Developing Gamified Gardening Resources for Schools in Thessaloniki

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1.0 Introduction

The integration of environmental sustainability education into primary and secondary schooling has become increasingly important as global communities confront escalating environmental challenges (UNESCO, 2021). However, many education systems struggle to provide engaging resources that translate sustainability concepts into a practical, everyday understanding (Ludin et al., 2025).

The Greek Ministry of Education introduced environmental education (EE) into the primary and secondary curricula in 1990–1991 through interdisciplinary projects that promoted critical thinking and environmental responsibility (Moschopoulou & Karakatsani, 2020). However, because EE is not a mandatory subject, its implementation largely depends on individual teacher initiative, leading to inconsistent access and uneven learning across schools and classrooms (Ntona et al., 2023; Moshou & Drinia, 2025). This variability creates challenges for educators seeking structured, accessible tools to support sustainability instruction.

To address these challenges, educators have begun using school gardens to teach sustainability through hands-on learning. These initiatives increase environmental literacy, student engagement, and social-emotional skills such as responsibility and self-reliance (Christian et al., 2014; Howarth et al., 2020). Similarly, research on digital and gamified learning shows that features such as challenges and goal-oriented progression can enhance students' motivation and extend learning beyond the classroom (John et al., 2023; Nam, 2021).

Despite these advances, a gap remains between community-based sustainability knowledge and its practical integration into classroom instruction. Existing initiatives often

emphasize either hands-on gardening without consistent curricular alignment or digital tools lacking grounding in local agricultural practices and classroom realities (Makrakis & Kostoulas-Makrakis, 2016; Dede, 2014). As a result, schools frequently lack cohesive resources that integrate experiential gardening, sustainability education, and curriculum-aligned technology in ways that teachers can realistically implement (Stevenson et al., 2017).

The Self-Help Promotion Program (SHPP) is a Thessaloniki-based organization that supports individuals recovering from substance use disorders. In 2024, SHPP established the farming cooperative Treli Rhodia to foster a supportive work environment while promoting permaculture practices, including organic farming and ecological sustainability. In 2025, WPI students collaborated with SHPP to develop a digital crop database for Treli Rhodia, making its gardening resources more accessible to the public (Rooney et al., 2025). SHPP now aims to extend these resources—including the Treli Rhodia database—to local schools through an app that combines hands-on gardening with gamified learning, while facilitating connections with Treli Rhodia workers and participating schools and teachers to support stakeholder engagement.

The goal of this project is to develop a gamified educational app that supports sustainability and gardening initiatives in primary and secondary schools. To achieve this goal, we have identified the following four objectives:

1. Evaluate the integration of sustainability and gardening materials within school curricula.
2. Assess student engagement in current pilot gardening initiatives.
3. Gather perspectives from Treli Rhodia workers for gamification and app design.
4. Develop a functional prototype of the application.

2.0 Background

This chapter examines school gardening as a means of bolstering sustainability practices and developing positive habits in students. It explores the history of environmental education and current practices and discusses the strengths and limitations of hands-on or experiential learning. Section 2.2 provides an overview of the integration of information and communication technology in Greek schools and of students' access to technology in primary and secondary schools. Finally, Section 2.3 discusses gamification practices, including student motivation and game mechanics.

2.1 Environmental Education Through School Gardening

Gardening provides a range of educational benefits, but within environmental education, school gardening serves as a targeted tool for teaching sustainability concepts through experiential learning. Functioning as living classrooms, school gardens enable students to engage directly with ecological systems, helping develop environmental literacy and an understanding of the relationship between human activity and natural processes (Green & Somerville, 2015; Lee et al., 2022). By moving learning beyond abstract instruction, garden-based education encourages students to apply sustainability principles through observation, participation, and problem-solving.

Research shows that hands-on gardening experiences strengthen students' environmental identity, fostering both knowledge acquisition and sustainable behaviors rather than awareness alone (AlAli et al., 2025). This approach supports interdisciplinary learning by integrating science, ecology, and social responsibility into practical activities, allowing schools to teach sustainability as an interconnected system rather than an isolated topic (Benatti, 2024). Active

garden education models further emphasize collaboration and real-world decision-making, reinforcing long-term interest with sustainability practices (Lee et al., 2022).

Historically, European education once mandated school gardening, as in 1800s Prussia, where it offered students hands-on environmental experiences (Papadopoulou et al., 2020). Over time, the role of school gardening shifted from environmental pedagogy to addressing issues such as childhood obesity and nutrition. In Thessaloniki, Greek educator Alexandros Delmouzos advocated for deeper integration of environmental programs into local schools (Papadopoulou et al., 2020). Today, many environmental education initiatives incorporate gardens located directly within school grounds, where students participate in structured gardening activities as part of their learning experience (Papadopoulou et al., 2020). This evolution highlights the need to examine how school gardening can be meaningfully implemented within contemporary school systems.

2.1.1 Experiential Learning

Experiential learning is a pedagogy that derives knowledge from hands-on experiences. Across the globe, primary (ages 6-12) and secondary schools (ages 12-18) have implemented gardens to promote experiential learning. Some teachers have adopted experiential learning as an educational pedagogy that emphasizes a student-led, hands-on approach (Institute of Experiential Learning, 2025). In school gardening, educators use gardening practices to increase engagement with agricultural and environmental content, foster cooperation among students, promote inclusivity in education, and offer other personal benefits associated with gardening (Papadopoulou et al., 2020).

Educators have divided agricultural studies into smaller subcategories and distributed them across different sciences (e.g., horticulture, soil science, and environmental science),

leading to a lack of overall understanding of agriculture (Goldman & Alkaher, 2024). Experiential gardening has dwindled in scope, but there is hope of reversing that trend. Studies on school gardening and the notable benefits it brings to students and teachers root this hope in evidence.

