Teaching Environmental Awareness with Smart IoT Planters in Learning Spaces [TEASPILS]

Intellectual Output 6

Extended report

Gamification framework to utilise digital sensor evidence for pedagogic environmental awareness

Project information

Acronym:	TEASPILS
Title:	Teaching Environmental Awareness with Smart IoT Planters in Learning Spaces
Agreement number:	2020-1-ES01-KA203-082258
Sub-programme or KA:	KA203 – Strategic Partnerships for higher education
Project website:	www.teaspils.eu
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Project period:	Starts on 01/09/2020 and ends on 31/08/2023
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	Hochschule für Agrar und Umweltpädagogik (HAUP)
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	Pädagogische Hochschule Wien (PHW)
	Universidad Pompeu Fabra (UPF)
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Gamification framework to utilise digital sensor evidence for pedagogic environmental awareness

Introduction

Gamification is a term that goes back many years and its benefits are widely seen in many applications. In this report we focus on gamification in education. The use of gamification has been widely used in various domains for increasing engagement and interest towards a non-game environment / system. Current research has shown that gamification is indeed a good approach in the educational domain [8] as long as it is focused. In the educational context it was used in courses for teaching programming languages [9], medical education [10], and in higher education [11]. The work of [12] which is relevant to our work, explores the use of gamification and how it affects pro-environmental behavioral change. They conclude that "... gamification approaches have the potential to educate and encourage pro-environmental behavioral change, as long as they combine in their design extrinsic and intrinsic motivational elements, short-term and long-term drivers, and game attributes that encourage taking action in real life". Our aim is to develop a gamification framework which will be applied on all aspects of the project, i.e., the SPOC, the Dashboard, and the Spike, and provide a holistic approach which can be utilised by teachers.

In line with these results, the Teaspils project developed a gamification framework to utilise digital sensor evidence for pedagogic environmental awareness purposes. Gamification has been used as a pedagogic strategy for student engagement for some time, and it is the objective of this work package to integrate this into the TEASPILS pedagogic model. The collected datasets from the various ambient technologies and sensors offer themselves for devising quantitative gaming strategies, such as leaderboards, points, levels and other comparative competitions between plants, pupils and at inter-school level.

The proposed gamification framework was designed to be combined with the rest intelectual outputs of the project:

1. IO1. The Small Private Online Course (SPOC) and the Open Online Course
2. IO2. The Smart IoT planters (Spike)
3. IO3. The Visualisation dashboard to show sensor data
4. IO4. The Pilot studies

Gamification User Types

For each of the aforementioned outputs we propose a number of game mechanics that can be utilized to increase engagement. The first step in utilizing and exploring game mechanics in any of the above environments is to identify which elements are appropriate for each type of user. To identify the user types we use Marczewski's standardized questionnaire (see Table 1). Based on Marczewski's user type hexad [1], there are 6 types of users:

1. **Socialisers** who are motivated by *Relatedness*. They want to interact with others and create social connections.
2. **Free Spirits** who are motivated by *Autonomy and self-expression*. They want to create and explore.

3. **Achievers** who are motivated by **Mastery**. They are looking to learn new things and improve themselves. They want challenges to overcome.
4. **Philanthropists** who are motivated by *Purpose and Meaning*. Members of this group are altruistic, wanting to give to other people and enrich the lives of others in some way with no expectation of reward.
5. **Players** who are motivated by *Rewards*. They will do what is needed of them to collect rewards from a system. They are in it for themselves.
6. **Disruptors** are motivated by *Change*. In general, they want to disrupt your system, either directly or through other users to force positive or negative change.

User type	Question	1	2	3	4	5	6	7
Philanthropist	It makes me happy if I am able to help others.							
	I like helping others to orient themselves in new situations.							
	I like sharing my knowledge.							
	The wellbeing of others is important to me.							
Socialiser	Interacting with others is important to me.							
	I like being part of a team.							
	It is important to me to feel like I am part of a community.							
	I enjoy group activities.							
Free Spirit	It is important to me to follow my own path.							
	I often let my curiosity guide me.							
	I like to try new things.							

