions the walk would lose its user-friendliness, and it could create confusion. Additionally, some promotional materials were created - a poster and a brochure - to explain the concept of the walk and invite students to participate. The idea was to present the walk during the campus fair as part of the orientation week starting on the 1st of September 2023. After the presentation, the poster remained to be displayed at the campus monitors several times while the walk was operational.

3.4 Start of the Walk

The walk commenced on the 1st of September 2023, during orientation week. At the campus fair, the coordinating team member was present to promote the walk and to engage students participating in the fair. The walk sparked curiosity among the students, and the discount on coffee created extra value as well. Some students were interested in the virtual badge to enhance their resumes for job hunting in the future.

The walk was aimed to be operational from the 1st of September until the 20th of October, i.e. half the semester, until the academic break. The reason for this was to let students absorb the knowledge and reduce the time pressure. Additionally, hiding the checkpoints among the campus buildings created curiosity and interest in randomly learning new knowledge.

3.5 Results, Management, and Follow-Up

The Moodle platform allowed monitoring of progress, and the coordinating team member could follow the progress and troubleshoot problems. The troubleshooting was mostly related to one of the tasks which did not allow a restart if it failed. Some of the students could not finish the walk due to this issue. Surprisingly, there were no technical problems with most of the tasks, and they were easy to follow. In total, 50 participants were recorded as having completed the walk, 35 on the Moodle platform and 15 on the Google survey for visitors.

3.5.1 Presentation of First Results

At Lahti Science Day 2023, a member of the coordinating team presented an innovative walk concept to showcase the Sustainability Campus Walk at the local level, providing insights into its planning, implementation, and results. The presentation captured the audience's interest, as it offered a practical example of how sustainability principles could be integrated into everyday activities within the campus environment. Attendees were particularly engaged, posing numerous questions about the planning process, the specific sustainability measures adopted, and how the initiative could be adapted or scaled for other campuses or communities. The lively discussion that followed demonstrated a genuine interest in exploring similar sustainable practices, highlighting the relevance and potential impact of the campus walk project.

3.5.2 Creation of the Course Based on the Walk

In late November 2023, the project’s creation team met with a teaching support specialist and degree manager to discuss the creation of a one ECT course for bachelor’s degree students. The

content of the Moodle page was copied to the course page and issues reported by students were fixed. Additionally, the instructions were slightly modified as enrolment on the course required application via the university system. We used a normal study registration and study progress monitoring system for this course.

3.5.3 Course Status and Follow-up

Currently, the course is still running as a hop-on/hop-off course, offering one ECT. On average, the course has 20 active students enrolled via the university system. This course serves as preparation for transition to on-site teaching. Currently the course is part of Sustainable Solutions, a bachelor's program in environmental engineering, which is offered entirely online. However, it is expected that the program will be offered on campus starting from autumn 2025. Therefore, this form of blended learning is expected to be useful for international as well as Finnish students during the transition period.

3.6 Further Development Work

We acknowledge that our Sustainability Campus Walk requires further development to achieve full inclusivity. To address this, we plan to arrange a meeting with the audial team, which is responsible for providing podcasts and other audial content to the faculties' research teams. This collaboration will help ensure that the audio components are accessible and engaging for all participants, including those with visual impairments. Additionally, we will organize a run-through check and analysis with a special needs teaching specialist. This specialist will help us evaluate the walk's materials and structure, offering insights on how to make them more inclusive for individuals with various disabilities.

To further enhance the inclusivity and adaptability of the Campus Walk, we plan to integrate artificial intelligence (AI) into our development process. AI is an interdisciplinary topic with applications in many fields and disciplines, including medicine, law, linguistics, and education. AI could be used to analyze participant feedback and identify areas where improvements are needed. Moreover, AI-driven natural language processing could personalize audio content based on individual preferences or needs, such as adjusting the complexity of information for different age groups or learning levels. AI could also provide real-time language translation, making the walk accessible to a more diverse audience. In addition, AI technologies related to grading which adapts to students' needs, predictive analysis of learning, differentiation and personalization of learning activities, real-time learning analytics, all-round support from AI tutors, and targeted individualized feedback are just a few of the many advances made in the field of artificial intelligence in education. By leveraging AI technologies, we aim to create a more dynamic and adaptable experience, ensuring that the Campus Walk is inclusive and engaging for everyone. A digital and gamified education system based on AI might be able to pick up on the nuances of its user, such as the player's goals, the learner's misconceptions, or even the human's current emotional state (Kurni et al., 2023).