Studies worldwide show that school gardens benefit students' mental and physical well-being, environmental literacy, and learning. Gardening reduces anxiety, boosts self-esteem, and promotes physical activity and healthier eating (Papadopoulou et al., 2020). Hands-on learning increases engagement and retention: practical learning yields higher knowledge absorption rates than lectures. In addition, experiential gardening cultivates awareness of local and global sustainability (Dahl & Cushing, 2022).

Experiential education complements in-class learning and benefits a broader range of students due to its inclusivity. Experiential learning through school gardens is a desirable component of schooling, not only to increase environmental literacy but also to foster students' interpersonal and personal well-being. Working outside fosters teamwork and promotes equity, helping to address classroom divisions by leveling the playing field for learning opportunities (Johnson, 2012). Increasing the frequency of school gardening will teach future generations about environmentally friendly methods and cooperation, unlike current environmental educational methods, which promote individual learning separate from cooperation, and decrease accessibility among students based on skill level (Burt et al., 2018).

2.1.2 Potential Drawbacks to Implementation of Experiential Learning

Despite the many benefits of experiential learning, teachers often struggle to implement it effectively in the classroom due to limited training in experiential pedagogy, difficulty aligning hands-on activities with existing curricula, and challenges in assessing student learning within

traditional grading systems (Johnson, 2012). Each teacher's pedagogy must align with students' experiential activities, requiring educators to understand experiential learning to serve as effective guides. As traditional grading measures cannot adequately assess gardening practices, teachers must also adopt different evaluation methods that emphasize qualitative growth rather than the quantitative measurements common in many grading systems (Klemmer, Waliczek, & Zajicek, 2005). Teachers can better engage students by implementing information and communication technologies (ICT), which provide alternative methods for tracking student progress in both traditional and hands-on learning (Duda, 2024).

2.2 ICT in Greek Primary Schools

Information and Communication Technology (ICT) integration has been ongoing in Greek primary schools since the late 1980s. Beginning as limited computer installations and pilot programs, with European Union (EU) support in the early 2000s, Greece launched a digitization initiative, funding computer labs and providing basic internet access to schools nationwide (Anastasopoulou et al., 2025).

The outcome of this technocratic jubilee was the establishment of digital education infrastructure such as the *Panhellenic School Network,* which provides schools with email services and internet connectivity (Anastasopoulou et al., 2025). In the 2010s, the *Digital School* and *New School* programs provided over 7,500 open educational resources and more than 100 interactive e-textbooks in repositories such as *Photodentro* and introduced a weekly ICT course for upper-primary students across much of the country (Anastasopoulou et al., 2025; Nikolakopoulou & Pierri, 2024).

Today, Greek primary schools have a more robust digital environment than ever before. In 2024, the European Center for the Development of Vocational Training reported that nearly all Greek primary schools had basic internet connectivity and on-site computing facilities, with many classrooms equipped with interactive whiteboards and projectors (Anastasopoulou et al., 2025; CEDEFOP, 2024).

2.2.1 Limitations of ICT Integration

However, despite recent progress, several barriers continue to slow the integration of ICT into Greek primary education. For instance, although Greece maintains a broad ecosystem of digital platforms, limited coordination among them creates logistical burdens for teachers and reduces effective adoption (Anastasopoulou et al., 2025; Lavranos, 2025). Moreover, weak alignment between digital tools and traditional curricula and assessment practices leads many educators to treat online activities as supplementary, relying primarily on board-and-paper-based instruction for core subjects (Roussinos & Jimoyiannis, 2019). Additionally, although many teachers have completed state-led A- and B-level ICT certifications to improve their digital competence, older teachers often still lack the confidence or proficiency to integrate digital tools effectively (Aivazidi & Michalakelis, 2023; Anastasopoulou et al., 2025; Tzafilkou et al., 2023).

2.2.2 ICT and Mobile Device Access in Thessaloniki

Despite systemic and generational barriers, a case study in Thessaloniki suggests that successful digital education is possible in urban Greek municipalities. For example, an *eTwinning* project—an EU initiative connecting schools across countries via online platforms—titled *Our Culture, Our Future* enabled a Thessaloniki primary school to collaborate with schools in Italy and Finland, using web-based tools to co-create digital presentations and quiz games on cultural heritage (Anastasopoulou et al., 2025).

However, broader social dynamics complicate the scalability of digital education in Greece, as pandemic-era screen fatigue and persistent inequalities in household technology access—including disparities in internet connectivity and computer and mobile device availability—contribute to unequal digital education outcomes beyond the classroom (Anastasopoulou et al., 2025; Psani et al., 2022). Additionally, with smartphone use generally restricted during instructional hours except under teacher supervision, combined with uneven access to devices and reliable internet at home, these constraints limit how students engage with technology inside and beyond the classroom, resulting in a rigid framework for aspirational smartphone integration into future lesson plans—namely, gamified educational apps (Daskalaki et al., 2020; OECD, 2023).

2.3 Gamification

While access to technology enables users to access learning resources, gamification can facilitate sustained engagement and deeper learning. Gamification is the integration of game design elements into non-game contexts to enhance user engagement and retention (Koivisto & Hamari, 2019). Gamification has seen a significant increase in use, especially in education. As schools and society continue to digitize, the methods educators use to teach must evolve (Nam, 2021, p. 287). Gamification has emerged as a particularly effective training modality.

2.3.1 Intrinsic and Extrinsic Motivation

Gamification relies on two primary forms of motivation: extrinsic and intrinsic. Extrinsic motivators provide external rewards such as points, badges, or leaderboard rankings, offering immediate feedback and visible recognition (John et al., 2023). In contrast, intrinsic motivators

stem from internal drivers such as personal interest, satisfaction, autonomy, and a sense of mastery (John et al., 2023).