		1	2	3	4	5	6	7
	Being independent is important to me.							
Achiever	I like defeating obstacles.							
	It is important to me to always carry out my tasks completely.							
	It is difficult for me to let go of a problem before I have found a solution.							
	I like mastering difficult tasks.							
Disruptor	I like to provoke.							
	I like to question the status quo.							
	I see myself as a rebel.							
	I dislike following rules.							
Player	I like competitions where a prize can be won.							
	Rewards are a great way to motivate me.							
	Return of investment is important to me.							
	If the reward is sufficient I will put in the effort.							

1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, 7=Strongly agree

To apply the questionnaire, we ask students to rate how well each item describes them in a 7-point Likert scale.
Questions are presented in random order and without any identifying labels.Then we separately add the scores of the items corresponding to each subscale

For each user type, existing research suggests a number of game mechanics that can be applied. We must also keep in mind that a user might fall in more than one categories

Gamification Elements appropriate for each user type

There are numerous game mechanics which can be applied to a learning scenario, but proper identification of the most relevant game mechanics for the appropriate user type is important. After pinpointing the type of users who are involved in an activity we can propose certain mechanics to address the versatile needs of the students. Another strategy is to have game mechanics from all categories and of course could also try to have

User type	Game Element proposal by Marczewski
Philanthropist	Collection and Trading
	Gifting
	Knowledge sharing
	Administrative roles
Socialiser	Guilds or Teams
	Social networks
	Social comparison or pressure
	Social competition
	Social discovery
Free Spirit	Exploratory tasks
	Nonlinear gameplay
	Easter eggs
	Unlockable or rare content
	Creativity tools
	Customization
Achiever	Challenges

	Certificates	
	Learning	
	Quests	
	Levels or Progression	
	Boss battles	
Disruptor	Innovation platforms	
	Voting mechanisms	
	Development tools	
	Anonymity	
	Anarchic gameplay	
Player	Points	
	Rewards or Prizes	
	Leaderboards	
	Badges or Achievements	
	Virtual economy	
	Lotteries or Games of chance	

Gamification Mechanics for the Smart IoT planter (Spike)

A major aspect of the project is the use of the Spike in a classroom setup where pupils will use it to take measurements and interact with the plant(s). The gamification framework can find application either by directly integrating with the Spike, the accompanying Telegram bot or in a physical classroom modality (tech-less). As we presented in the previous Section, the Spike is one of the tools used to record sensor data and use them in a learning scenario. This leaves the door open to a number of gamification mechanisms, such as badges, leaderboards, quests, certificates, gifts, etc.

Moreover one could also suggest an approach which is more exploratory, where pupils (individually or in small groups) are assigned a plant in a pot and need to identify the values in the Spike and the dashboard where their plant is happy, unhappy, thirsty, etc. Table presents an example of plant feelings mapping with the monitoring of Spike sensor values, visual observations by pupils and possible tasks for them to undertake. This is just an example where teachers are free to expand and connect with other learning activities suitable for their teaching.

Direct integration with the SPIKE can be achieved by:
1. Providing feedback to the student of the plant's feelings. This could be achieved by mapping the various sensor readings with thresholds and feelings or state (happy, unhappy, thirsty, etc. This can be visually represented using Emoji Emotion icons (🥶, 😬, etc.). These icons can be printed on the SPIKE and a led can light under the icon to indicate the state. A more tech oriented solution would be to draw the emoji on the led screen of the SPIKE. Since we plan to have a number of SPIKES in different classrooms with different plants, it is also suggested to allow a configuration/calibration mode for each SPIKE to map these plant specific values to the designated SPIKE.
2. Display the Emoji Emotion icons in the telegram bot.
3. Award badges or points to students who completed a task using the telegram bot. This can work both in an individual mode where a student uses their phone as their personal log or in group-based setup where a student is responsible for coordinating a group of students and record their findings.
4. The telegram bot can also be used to present a leaderboard and update it frequently based on the completed tasks of the individual or the group.
5. Use the screen of the SPIKE or additional components to show the effect of actions on the plant. Some examples can be found in https://learn.adafruit.com/plantagotchi-pybadge-plant-monitor
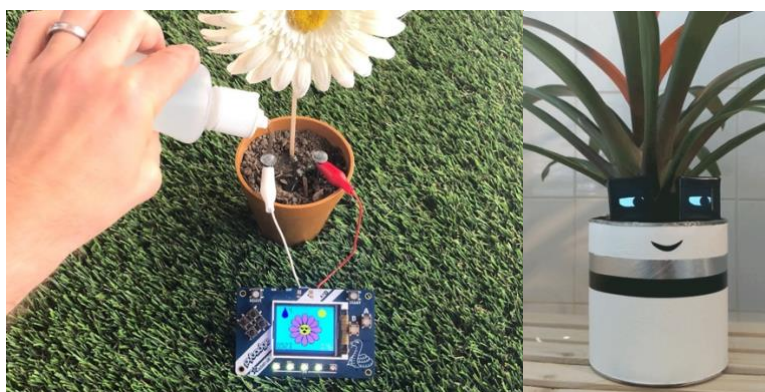
Gamification does not only need to be applied using technological means, but it can be used successfully without any. Based on the learning activities provided, a set of game mechanics can be used to promote engagement towards a learning activity. In the following table we depict some examples of such activities in a university level course