In addition, the strategy of a social network within the campus walk could be introduced. Allowing students to join the leaderboard in competition with each other as well as to create their own virtual world of personalities and add a competitive element to the task completion process can create a more engaging solution which enhances student involvement and motivation (Alsawaier, 2018).

4. RESULTS AND DISCUSSION

4.1 Assessing the Usefulness of Gamification Elements in ESD Learning

The tasks of the Sustainability Campus Walk were formulated as a board game (Severengiz et al., 2018), which was presented as a map of the campus with marked checkpoints, where students could find the materials. A badge (Rohan et al., 2020) was awarded after the completion of quizzes, which could be exchanged for a physical badge to receive further discounts. Below is a quick list of the gamification elements used in the campus walk, taken from Rohan et al. (2020), with a brief explanation of how they were used:

- Quests: when connecting project acronyms with a full description in the case of circular economy projects or matching a pair in a memory game about sustainable food.
- Clues: finding answers to fill in the gaps after reading materials in sustainable laboratories.
- Crosswords and word trivia quizzes: searching for answers in materials to solve word puzzles on the future of the campus area or sustainable campus greening.
- Fill in quizzes: about sustainable mobility to strengthen information recall about modes of sustainable transport.

All these elements allowed for the creation of interactive content that students could engage with while learning about various sustainability initiatives the university has been pioneering. This approach made the learning process more enjoyable and helped reinforce the importance of sustainability in everyday campus life. By integrating gamification into the educational experience, students were able to better retain information and feel more connected to the university's commitment to sustainability. Participation created a feeling of community and a deeper rapport with the university's values.

4.2 Assessing Learning Outcomes

Students' learning outcomes showed that the project led to increased awareness and understanding of sustainability issues within the study environment and practical application of sustainable practices in daily life. It also enhanced students' critical thinking and problem-solving skills regarding sustainability challenges.

The learning outcomes showed that the project still requires further development to serve a wider audience. As noted by Severengiz et al. (2018), careful planning of time use is crucial when building gamified solutions for learning, as they take longer to complete than multiple-choice tests. To make the content more engaging, more stakeholders should be involved to provide novel and diverse information. Additionally, having several team members can help diversify tasks and boost creativity.

4.3 Discussion

The results provide valuable insights into best practices for incorporating gamification in educational settings, significantly enhancing the effectiveness of sustainability education.

To answer the first research question, the implementation of SAL with a stakeholder group brings some benefits. It helps provide more context-rich material for the study content, as various stakeholders have different ways of addressing sustainability problems. Additionally, the creativity involved in building an interactive gamified learning experience is passed on to students, as multiple stakeholders results in the use of more diverse solutions.

To answer the second research question, a collaborative approach can be used when the university wants to show the diversity of solutions which have been implemented in various streams of science. It ensures more thorough planning and provides more perspectives. In addition, a collaborative team allows for the creation of a more inclusive and knowledgeable package, thereby enhancing student learning.

Our research provides a robust framework for future iterations of similar courses in various scientific fields, particularly in environmental engineering and sustainability, to ensure these programs are more effective and engaging. Because Moodle is widely used in educational institutions worldwide (Aida, 2023) and universities have their own compulsory platforms to follow progress in studies, this example of gamified learning can be easily adapted as a common practice in other higher education institutions. It is crucial to dedicate the necessary time and human resources to optimize the learning solution and its effectiveness.

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REFERENCES

Aida, S., 2023. Impact of E-Learning Orientation, Moodle Usage, and Learning Planning on Learning Outcomes in On-Demand Lectures. *Education Sciences*, Vol. 13, No. 10, 1005.

Alsawaier, R. S., 2018. The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology,* Vol. 35, No. 1, pp. 56-79.

Andriamiarisoa, R., 2018. *Impact of Gamification on Student Engagement in Graduate Medical Studies* (Doctoral dissertation, Walden University).

Argyris, C., Putnam, R. and Smith, D. M., 1985. *Action Science: Concepts, Methods and Skills for Research and Intervention*. San Francisco: Jossey-Bass Publishers.