In the past, developers relied heavily on extrinsic motivators, often resulting in reduced novelty and diminished long-term motivation (John et al., 2023). Designing an effective gamified experience, therefore, requires a careful balance between intrinsic and extrinsic forms of motivation. Research suggests that a structure that emphasizes roughly two-thirds extrinsic and one-third intrinsic motivators can help sustain both short-term engagement and long-term commitment (see Figure 2.1) (John et al., 2023).

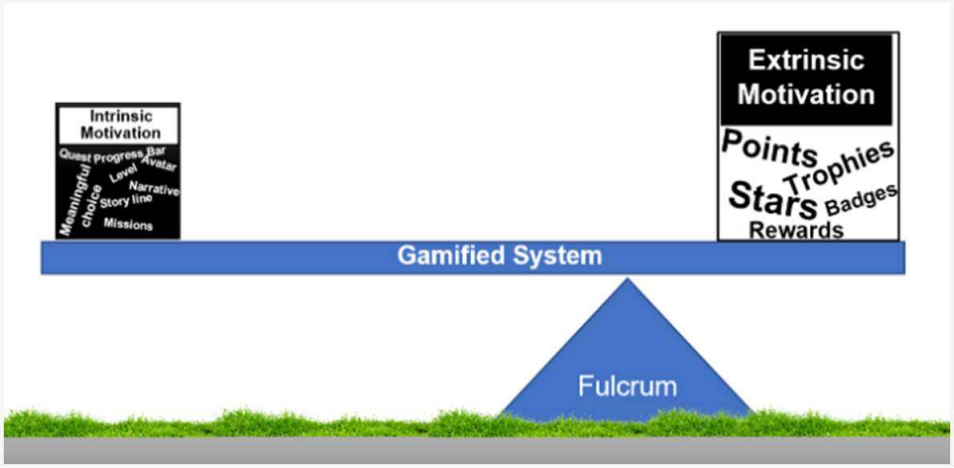

Figure 2.1: Fulcrum representation of balancing extrinsic and intrinsic motivation. (John et al., 2023)

2.3.2 Game Mechanics

Research shows that gamification systems that incorporate multiple mechanics—such as progress tracking, challenges, social interaction, and feedback—are more effective than single-mechanic approaches, such as leaderboards alone (Rosenfelder, 2023; Pappas, 2025). Combined gamification elements produce stronger motivational and learning outcomes because they target

different aspects of engagement (Siler & Homner, 2020). For instance, progress tracking and structured challenges strengthen learners' sense of competence, while technology-assisted feedback supports knowledge and skill acquisition through timely guidance (Huang et al., 2025). Social interaction further enhances engagement by fostering relationships and shared accountability. These findings align with Self-Determination Theory, which emphasizes competence, autonomy, and relatedness as drivers of motivation (Deci & Ryan, 2000). Overall, layered gamification systems are more effective because they activate multiple motivational pathways simultaneously, leading to more sustained engagement.

In addition to incorporating multiple mechanics, varying game modes and activity types can further strengthen sustained engagement. Research shows that gamified systems are more effective when they remain dynamic rather than static, as variation reduces motivational fatigue and supports long-term participation (Sailer & Homner, 2020; Gini et al., 2025). Providing options such as collaborative challenges, individual practice, and exploratory tasks allows users to engage with content in ways that match their preferences while also fostering autonomy (Deci & Ryan, 2000). By rotating or combining activity modes, gamified systems can reduce monotony and maintain interest, creating a more adaptable learning experience (Nam, 2021).

2.3.3 Personalization

In gamification, personalization is central to the user experience. Examples of personalization are common in video games; character creation, unique choices, and tailoring the experience to the user are just a few mechanics that add personalization. Users tend to differ in learning styles; some excel with auditory lessons, while others learn more from writing out answers. A learning game should support a wide range of learning styles, enabling more students

to engage, excel, and learn through the app. Ensuring accessibility is therefore essential to the app's success, as it allows individuals with varying educational backgrounds, ages, and levels of digital literacy to engage with the experience equally effectively (Nam, 2021).

2.3.4 Student Impact

Research consistently reinforces that gamification has a strong positive effect on learning outcomes and engagement across diverse educational settings: a recent meta-analysis of 41 studies involving over 5,000 students found that gamified interventions produced significantly higher learning outcomes than traditional approaches, suggesting that gamifying can measurably boost motivation and participation in educational contexts (Gini et al., 2025).

This evidence is especially relevant for mobile learning environments. Mobile devices offer distinct advantages over computer or paper-based learning in terms of accessibility, portability, and immediacy. Unlike desktop tools, smartphonesand tablets allow learners to engage with content at any time and from any location, making them particularly well-suited for informal, self-directed learning (Dede, 2014). Research further suggests that mobile-first design, where content is structured around the constraints and affordances of handheld devices, proves stronger learning engagement than simply adapting existing computer-based materials (Pappas, 2025). Because mobile applications are typically used in short, intermittent sessions, they must capture attention quickly and provide immediate reinforcement. Gamification supports this structure by breaking larger learning objectives into smaller, achievable tasks or quests and providing clear feedback to reinforce continued use (Pappas, 2025). For example, Duolingo (https://www.duolingo.com) is a successful app structured around brief one- to five-minute activities that encourage habitual engagement through rapid rewards and visible progress.

Gamification plays a critical role in improving engagement and learning across a wide range of educational contexts. By designing systems that thoughtfully balance intrinsic and extrinsic motivation, vary game mechanics, and accommodate diverse learning styles, developers can create effective gamified experiences (Nam, 2021). When these elements work together, they sustain engagement and support meaningful learning outcomes (Gini et al., 2025).