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|	Action / Task	Game element	User Type
P1	Add the title of "Group Coordinator" to the pupil that helps other pupils in monitoring the Spike sensor values.	Administrative role	Philanthropist
P2	Keep the plant diary up to date and share it with the rest of the class as a good example for others.	Knowledge sharing	Philanthropist
P3	Pupils can give a "thumbs up" card to another pupil who is identified as the one that provided the best care for their plant.	Gifting	Philanthropist
S1	Allow pupils to form teams and take care of a plant of their choice in the classroom while monitoring the temperature. Pupils compare the soil temperature from the Spike and dashboard with other teams plants and try to identify the differences and why these differences occur (e.g., sun exposure, type of plant)	Teams	
S2	In a team of pupils, vote for the pupil who was the expert in a specific task such as watering the plant, spraying leafs, etc.	Competition	Socialiser
F1	Ask pupils to find ways to check if pollution affects the health of a plant by asking them to place it in different places in their school and use the Spike to measure the CO_2. The pupil who demonstrates their methodology is rewarded with the badge of "Scientific Explorer"	Exploration	Free spirit
A1	In a scenario where pupils take care of a plant, we record each week the plant state (height, number of leafs, etc.) and award badges to the pupil whose plant had the best measurements each week. When a badge is awarded, the pupil levels up and this is presented in a time line depicting its progression. At the end of the month a certificate is awarded to the pupil who reached the highest level.	Certificates & Levels	Achiever
P1	Award a badge to a pupil who successfully completes a specific task on the plant. For the duration of the school year, award points for each task to the pupil and record them on a leaderboard.	Reward & Leaderboards & Levels	Player
P2	Create a virtual plant coin to "pay" pupils for their service towards taking care of a plant that produces fruits. When the fruits are ready then these can be used as physical "coins" for trading.	Virtual Economy	Player
D1	Present pupils with a setup for measuring the CO_2 of a plant. Ask pupils to propose and implement new ideas to perform the measurement using the Spike and the Dashboard.	Innovation Platform	Disruptor

This table maps plant feeling with sensor values, observations made by pupils and the respective messages or graphics, and possible tasks pupils can perform.

Plant feeling / state	Sensor values	Observations	Message / graphic	Task for pupils
Happy	1) V1 > Humidity > V2 2) V3 > CO2 > V4 ...	Green leaves No signs of illness	Happy face message	Spray the leaves with water
Unhappy	1) Humidity < V1 ...	Leaves falling	Unhappy face Encourage the student to find what is wrong	Check moisture in the pot Check for pests Check leaves' color
Thirsty	1) Humidity < V1 2) Temperature > T1 ...	The pot is completely dry	Thirsty graphic	1) Assess the moisture in the pot by finger test 2) Water the plant
Suffocating	1) Humidity > V1	Leaves are yellow	Suffocating graphic	1) Assess the moisture in the pot by finger test
…	...	...	...	...

Gamifying The Visualisation dashboard

In this section we introduce the teaspils pedagogic model which will be used as the point of reference for all gamification actions proposed.