Bakhanova, E., Garcia, J. A., Raffe, W. L. and Voinov, A., 2020. Targeting social learning and engagement: What serious games and gamification can offer to participatory modeling. *Environmental Modelling & Software*, Vol. 134, 104846.

Bryant, P., 2021. *Making the most of the spaces we have: Design principles for successful hybrid and hyflex learning*. Disruptive Innovations in Business Education Research Group. October 8, 2021. [Online]. Available at: https://diberg.blog/2021/10/08/making-the-most-of-the-spaces-we-have-design-principles-for-successful-hybrid-and-hyflex-learning/

Bryant, P., 2023. Student experience and digital storytelling: Integrating the authentic interaction of students work, life, play and learning into the co-design of university teaching practices. *Education and Information Technologies*, Vol. 28, No. 11, pp. 14051-14069.

Carman, J. M., 2002. *Blended learning design: Five key ingredients*. KnowledgeNet. [Online]. Available at: http://facilitateadultlearning.pbworks.com/f/Blended_20Learning_20Design_1028.pdf

Denmeade, N., 2015. *Gamification with Moodle.* Packt Publishing Ltd.

Dieleman, H. & Huisingh, D., 2006. Games by Which to Learn and Teach about Sustainable Development: Exploring the Relevance of Games and Experiential Learning for Sustainability. *Journal Of Cleaner Production*, Vol. 14, No. 9-11, pp. 837-847.

Dominguez, A. et al., 2013. Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, Vol. 63, pp. 380-392.

Feng, X. and Yamada, M., 2021. An Analytical Approach for Detecting and Explaining the Learning Path Patterns of an Informal Learning Game. *Educational Technology & Society*, Vol. 24, No. 1, pp. 176-190.

Fischer, K. and Isenmann, R., 2023. Education for Sustainability at Distance and Online Learning Universities: Methodologies and Good Practices for Educating Sustainability Experts and Leaders of the Future. In W. Leal Filho, A. Lange Salvia, E. Pallant, B. Choate and K. Pearce (Eds.) *Educating the Sustainability Leaders of the Future* (pp. 147-169). World Sustainability Series. Springer, Cham.

Hamari, J., Koivisto, J. and Sarsa, H. 2014. Does Gamification Work? A Literature Review of Empirical Studies on Gamification. *2014 47th Hawaii International Conference on System Sciences*, Waikoloa, HI, USA, pp. 3025-3034. doi: 10.1109/HICSS.2014.377

Hueske, A.-K., Pontoppidan, C. A. And Iosif-Lazar, L.-C., 2022. Sustainable development in higher education in Nordic countries: exploring E-Learning mechanisms and SDG coverage in MOOCs. *International Journal of Sustainability in Higher Education*, Vol. 23 No. 1, pp. 196-211. https://doi.org/10.1108/IJSHE-07-2020-0276

Kananen, J., 2014. *Laadullinen tutkimus opinnäytetyönä: Miten kirjoitan kvalitatiiviseopinnäytetyön vaihe vaiheelta*. Jyväskylän ammattikorkeakoulun julkaisuja. Suomen Yliopistopaino. Oy – Juvenes Print.

Kurni, M. et al, 2023. AI-Enabled Gamification in Education. In *A Beginner's Guide to Introduce Artificial Intelligence in Teaching and Learning*. Springer International Publishing AG, pp. 105-114.

Landers, R., 2019. Gamification Misunderstood: How Badly Executed and Rhetorical Gamification Obscures Its Transformative Potential. *Journal of Management Inquiry*, Vol. 28, pp. 137-140. doi: 10.1177/1056492618790913

Lozano, R., 2010. Diffusion of sustainable development in universities' curricula: an empirical example from Cardiff University. *Journal of Cleaner Production*, Vol. 18, pp. 637-644.

MacKinnon, R. J. et al., 2015. Self-motivated learning with gamification improves infant CPR performance, a randomised controlled trial. *BMJ Simulation & Technology Enhanced Learning*, Vol. 1, No, 3, pp. 71-76. Available at http://www.himss.org/ojni

Nair, S. and Jain, M., 2021. Evaluation of Gamified Training A Solomon Four-Group Analysis of the Impact of Gamification on Learning Outcomes. *TechTrends*, Vol. 65, No. 5, pp. 750–759.