Chapter 3.0: Methodology

The goal of this project is to develop a gamified educational app that supports sustainability and gardening initiatives in primary and secondary schools. To achieve this goal, we have identified the following objectives:

1. Evaluate the integration of sustainability and gardening materials within school curricula.
2. Assess student engagement in current pilot gardening initiatives.
3. Gather perspectives from Treli Rhodia workers for gamification and app design.
4. Design, develop, and test a functional prototype of the application.

The team will conduct this project from March 16, 2025, to May 6, 2025. During this period, we will implement surveys, focus groups, mobile app testing, and non-participant observations involving student stakeholders. All research and testing will take place at partner schools selected by our sponsor to pilot the app, as well as at the Treli Rhodia greenhouse.

Because teachers regularly introduce gardening concepts to children who often have little or no prior experience, while greenhouse volunteers have learned gardening relatively recently

through SHPP's rehabilitation programs, perspectives from both groups will help inform game design approaches that effectively support beginner-level learning. App testing with students, teachers, and greenhouse workers will support iterative refinement by identifying usability challenges and opportunities for improvement. Overall, engaging with teachers, students, and greenhouse staff through these methods will help us understand both the educational and agricultural aspects needed for the mobile app.

We will use the resources available to SHPP to reach out to local school systems–such as Pinewood(American International Schools) and German Schools of Thessaloniki (DST)-through email to see which schools offer environmental education curricula, and which ones are willing to try our app.

3.1 Evaluate the Integration of Sustainability and Gardening Materials within School Curricula

Our first objective is to evaluate existing school gardening and environmental education practices. Surveys and interviews with teachers at said partner schools will provide essential insight into curriculum integration and effective strategies for student engagement, informing the development of inclusive and accessible educational content within the app. Additionally, teachers will serve as an indirect source of information about parental attitudes toward student learning, providing contextual information that may not be feasible to gather directly from families within the project's limited timeline.

3.1.1 Surveying Teachers on Current Curricula

Surveys are versatile and reliable tools for gathering and assessing information on a given topic (DeCarlo, 2018). They allow for standardized questions, making them effective for analyzing specific research areas within the project's scope across a large participant group

(DeCarlo, 2018). Because all respondents receive the same questions, surveys yield a more structured, quantitative dataset than the qualitative insights typically obtained from focus groups or interviews (DeCarlo, 2018). Additionally, surveys are highly flexible and can be applied across a wide range of topics, enabling researchers to gather diverse and valuable information (DeCarlo, 2018).

Our sponsor is currently communicating with schools that have implemented gardening programs. As of 2025, our sponsor is in active communication with 2 schools for pilot testing. To evaluate the current progress of school gardening curricula and gain insight into students' learning experiences both inside and outside the classroom, we will survey teachers at these schools. Surveys are selected in place of interviews to minimize time demands on teachers and respect their professional responsibilities and personal commitments while still allowing for meaningful data collection.

Preliminary surveys will address existing curricula, gardening practices, student engagement with sustainability and experiential learning, technology accessibility at school and home, and teacher perceptions of parental attitudes toward digital learning and their children's participation in ongoing gardening programs (Appendix D). Our team will use Qualtrics to create the preliminary surveys, which will be sent to the teachers of partner schools via email. Our team will survey during the first two weeks of the project to inform the app's initial development.

Before the survey, teachers will review the consent form (Appendix A), which explains the study's purpose, voluntary participation, and data use. They may withdraw at any time without consequence. The process ensures anonymity and prevents the collection of identifying information. Contact details for the research team, advisors, and the Institutional Review Board

are provided for questions or concerns. This consent process communicates study expectations, confidentiality, and participant rights, addressing key ethical considerations.

3.2 Assess Student Engagement within Ongoing Pilot Gardening Initiatives

Our second objective is to explore how primary and secondary schoolchildren engage in school gardening activities. To achieve this, we will conduct structured non-participant observations of students participating in gardening activities and tour the school gardening facilities where SHPP plans to pilot the app. This step is used to gather information about how easy the app is to implement and where students get hung up, any bugs or improvements we may need to make. This step is used to gather information about how easy the app is to implement and where students get hung up, any bugs or improvements we may need to make.

3.2.1 Observing Students

The team will use observation to understand how schools organize gardening activities and how students interact with peers, teachers, and gardening materials during instructional periods. The research team will serve as known non-participant observers during scheduled visits coordinated with participating schools and SHPP. Observations will take place during regularly scheduled gardening sessions throughout the middle weeks of the project, with visits arranged in advance to align with school schedules. They will occur at the school gardening initiatives in participating schools. Observations will be coordinated by SHPP staff to fit best around student and teacher schedules. All observation activities will only proceed under the supervision of classroom teachers or designated school staff to ensure alignment with school procedures and student safety.

To ensure consistency across observation sessions, the team will use a structured observation guide (Appendix E) to document field notes during each visit. The guide will include predefined categories of observable behaviors, such as student participation in assigned gardening tasks, collaboration and communication among students, responsiveness to teacher instructions, use of gardening tools and materials, and transitions between activities. Observations will focus on group-level interactions rather than individual student performance. Each observation session will last approximately 45-60 minutes and will occur during scheduled gardening lessons, with multiple visits conducted throughout the middle weeks of the project, subject to school schedules. The team will record field notes throughout each observation period using standardized templates to promote consistency among team members. During these sessions, the team will not take photographs, record videos, or document identifying information of students.