An example of gamification elements applied on the Dashboard
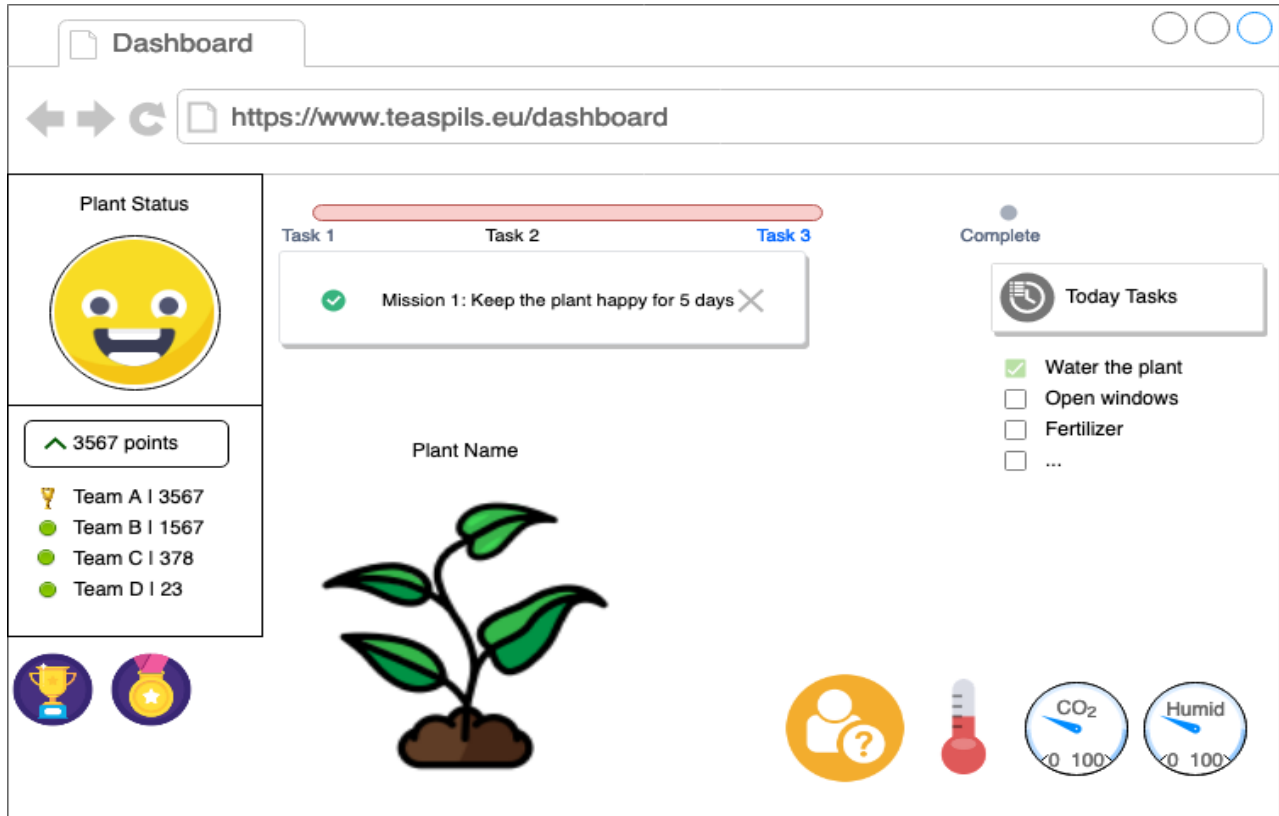
For properly identifying the gamification elements we will use we need to have a clear delineation of the learning goals we want to achieve and the learning activities that will take place. Each partner should provide a draft of the planned learning activities using the spreadsheet aiming to better understand the type of activities that will take place and propose appropriate gamification strategies:
https://docs.google.com/spreadsheets/d/1pvKRF0OLFNm1nlRkBTURITeKSkW9ACRyfwAXAFLS SJM/edit#gid=0

Gamifying the SPOC

One of the central outputs of the project is the delivery of a Small Private Online Course (SPOC) which focuses on promoting environmental awareness using plants and ambient technologies in schools. In the first instance, the SPOC supports the participants in their tasks during the pilots. Accompanying material is provided for the participants, especially for the supervisors of the pupils (e.g. class teachers). As seen in Figure 1, a user-friendly SPOC webpage makes it easy for learners to choose a session and interact with its content as well as with other learners.