Ololube, N. P. et al, 2015. Barriers to Blended Teaching and Learning in Sub-Saharan Africa: Challenges for the next decade and beyond. In N. Ololube (Ed.), *Advancing Technology and Educational Development through Blended Learning in Emerging Economies*. IGI Global, pp. 232-247. https://doi.org/10.4018/978-1-4666-4574-5.ch013

O'Neill, K. et al, 2018. Mobile technology, just-in-time learning and gamification: Innovative strategies for a CAUTI education program. *On-Line Journal of Nursing Informatics*, Vol. 22, No. 2.

Pretorius, R. W. et al., 2021. Using Real-World Engagements for Sustainability Learning in ODeL in the Global South: Challenges and Opportunities. *International Journal of Sustainability in Higher Education*, Vol. 22, No. 6, pp. 1316-1335.

Rohan, R., Pal, D. and Funilkul, S., 2020. Mapping Gaming Elements with Gamification Categories: Immersion, Achievement, and Social in a MOOC Setting. *2020 14th International Conference on Innovations in Information Technology (IIT)*, pp. 63-68. https://doi.org/10.1109/IIT50501.2020.9299047

Ruipérez-Valiente, J. A. et al, 2019. What does exploration look like? Painting a picture of learning pathways using learning analytics. In D. Ifenthaler and Y. Kim (Eds), *Game Based Assessment Revisited*. Springer: Cham, Switzerland, pp. 281-300. doi: https://doi.org/10.1007/978-3-030-15569-8_14

Saarinen, H., 2022. *Toimintatutkimuksella ratkaisu käytännön ongelmaan*. Väitöskuiskaaja-blogi / Thesis Whisperer blog. https://blogs.uwasa.fi/thesis/toimintatutkimuksella-ratkaisu-kaytannon-ongelmaan/

Severengiz, M. et al., 2018. Influence of gaming elements on summative assessment in engineering education for sustainable manufacturing. *Procedia Manufacturing*, Vol. 21, 429-437.

Shi, D. et al., 2020. A learning path recommendation model based on a multidimensional knowledge graph framework for e-learning. *Knowledge-Based Systems*, Vol. 195, 105618. https://doi.org/10.1016/j.knosys.2020.105618

Sivapalan, S., 2017. Sustainability, Blended Learning and the Undergraduate Communication Skills Classroom: Negotiating Engineering Undergraduates' Expectations and Perceptions. *On the Horizon* 25.1 (2017): 7–23.

Su, C., 2017. Designing and developing a novel hybrid adaptive learning path recommendation system (ALPRS) for gamification mathematics geometry course. *Eurasia Journal of Mathematics, Science and Technology Education,* Vol 13, No. 6, pp. 2275-2298. https://doi.org/10.12973/eurasia.2017.01225a

Suojanen, U., 2014. Toimintatutkimus ammatillisen kehittymisen välineenä. *Metodix –Metoditietämystä kaikille*. https://metodix.fi/2014/05/19/suojanen-toimintatutkimus/

Tam, V. et al, 2014. A new framework of concept clustering and learning path optimization to develop the next-generation e-learning systems. *Journal of Computers in Education*, Vol. 1, No. 4, pp. 335-352.

Tang, T. T. and McCalla, G. G., 2010. Data mining for contextual educational recommendation and evaluation strategies. In *Handbook of Educational Data Mining*. Chapman & Hall/CRC. Data Mining and Knowledge Discovery Series. CRC Press. Taylor & Francis Group.

Tuomala, A.-M., 2022. Virtual Studies in Learning of Solving Sustainability Challenges. *IADIS International Journal*, Vol. 21, No. 1, pp. 32-45. [Online]. Available at: https://www.iadisportal.org/ijwi/papers/202321103.pdf

Wetzler, J. R., 2013. *A case study of a "collaborative organizational innovation" intervention, combining action research and design-thinking methodologies* (Doctoral dissertation, Columbia University). ProQuest Dissertations Publishing.

Yang, S. J. H, 2021. Guest Editorial: Precision Education - A New Challenge for AI in Education. *Educational Technology & Society*, Vol. 24, No. 1, pp. 105-108.