Because this study involves minors in school settings, our team will give careful attention to ethical considerations and informed consent. Prior to conducting observations, permission will be obtained from school administrators and participating teachers to ensure compliance with school policies, parental or guardian consent is going to be secured in accordance with school requirements, and student assent will be respected where appropriate. Observations will take place only in public or instructional settings, and all data is anonymous and is written in aggregate form to protect student privacy. As non-participant observers, the research team will not intervene in activities or evaluate individual students, but will document general behavioral patterns and learning interactions relevant to the project's objectives.

3.2.2 Touring School-based Gardening Facilities

During the initial weeks on site, the team will visit SHPP-sponsored school gardening initiatives to develop a comprehensive understanding of each site's physical and operational context. These visits will allow the team to assess the scale, layout, and maintenance of the gardens, as well as the resources, infrastructure, and organizational practices that support ongoing gardening activities. The team will take field notes during each visit to document the structure and condition of the garden spaces. These observations will help establish the scope of each initiative and directly inform the app's design, development, and testing by ensuring the team grounds its subsequent design decisions in the physical and operational realities of the gardening locations. Each site visit will last 45-60 minutes, with multiple visits scheduled over the first two weeks of the project as coordinated with SHPP and the schools.

3.3 Gather Perspectives from Treli Rhodia workers for Gamification and App Design.

The third objective is to gather perspectives from Treli Rhodia workers and use their insights to inform the app’s development. Their experiences will provide agricultural guidance to strengthen the app’s environmental education content and database integration features. To collect these perspectives, we will conduct weekly visits to the Treli Rhodia greenhouse and hold separate focus groups with workers, using their practical experience to brainstorm game features and guide content and usability decisions.

3.3.1 Visiting the Treli Rhodia Greenhouse

Weekly visits to the greenhouse will allow the team to gain a participatory, hands-on understanding of beginner-level gardening practices. Each visit will last approximately 60 to 90 minutes, during which the team will participate in and observe the workflow, garden layout,

plant-care routines, and tool use. The team will record field notes during each visit using a standardized observation guide (Appendix F) to capture insights relevant to app content, game mechanics, and database integration. Treli Rhodia staff will coordinate the visits to minimize disruption to greenhouse operations and supervise at all times to ensure safety and adherence to organizational policies. Engaging directly with the greenhouse environment and staff ensures that the app's content reflects realistic tasks, workflows, and challenges, rather than relying solely on secondary information from the database.

3.3.2 Focus Groups with Treli Rhodia Workers

A focus group provides a structured, discussion-based method for gathering rich, interactive data from multiple participants simultaneously (DeCarlo, 2018). Focus groups are more time-efficient than other question-based methods, as the facilitator prepares only a few key questions rather than an extensive list. Compared to individual interviews of similar length, focus groups provide richer data and illuminate different dimensions of participants' understanding. This format allows Treli Rhodia staff who have learned and practiced gardening from a beginner level to share insights that directly inform the development of realistic, educational app features. The team will hold one focus group session at the greenhouse during the term, lasting approximately 60 minutes. The team will schedule the session in coordination with the greenhouse manager to minimize disruption to daily operations and ensure participant availability. The team will work with one of the translators provided by either the sponsor or WPI to conduct the focus group, seeing as many of the workers will not be proficient in English.

The focus group will brainstorm game mechanics and app features, drawing on workers' experiences learning to garden and navigating challenges as beginners. The greenhouse manager

will recruit participants by identifying staff available and willing to participate. The session will take place in a quiet area of the greenhouse, separate from ongoing gardening tasks, to allow uninterrupted discussion. A project team moderator will guide the discussion using a structured focus group guide (Appendix G) to ensure consistency, encourage equitable participation, and document actionable recommendations for app design. The team will record feedback as written notes, with no identifying information collected. If scheduling or language barriers limit participation, the team may supplement the focus group with a short follow-up survey, allowing staff to provide additional feedback efficiently. This process ensures the team grounds the app's features in the hands-on experiences of beginner gardeners, making them both practical and pedagogically relevant.

3.4 Developing the App

The fourth objective of this project is to design, develop, and test a functional gamified sustainability education application. This phase translates insights gathered from surveys, focus groups, and observations into a usable digital tool aligned with local classroom contexts and gardening practices in the pilot programs. Development and testing will occur concurrently, enabling continuous refinement based on stakeholder feedback.

3.4.1 Design

Figure 3.2 - *Overall skeleton design of the application*

Our design came from our own personal experiences of simple user interfaces (UI), and knowledge of other gamified learning mobile applications such as Duolingo. Our team has designed our UI to be as user-friendly as possible while meeting all of our sponsors' requirements, including challenges, quizzes, and profiles. This diagram was our ‘skeleton’ design for the app. Through multiple development stages, we created a public GitHub repository (link), where stakeholders can see our progress. Although it is still in a very basic, bare-bones stage, it demonstrates the work put into the design and the concepts discussed. We first started by looking at the home screen, the space where users will open the app and utilize to navigate aspects of the application.

The Home Screen:

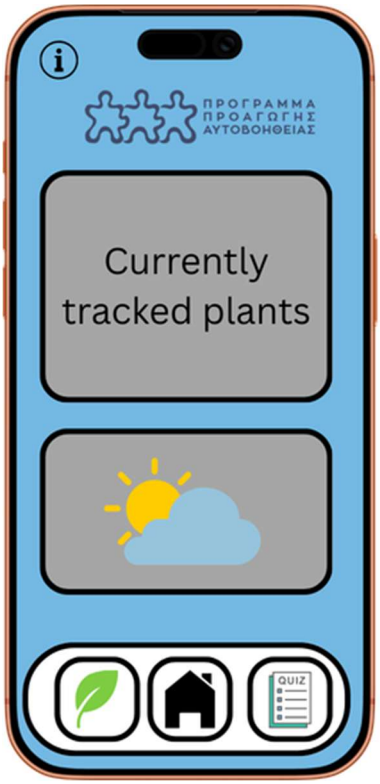

Figure 3.2 - *Application home screen*

The home screen is designed to give the user as much access to the application's other main activities and functions. Users have access to the plant library and database on the bottom left of the navigation bar (navBar). And on the bottom right is the quiz screen, where students can put their capabilities to the test. At the top of the home screen is SHPP's logo. In the top-left corner is an info screen that shows the user's in-app settings and privacy information. In the middle of the screen are two widgets, ‘currently tracked plants’ and ‘ weather’. The ‘currently tracked plants’ section will project the plants that the user currently has recorded as being planted and being tended to in the gardens. Users can select each plant to see suggestions based on meteorological patterns and information from the Treli Rhodia database. The ‘Weather’ screen shows the current weather in Thessaloniki. This allows the app to display a screen or send a push notification about the current weather, helping users make more informed decisions based on current conditions.

The Plants Screen:

The info screen maintains the navBar at the bottom of the screen. It also displays a collection of plants grown at the Trelia Rhodia greenhouse; these are clickable icons. When a user taps an information card, they will be presented with information on how to grow the plant and the best time of year to plant, based on information from the Treli Rhodia database. This will allow the user to easily access information on all plants in the database, which are likely to be grown in school gardening initiatives.

Figure 3.3 - *Application plant screen*

The Quiz Screen:

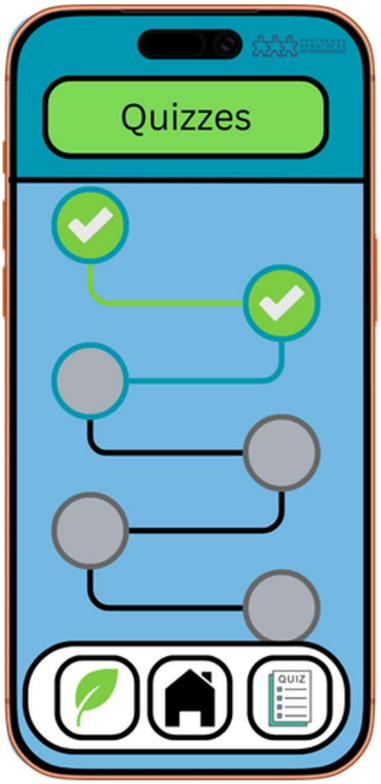

Figure 3.4 - *Application quiz screen*

The Quiz Screen is where students can view their current quizzes. As they progress, they can access more difficult quizzes, unlocking further challenges along the way. These quizzes will be designed based on the previously mentioned surveys of teachers, allowing our team to tailor them to current environmental education curricula. These buttons will lead to a fourth screen, where the user is given a test based on their current progression in the app. Their progression is based on how many quizzes they have passed or haven't passed, in a path progression fashion.

The Quiz Subscreen:

This screen shows where the students will be presented with quiz material. The interface is similar to other gamified education apps, such as Duolingo, Quizlet, and Kahoot. These gamified forms of education found the best approach to be multiple-choice questions, and we seek to model these predominantly successful applications of gamification in our application. The quizzes will also offer supplementary content, available at the bottom via the 'Hint?' button, where students can refer to the material and return to the quiz to complete it.

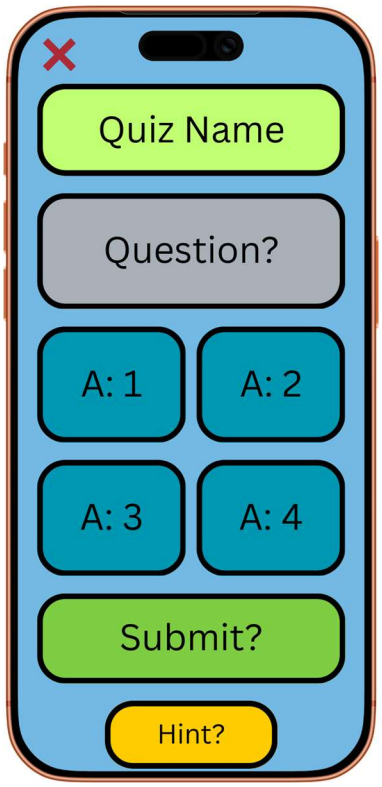

Figure 3.5 - *Application quiz subscreen*

3.4.2 Development

Application development will follow an iterative, user-centered design approach. Findings from teacher surveys, student and greenhouse observations, and focus groups with Treli Rhodia workers will inform initial design decisions. These findings will shape the app's learning objectives, user interface structure, accessibility considerations, and gamification mechanics.

The development process will include:

- Translating sustainability and permaculture learning goals into interactive modules appropriate for primary and secondary students.

- Designing gamification features that balance intrinsic motivators, such as mastery and autonomy, with extrinsic motivators, such as points, levels, or achievements.

- Creating visual and structural elements that are intuitive for beginner users with varying levels of technological expertise

- Ensuring alignment with classroom constraints identified by teachers, including limited time, technology access, and curriculum requirements.

We will begin by creating wireframes and low-fidelity prototypes to test the app's layout, navigation, and content clarity. Based on early feedback, these prototypes will be refined into a functional version capable of being piloted within selected partner schools of Treli Rodhia Greenhouse.

3.4.3 Testing

Testing methods will include structured internal prototype evaluation conducted by the research team and SHPP sponsors, followed by survey-based feedback from teachers after app use during scheduled gardening sessions. Internal testing will involve completing predefined in-app tasks to assess technical functionality, navigation clarity, language simplicity, accessibility, and consistency of game mechanics. Identified issues will be documented systematically and addressed before the exposure of students.