Instructions for actions in inquiry-based learning, such as plant care, are also made available in this online course, as well as instructions and guidelines on how to use the provided technology (hardware & software). Teaching materials to introduce young children to the Internet of Things (IoT) in combination with engaging with learning and ambient technologies are developed to support the exploitation by the pilot schools. In addition, the exchange within and between pilot groups can be enabled and promoted on the online platform, and direct support from the project team can be requested.
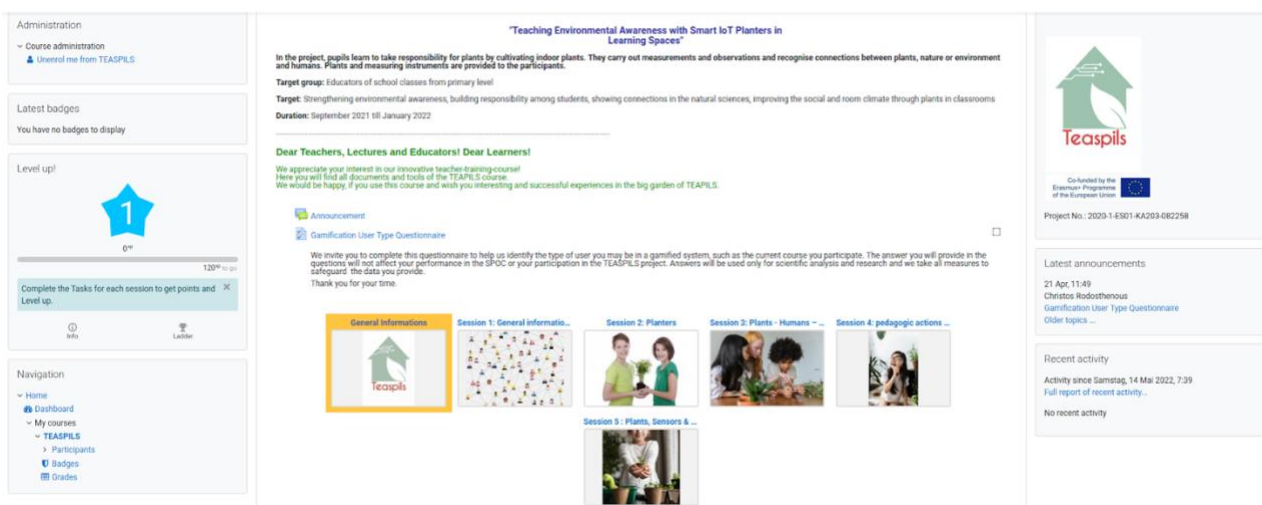
TEASPILS SPOC homepage depicting the main area where learners can choose a session and interact with its content.

The second phase of the TEASPILS project foresees the transformation of this SPOC into an unguided self-study open online course, to be released as an Open Education Resource (OER). This means the current content of the SPOC will be shared openly through an open licence and access to the course will be opened up to everyone. This online course not only serves the continued exploitation of the developed materials and methods, it also enables self-study and deep learning of the topic area. Teachers will be able to use the provided OERs in their own settings and adapt them to suit the learning needs of their students or pupils, focused on digital skills and environmental awareness.

Syllabus and Activities

The SPOC is composed of 5 units/sessions, each of which includes a 2 hour synchronous lecture while the educational content is also made available to learners asynchronously. Each session is recorded and can be viewed at any time. The 5 Sessions are briefly described In the next paragraphs.

Session 1 - General information & getting to know people: In this session we welcome learners to the SPOC and to the TEASPILS project in general. We also explain the learning goals and the requirements for the course, i.e., tasks, procedures, expectations. In this session we expect learners

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to introduce themselves and to get to know each other. The presentations touch topics such as the influence of plants on learning behaviours, plants and room climate, plants and the classroom community and provide the opportunity for brainstorming on common/country-specific indoor plants.

Learners are encouraged to use the course forum to introduce themselves and start a discussion on their interests. Moreover, learners are introduced to the ILDE+1 community portal where they can explore, find, and share learning activities for teaching environmental awareness.

Session 2: Plants/plants requirements/planters: In this session we discuss input criteria and/or work out criteria for plants in classrooms and considerations for selecting plants. This discussion extends to which plants are recommended for classrooms and initiates a dialog with the participants on which rooms/classrooms in their school may be used for placing the plants. Learners are presented with recommendations for soil, watering, fertilisation, light and indoor plant care, signs of health and plant growth, and photosynthesis.
In terms of activities, learners are introduced to a "Plant Diary" which is used to record when the plant was bought/ brought into class, the location of the plant in the classroom - light/ shade, how often it needs water and how much, and how much the plant grew in the last month. They are asked to select and buy a plant for their school/ classroom and create a 2 minute video explaining why they have chosen the specific plant and their video is uploaded to a course forum and made available to other learners for viewing it.

Session 3: Plants - Humans – Society: In this session we discuss the influence of plants on humans and society, focusing on generating awareness of the meta-physical impact of plants on humans and society, and providing ideas for learning activities based around human-plant relationships. In addition, we present possible threats to plants, biodiversity and Sustainable Development Goals (SDGs).
Learners are asked to answer a questionnaire to prepare for Session 4 of the SPOC. In case some learners did not complete the activity of buying a plant in Session 3, they are asked to do so.

Session 4: Pedagogic action research: In this session we reflect on the teaching-learning goals and their circumstances. We analyse the answers from the questionnaire, and we discuss inquiry-based and exploratory learning. During this session we also present research and Citizen Science possibilities and discuss the development of teaching-learning settings.

Session 5: Planters, sensors and visualisation technology: In this last session we discuss sensors and measurement technologies, providing information on handling sensors and main issues for handling parameters. This session focuses on sensor data for learning activities, dashboards, and more specifically the TEASPILS dashboard.

Learners are presented with learning activities using the data visualization dashboard and they are asked how the dashboard could be used in different learning activities, providing the means for a brainstorming & sharing of ideas activity. It is noted that gamification mechanics are built within all Sessions' activities in ways that encourage the participants to increase their engagement and their understanding of the underlying materials. Participants who complete the SPOC activities will also attend (in physical presence) a workshop where we will discuss and exchange experiences on the project and walk through the design of learning activities.

SPOC and Content Design

To host the SPOC, the project team setup a course on the Moodle Platform. That course is not accessible by everyone, but only from the SPOC participants which were selected by each of the participating institutions. Each member of the project team was responsible for a section of the

SPOC, its contents and its activities. The layout of the course comprises six sections, one section for each session and an always visible section which includes general information on the SPOC and an area for announcement forums and questionnaires. To present a unified output to all sessions, the project team decided to use the following design: 1) At the start of each section the tasks and objectives of the session are visible along with the syllabus, 2) Next, comes the educational material in the form of presentations, videos, and useful links, 3) Following are the activities for the particular session, and 4) the self-evaluation activity.

For preparing the content, presentation templates created by the project team were used. All presentations were converted to pdf files and uploaded to the corresponding section. Tasks and activities were materialised using either a forum type activity in Moodle which allows collaboration or a quiz type of activity.

After each Session, a self-assessment quiz was provided to allow learners to identify their progress. These quizzes included questions relevant to the presentations and content of the particular session. Each quiz could be attempted unlimited times and the highest grade of these attempts was recorded. The quiz activity was marked as complete when the learner achieved 50% of the required score.

Applying gamification mechanics in the SPOC

In this report, we present the gamification mechanics chosen for the SPOC and how these are applied in the Moodle eLearning platform used to increase the engagement and participation of the learners on the SPOC. The objective of the gamification approach used is to increase the participation of learners to the activities of the SPOC and to the delivered content throughout the duration of the course and not only within the 2 hours per session for synchronous learning.

The application of gamification in the SPOC approaches learners using a badge system where learners are awarded a badge when they complete all tasks and self-evaluation quizzes of a session, a point system where learners acquire points for performing certain tasks in the SPOC, a leaderboard and a level up system which are directly connected to the point system and provides learners the means to compete with other learners on getting higher in the leaderboard and getting to a higher level. This is in line with similar approaches used by others in the field [6,7]. Moreover, at the end of the course and when all conditions are met, i.e., a learner gets all session badges, learners receive a certificate of completion.