Following internal refinement, students and teachers will provide feedback through structured surveys administered after interacting with the app. Survey items will assess ease of navigation, clarity of instructions, perceived engagement, educational value, age appropriateness, and alignment with gardening and sustainability learning objectives. Surveys will include rating-

scale items and short open-ended questions to capture both quantitative trends and qualitative insights. All responses will be anonymous and analyzed in aggregate form.

This iterative process will allow the team to identify technical limitations, unclear instructions, accessibility concerns, and ineffective game mechanics and implement targeted revisions between testing rounds. Particular attention will be given to readability, developmental appropriateness, user interface simplicity, and alignment with experiential learning goals.

By integrating internal evaluation and stakeholder survey feedback directly into the refinement cycle, the final prototype will reflect both pedagogical priorities and practical realities of classroom implementation. The resulting application will be contextually grounded, developmentally appropriate, and classroom-ready, enhancing sustainability education and supporting beginner-level gardening literacy among primary and secondary students.

3.5 Proposed Timeline

While the team will finalize the timeline and our methodology in close collaboration with our sponsors at SHPP, **Table 3.1** profiles the estimated project roadmap we plan to follow.

Table 3.1: Proposed Project Timeline (will be revised for final submission).

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Appendices

Appendix A: Teacher Survey Consent Form and Preliminary Teacher Survey Questions

We are a group of four students from Worcester Polytechnic Institute, Massachusetts, USA, working on a collaborative project with the Self-help Promotion Program (SHPP) to develop a gamified educational app that supports sustainability and gardening initiatives in primary and secondary schools. The purpose of this survey is to assess curricular integration of sustainability and gardening material within the classroom and to inform feasible app integration within these classroom realities. We will ask questions about your teaching experience, how sustainability and gardening fit into your classroom, how students participate in and learn from these activities, the role technology plays in learning, and any practical factors that shape what is possible in your teaching environment. This survey will take approximately 10 minutes to complete. Your participation is completely voluntary, and you may withdraw at any time. Please remember that your answers will remain anonymous. No names or identifying information will appear on the questionnaires, in any project reports, or in publications. Your participation is greatly appreciated. Should you have any questions or concerns, we can be reached at gr-SHPP-D26@wpi.edu or through our advisors Melissa Butler (mbutler@wpi.edu) and Robert Kinicki (rek@wpi.edu). For more information about this research or about the rights of research participants, please contact irb@wpi.edu.

Section A: Teacher Background

Q1. What grade level(s) do you currently teach?

☐ Primary (Grades ___)

☐ Secondary (Grades ___)

Q2. How many years of teaching experience do you have?

☐ 0–3 years

☐ 4–7 years

☐ 8–15 years

☐ 16+ years

Q3. What subject(s) do you primarily teach?

(Short answer) _____

Section B: Gardening & Sustainability Teaching Context

Q4. What environmental or sustainability topics are currently included in your teaching?

(Short answer) _____

Q5. How is gardening or sustainability incorporated into your classroom or school activities?

(Short answer) _____

Q6. What learning goals do you hope students achieve through gardening activities?

(Short answer) _____

Q7. How often do you incorporate garden-based or experiential learning into your curriculum?

☐ Every day

☐ 3–4 times per week

☐ 1–2 times per week

☐ Monthly

☐ Rarely

☐ Never

Section C: Student Engagement

Q8. Which aspects of gardening activities do students seem most engaged in?

(Short answer) _____

Q9. Which aspects appear most challenging for students?

(Short answer) _____

Q10. How do students typically interact during gardening lessons?

☐ Mostly collaborative group work

☐ Mix of group and individual work

☐ Mostly individual work

Section D: Technology & Learning Practices

Q11. What digital tools or technologies do students currently use for learning?

(Short answer) _____

Q12. In your experience, students respond best to:

☐ Technology-based learning

☐ Hands-on / experiential learning

☐ Lecture-style learning

☐ A combination of methods

Q13. Have you used gamified learning strategies (e.g., points, rewards, challenges, competition)?

☐ Often

☐ Sometimes

☐ Rarely

☐ Never

Section E: Home–School Learning Context

Q14. To your knowledge, do students continue gardening or sustainability activities outside of school (e.g., at home or in the community)?

☐ Often

☐ Sometimes

☐ Rarely

☐ Not sure

Section F: Classroom Constraints

Q15. What challenges limit your ability to implement gardening or sustainability activities?

(Check all that apply)

☐ Limited time

☐ Curriculum requirements

☐ Lack of resources

☐ Limited outdoor space

☐ Technology access

☐ Training/support

☐ Other: _____

Q16. Please share any additional comments about sustainability education or gardening in your classroom.

(Short answer) _____

Appendix B: Gamified App Testing Consent Form

Project Title: Developing a Gamified Educational App for Sustainability and Gardening

Investigators: WPI Student Team, gr-SHPP-D26@wpi.edu

Project Purpose:

The purpose of this project is to test a prototype of a gamified educational app designed to support sustainability and gardening initiatives. Your feedback will help improve the app's content, usability, and design for beginner-level learners.

Procedure:

You will be invited to interact with the app at the Treli Rhodia greenhouse. During the session, you will follow guided tasks in the app and share your thoughts and observations with the team. Field notes will be taken to document your feedback. No audio or video recordings will be collected unless you explicitly consent. The session will last approximately 60 minutes.

Risks and Benefits:

There are no known risks or direct benefits to participation. Your involvement will contribute to the improvement of an educational tool designed for local schools.

Use of Data:

Your input will be used by the project team to refine app features, content, and usability. All information will remain anonymous, and no identifying information will be included in reports, publications, or presentations.