The Badge System

To implement the badges we used Moodle integrated badge system and provided a set of completion conditions for the activities. There are seven badges available, five of which correspond to one badge per session and two badges which are awarded when certain activities are completed at the eLearning platform. In Table 1 we present all the badges available and the conditions for awarding them.

| Badge	Title	Conditions
	Intro to Learning Spaces	Learners start a discussion at the "Welcome and introduction" forum Complete the Session 1 - Self-Assessment quiz
	Planters	Complete the Session 2 - Self-Assessment quiz
	Plants - Humans – Society	Complete the Session 3 - Self-Assessment quiz Answer the Preparation for Session 4 Questionnaire
	Inspired by Citizen Science	Complete the Session 4 - Self-Assessment quiz
	Dashboards in my teaching	Complete the Session 5 - Self-Assessment quiz

	Activity platform user	Manually awarded to participants who register to the ILDE+ platform and view the activities already shared by other learners. Learners also need to add a comment at least to one of the existing activities.
	Classroom-plant Shopper	Automatically awarded to participants who buy a plant and post the reasons they chose the particular plant in the forum.

To automatically award a badge we use the Moodle activity completion feature and choose the criteria, i.e, a forum post, a minimum grade achieved on a quiz, etc.

The Point System - Leaderboard and Levels

Another popular game mechanic is the use of points. Learners get points when they successfully complete certain tasks. In the TEASPILS SPOC we used such a system based on the "Level Up!" plugin1. For the purposes of the SPOC we setup the system for 10 Levels and each learner moves up a level when they reach a predetermined level of points. Learners get points for logging into the platform, viewing content and completing tasks using Moodle activities. The number of points given are chosen based on the importance of the task. For example, completing an activity gives more points than just logging to the platform.

This plugin also allows learners to view their individual points and level, and also have access to the leaderboard where they can compare their achievements with those of other learners. In Figure 2, we present both the leaderboard (left) and the "Level Up!" block (right). The leaderboard presents the level of each user, the number of points accumulated and a progress bar depicting the number of points required to move to the next level.
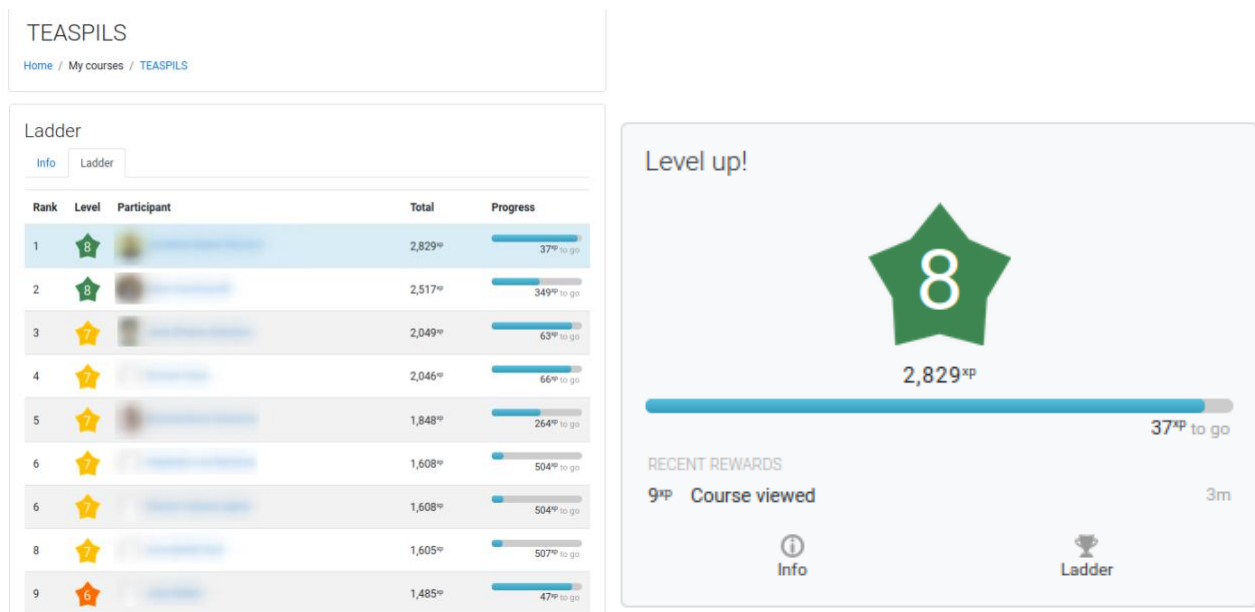
Further detail on the Gamification Framework developed by the TEASPILS Project were published in three conference articles with outstanding results:

Rodosthenous, C., Mavrotheris, E., Greller, W., & Tabuenca, B. (2022, September). Creating environmental awareness in education through IoT and gamification. In International Conference on Interactive Collaborative Learning (pp. 657-668). Cham: Springer I [Open article available here] Best paper award at ICL conference 2022.

Rodosthenous, C., & Mavrotheris, E. (2022). Applying Gamification Mechanics in an Environmental Education SPOC. In Proceeding of 14th International Conference on Education and New Learning Technologies (EDULEARN22) (pp. 9818-9825). IATED. 10.21125/edulearn.2022.2370

Tabuenca, B., Leo-Ramirez, A., Uche-Soria, M., Tovar, E., Greller, W., Rodosthenous, C., & Mavrotheris, E., (Septembrer, 2023). Unlocking the Potential of IoT for Interactive and Collaborative Learning: Case Studies in Higher Education. In International Conference on Interactive Collaborative Learning. Cham: Springer International Publishing. In press.

Bibliography

[1] Cetin, M., Sevik, H.: Measuring the Impact of Selected Plants on Indoor CO_2 Concentrations. Polish Journal of Environmental Studies 25(3), 973–979 (2016)

[2]Lohr, V.I., Pearson-Mims, C.H.: Children's Active and Passive Interactions with Plants Influence Their Attitudes and Actions toward Trees and Gardening as Adults. HortTechnology horttech 15(3), 472 – 476 (2005)

[3] Thor, D., Karlsudd, P.: Teaching and Fostering an Active Environmental Awareness Design, Validation and Planning for Action-Oriented Environmental Education. Sustainability 12(8) (2020)

[4] Tabuenca, B., B¨orner, D., Kalz, M.: Effects of an Ambient Learning Display on Noise Levels and Perceived Learning in a Secondary School. IEEE Transactions on Learning Technologies 14(1), 69–80 (2021)

[5] Tabuenca, B., Garc´ıa-Alc´antara, V., Gilarranz-Casado, C., Barrado-Aguirre, S.: Fostering Environmental Awareness with Smart IoT Planters in Campuses. Sensors (Basel, Switzerland) 20 (2020)

[6] Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From Game Design Elements to Gamefulness: Defining "Gamification". In: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments. p. 9–15. ACM (2011)

[7] Tabuenca, B., Greller, W., Leo, D.H., Casado, C.G., Alc´antara, V.G., Tovar, E.: Talking to Plants: an IoT System Supporting Human-plant Interactions and Learning. In: Proceedings of the LA4SLE 2021 Workshop: Learning Analytics for Smart Learning Environments (2021)

[8] Oliveira, W., Hamari, J., Shi, L. et al. Tailored gamification in education: A literature review and future agenda. Education and Information Technologies (2022). DOI: https://doi.org/10.1007/s10639-022-11122-4

[9] Learning pp. 513–535 (2019) 12. Papadakis, S., Kalogiannakis, M.: Using Gamification for Supporting an Introductory Programming Course. The Case of ClassCraft in a Secondary Education Classroom. In: Brooks, A.L., Brooks, E., Vidakis, N. (eds.) Interactivity, Game Creation, Design, Learning, and Innovation. pp. 366–375. Springer International Publishing (2018)

[10] Krishnamurthy, K., Selvaraj, N., Gupta, P., Cyriac, B., Dhurairaj, P., Abdullah, A., Krishnapillai, A., Lugova, H., Haque, M., Xie, S., Ang, E.T.: Benefits of Gamification in Medical Education. Clinical Anatomy (2022)

[11] Wiggins, B.E.: An Overview and Study on the Use of Games, Simulations, and Gamification in Higher Education. International Journal of Game-Based Learning 6(1), 18–29 (2016)

[12] Ouariachi, T., Li, C.Y., Elving, W.J.L.: Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices. Sustainability 12(11) (2020

[13] Gustavo F. Tondello, Rina R. Wehbe, Lisa Diamond, Marc Busch, Andrzej Marczewski, and Lennart E. Nacke. 2016. The Gamification User Types Hexad Scale. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16). Association for Computing Machinery, New York, NY, USA, 229–243. DOI: https://doi.org/10.1145/2967934.2968082

[24] S. Deterding, D. Dixon, R. Khaled, L.E. Nacke From game design elements to gamefulness: defining "gamification Proceedings of the 15th International Academic MindTrek Conference, Tampere, Finland, ACM (2011), pp. 9-15, 10.1145/2181037.2181040