Voluntary Participation:

Participation is entirely voluntary, and you may withdraw at any time without any penalty. If you have questions or would like more information about this project, please contact the team at gr-SHPP-D26@wpi.edu or our advisors, Melissa Butler (mbutler@wpi.edu) and Robert Kinicki (rek@wpi.edu). For information about your rights as a research participant, you may contact irb@wpi.edu

Appendix C: Student Observation Field Guide

Observer _____

Date: _____

School: _____

Grade Level: _____

Number of Students: _____

Location

☐ Outdoor Garden

☐ Classroom-Based Gardening

☐ Other: _____

Type of Activity

☐ Planting

☐ Harvesting

☐ Watering

☐ Maintenance

☐ Instruction

☐ Other: _____

Duration of Observation: _____ minutes

Engagement Indicators

A. Student Participation

☐ Majority actively engaged

☐ Some disengagement observed

☐ Frequent redirection needed

Notes:

B. Collaboration and Peer Interaction

☐ Strong teamwork

☐ Moderate collaboration

☐ Mostly individual work

☐ Conflict or disengagement observed

Notes:

C. Responsiveness to Teacher Instructions

☐ Immediate response

☐ Occasional clarification needed

☐ Frequent repetition required

Notes:

D. Use of Tools and Materials

☐ Confident and appropriate use

☐ Some uncertainty

☐ Limited access to materials

☐ Safety reminders needed

Notes:

E. Transitions Between Activities

☐ Smooth and efficient

☐ Minor downtime

☐ Noticeable disengagement

Notes:

Environmental Factors

Space layout effective? ☐ Yes ☐ No

Materials sufficient? ☐ Yes ☐ No

Weather: _____

Time of day: _____

Notes:

Reflections

Key Drivers of Engagement:

Barriers Observed:

Ideas for Gamification Integration:

Appendix D: Treli Rhodia Greenhouse Visit Observation Form

Observer: _____

Date: _____

Visit Number: _____

Greenhouse Area: _____

Staff Supervisor Present: _____

Type of Activity Observed / Participated In

☐ Planting

☐ Watering / Irrigation

☐ Harvesting

☐ Soil Preparation / Composting

☐ Maintenance (weeding, pruning, cleaning)

☐ Tool Organization

☐ Instruction from Staff

☐ Other: _____

Duration of Visit: _____ minutes

Participation and Learning Indicators

A. Beginner Task Accessibility

☐ Tasks easy to understand with explanation

☐ Required demonstration before participation

☐ Multiple steps difficult to follow

☐ High learning curve observed

Notes:

B. Workflow and Task Sequence

☐ Clear step-by-step process

☐ Moderate coordination required

☐ Tasks dependent on staff guidance

☐ Workflow unclear or inconsistent

Notes:

C. Interaction with Tools and Materials

☐ Tools intuitive for beginners

☐ Some uncertainty using tools

☐ Safety guidance required

☐ Limited access or sharing observed

Notes:

D. Staff Guidance and Instruction Style

☐ Demonstration-based learning

☐ Verbal explanation emphasized

☐ Trial-and-error encouraged

☐ Collaborative instruction

Notes:

E. Environmental and Spatial Factors

Layout supports workflow? ☐ Yes ☐ No

Tools easily accessible? ☐ Yes ☐ No

Work areas clearly defined? ☐ Yes ☐ No

Environmental Conditions: _____

Notes:

App Development Reflections

Realistic Beginner Challenges Observed:

Tasks Suitable for Gamification:

Potential Game Mechanics Inspired by Visit:

Database or Educational Content Ideas:

General Reflections

Key Insights from Participation:

Questions or Follow-Ups for Staff:

Connections to School Garden Observations:

Appendix E: Treli Rhodia Worker Focus Group Guide

Project: Gamified Sustainability Education Application Development

Location: Treli Rhodia Greenhouse

Session Duration: Approximately 60 minutes

Moderator: _____

Note Taker(s): _____

Date: _____

Number of Participants: _____

Purpose of the Focus Group

The purpose of this session is to gather insights from Treli Rhodia workers about their experiences learning gardening from a beginner perspective and to brainstorm ideas for realistic and educational game features for the sustainability learning application.

Participants are encouraged to share experiences, opinions, and suggestions openly. There are no right or wrong answers.

Opening Script (Moderator)

- Thank participants for attending.
- Explain project purpose and how feedback will inform app design.
- Remind participants:

- Participation is voluntary.
- Responses will remain anonymous.
- No identifying information will be recorded.
- The session will be documented through written notes only.

- Encourage respectful discussion and equal participation.

Section A: Gardening Learning Experience (10–15 minutes)

1. When you first began gardening here, what was most difficult to learn?
2. What skills or knowledge took the longest to understand?
3. What helped you learn gardening most effectively?
    - Watching others
    - Hands-on practice
    - Instructions or explanations
    - Trial and error
4. What mistakes do beginners commonly make?

Notes:

Section B: Beginner Challenges & Motivation (10–15 minutes)

5. What makes gardening enjoyable or motivating for beginners?
6. What causes frustration or confusion when learning gardening?

   What helped you stay interested while learning?

Notes:

Section C: Brainstorming Game Features (15–20 minutes)

8. If gardening were turned into a game, what activities would work well as challenges or levels?
9. What kinds of rewards or achievements would motivate learners?
10. What should a gardening game teach first?
11. What real greenhouse tasks should definitely be included?
12. Is there anything important about learning gardening that we did not discuss?

Prompt ideas (if discussion slows):

- Progress levels

- Skill-building challenges
- Cooperative tasks
- Problem-solving scenarios

Notes:

Closing Questions (5 minutes)

13. Is there anything important about learning gardening that we did not discuss?
14. What advice would you give someone designing a gardening learning app?

Final Notes:

Moderator Reflection (Completed After Session)

Key Themes Identified:

Promising Game Ideas:

Observed Points of Agreement or Disagreement:

Implications for App Design:
