

Integration and Promotion: Integrating Sustainability Research into Computer Science Teaching through Serious Games Assignments

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Abstract: “Serious Games” is a final-year 20 credit point module, undertaken as the default optional module for students on Undergraduate courses entitled BSc Computing and BSc Computer Science (Games Technology) at Nottingham Trent University, UK. The module focuses on developing students’ critical evaluation skills, enhancing their ability to design and implement solutions for a real-world design brief, working with clients and making final products accessible to a broad target audience. Historically this was achieved through engagement with a single client, often via a wider research project or local educational establishment of some sort. More recently, the module has retained two client project briefs, which the students are then empowered to choose between. With each client brief the module team has sought to add extra value for the students. For the previous two academic years, the module team has partnered with Green Academy, a strategic team within the University whose priorities include stimulating pedagogical innovation and practice sharing within the area of sustainability and pioneering a shared understanding of sustainability education. The resulting partnership has introduced a brief for students which combines vital industry skills with sustainability literacy. Working with and alongside the students who are undertaking the module, the module has developed Serious Games on a diverse range of local and global sustainability issues and has exposed students to university research culture and our sustainability research specialisms. It has also necessitated that students engage with and contextualise the United Nations Sustainable Development Goals and the UNESCO ESD competencies which they are tasked with integrating into their design solutions. The long-term intent of this partnership is for these design decisions to be utilised in the Green Academy’s ongoing strategy to further enhance the University’s pedagogical framework and sustainability education offer, and to improve the provision of Serious Games for use by clients outside the University. This report is a synoptic overview of the module design and insights from the two-year partnership as well as how these observations have been leveraged to improve the design and delivery of the module for future clients and students.

Keywords: Serious Games, Interdisciplinary, Student-led Design

1. Introduction

As a module undertaken by students seeking to complete courses in and receive awards for BSc Computer Science (Games Technology) and BSc Computing, the current and ongoing primary objective of the module is to provide students with experience of working with real-world clients and creating prototypes to meet client briefs. Clients may take the outputs forward, either deploying them within their workplace, or developing the prototypes further, potentially alongside the students. The tangible benefits of this model are clear to students; they create a piece of project work that has focus, utility, and is easily understood by a potential employer. Their output can demonstrate that they not only have the technical ability to provide a working prototype, but that they are also able to understand and work effectively to a client brief with all the important transferable skills and competencies inherent in that scenario.

Clients are selected for the module on a year-by-year basis, with clients approaching the Serious Games module team or vice versa when a synergy of aims is identified. Contact between the team and Green Academy was first established early in 2022. Discussions quickly developed into the two teams working together to create a coherent brief which would meet the existing aims of the module and the aspirations of the Green Academy. The key initial aspiration for Green Academy was an experimental one; to explore whether students could develop a viable serious game prototype to teach other students about sustainability. The teams also both wanted to provide through the brief an opportunity for Computer Science students to enhance their sustainability literacy and be exposed to university research culture; a unique feature of Higher Education which is sometimes inaccessible to students. To our knowledge the module does constitute a pioneering model within the Higher Education sector in the way it has approached embedding sustainability within the context of computing courses and game design.

1.1 Core Module Learning Outcomes

As part of the Computer Science (Games Technology) and Computing courses, the Serious Games module requires that students, regardless of the brief they select, demonstrate that they are able to:

- Research and investigate previous Serious Games in the selected sector (Parallel Products), and analyse their positives and drawbacks, and utilise knowledge derived from this in their design.
- Communicate with their client regularly, refining the brief and matching their design to it as close as possible.
- Gather feedback from their clients, peers and potential end users, and use this to refine their design
- Investigate the brief beyond the information given, including researching traditional non-games based pedagogy.
- Tailor the game to the entire projected userbase, being aware of the variety of disabilities and disorders that they may have.

Accessibility is an important element of the module which focuses on a “one size fits all” universal design philosophy (Gillern and Nash, 2023). Students need to ensure that design is as accessible as possible, especially as clients often supervise learning for a small number or even majority of students who have a cognitive or physical disability. Given the rapid increase in students (Hubble and Bolton, 2021) and Staff (HESA, 2024) with declared disabilities, especially cognitive and learning difficulties such as Autism Spectrum Disorder, Blindness, Dyslexia, and Physical/Motor impairments, these themes also tend to resonate with students, with many having diagnoses of or experiencing one of these conditions, or having class mates or close friends who do.

1.2 Green Academy Brief

Green Academy provided a brief for students to *create a game based on an area of NTU sustainability research*. Students were advised that the game should:

- Be engaging, accessible, informative and inspire further exploration by those who experience it.
- Make reference to the UN Sustainable Development Goals (<https://sdgs.un.org/goals>).
- Help players facilitate one or more of the UNESCO ESD competencies (AdvanceHE, 2021).

Students were given the following user considerations:

- Your game should work for short-term development; open ended simulations will not work, unless there is a natural stopping point to enable students to return to the game later.
- Game play time should be a maximum 10-15 minutes so that it can be used within lectures and tutorials followed by critical discussion and exploration of learning.
- It must be easily accessible to both students and academics on multiple types of software and be able to be used within the university IT systems e.g. a browser based game.
- People should *want* to play it, so an elements of creativity, fun and excitement are important. We want the game to be memorable and offer critical perspectives.

Green Academy attended near the beginning of the module to deliver a workshop where they launched the brief and led students through a series of discussion activities which introduced fundamental concepts of sustainability such as the United Nations Sustainable Development Goals, also known as the ‘SDGs’ or ‘Global Goals’ (<https://sdgs.un.org/goals>) and planetary boundaries (Richardson et al 2023). Students were prompted to consider how a serious game could facilitate the development of sustainability competencies such as problem-solving, self-awareness or systems thinking (AdvanceHE, 2021) within the player and what could ‘go wrong’ with such a game, so that they might avoid pitfalls associated with sustainability games and serious games in general (Ouariachi, Li and Elving, 2020; Watt and Smith, 2021).

Students were provided with a Google drive containing information folders for six different research projects led by NTU staff (and in one case co-led by a fellow NTU student from the School of Animal, Rural and Environmental Sciences). Each folder contained relevant research papers and one or more recordings of the researchers speaking about their research with the intention that this would enhance the sense of personal connection with the researcher. Students could browse each folder before deciding on one or more research projects upon which to base the game. The research projects were as follows:

- Climate change communications and politics (Poberezhskaya and Bychkova, 2021).
- Arctic lakes and carbon (Stevenson et al, 2021).

- Climate reporting by large companies (Pavlović and Miler, 2022).
- Climate change and biodiversity in 'winterbourne' chalk streams (Sarremejane et al, 2021).
- Citizens, environmental sustainability and local democracy - Nottingham's Carbon Neutral 2028 strategy (Henn and Arya, 2023).
- Local planning for climate change (Haupt et al, 2021).

Green Academy was invited back to attend several formative feedback sessions throughout the year to receive presentations from the students on their work so far, and to catch and advise on any potential flaws in the idea based on their specialist knowledge. Later in the year Green Academy also invited to observe the final demonstration of the prototypes, and finally to sit in on the final assessment session and provide feedback to inform student outcomes (though these were determined by the core module team in all cases).

2. First Year (2022-3 Academic Year)

In the first year of this collaboration, the cohort was split into two separate groups – 12 Games Technology Students and 15 Computing students. Alongside the brief provided by Green Academy, the Serious Games Team also partnered with a local Special Educational Needs specialist school, who requested a number of highly accessible games to assist their students with travel, cooking, and other elements of self-care.

Students were encouraged to use whatever development environment they were most comfortable with. Sessions teaching and supporting the students in using the Unity engine were held throughout the year, which was the development environment most students used. The students on the Computer Science with Games Technology course had previous Unity experience from their second year “Games Programming” module. While the remaining students taking this module also had programming experience, Unity can be time consuming to learn for those with no games development experience. Students were therefore encouraged to use freely available open-source assets where possible and were not assessed on the technical complexity of their games as much as they were on the “core idea”.

The final games were evaluated by a five-member panel consisting of module staff and other specialists in the field of Games Based Learning. The average grade awarded was used as a starting point, with the grade being elevated if the panel felt it was appropriate to combat the natural trend towards more moderate grades that tend to emerge because of taking the average of a grading panel.

3. Observations

Contrary to expectations, students responded better to more structured weekly sessions, than to the less teaching intensive teaching approach offered in the second term. The team’s aim was to enable them to embody their games design at their own pace, where coding support was offered when needed, in a less “hands on approach”. The pressures of other competing coursework deadlines exerted a deleterious effect here in students’ game production schedule. As a result, students voluntarily put themselves under crunch development conditions, which resulted in the final products being more variable in overall quality.

Further, many students were confused by the dual brief nature of the assessment, and a few attempted to meet both briefs. This resulted in a number of games that were not appropriately designed, though as they were required to submit their report for assessment at the end of the first term, most of these cases were caught, and students supported in reworking their design to clearly align with one brief or another.

Student feedback highlighted two primary issues with the scheduling of sessions.

- Students felt that the Unity Development sessions came too late in the year, preventing the students from managing their workload well and causing, in effect, crunch development.
- Students felt like that they did not have sufficient reason to come into sessions, as there was no obvious positive impact from doing so.

4. Second Year (2023-4 Academic Year)

In the second year, the cohort was one merged group of 21 students, of which 10 were on the Computing course, and 11 were on the Computer Science (Games Technology) course. Alongside the brief provided by Green Academy, the Serious Games Team also partnered with the Trent Institute for Learning and Teaching (TILT), who

requested a number of games to boost the internal provision of legally required training (specifically regarding the PREVENT duty, Safeguarding and British Values).

In response to student feedback and to try and maintain engagement, the entire module was more rigorously planned from the start. As highlighted by the previous cohort, Unity Tutorial Sessions were moved earlier in the year to accommodate students who had not used the tools before, and Research and Design focused labs were more evenly distributed throughout the year. The students were given a very clear format through which to log the feedback they obtained, and a number of formative feedback points were explicitly embedded into the teaching calendar. Sessions were also not only tied to the learning outcomes, but also very explicitly to the assessment. Further, students were always given an outlook of the next few weeks, informing the students of what they should be working on.

Entering the second term, we received a lot of student feedback through multiple channels from the Computing cohort that they felt like they needed more programming support earlier in the year. Thanks to flexible working and scheduling arrangements organised by the Team, we were able to rapidly adjust, integrating extra support Surgery sessions, and shifting Tutorials earlier in the year to compensate. The cohort responded very warmly to our proactivity in this manner, and engagement remained very high.

While moving the programming support sessions earlier in the year had a positive impact overall, some students found themselves scaling back their ideas based on what they thought they would be able to implement, rather than forming their ideas around the client's brief. In future years, students will be encouraged to "dream big" then implement as much functionality as they are able to, and explain any "out of scope" functionality during their demo.

We also arranged an explicit "Playtesting Day", where first year students were invited to trial some of the cohort's games and provide detailed feedback. The students were taught a rigorous playtesting process used in the games development industry, focused on making the test as unbiased and rigorous as possible.

- Designing the playtest to be playable with minimal instruction, utilizing Signifiers correctly.
- Preparing a cheat sheet and any emergency helpers in advance.
- Preparing questions in advance (Lemarchand, 2021).

This event ended up being far more popular than predicted, with nearly 70 first year students taking various courses throughout the department showing up for the playtesting session. This naturally caused some organisation issues, but most students benefitted greatly from this session, from finding bugs, gaining accessibility feedback or general enjoyability feedback.

The assessment was undertaken in a similar manner this year – though one extra component that was added was a formal structure for recording and proving feedback had been collected and utilised.

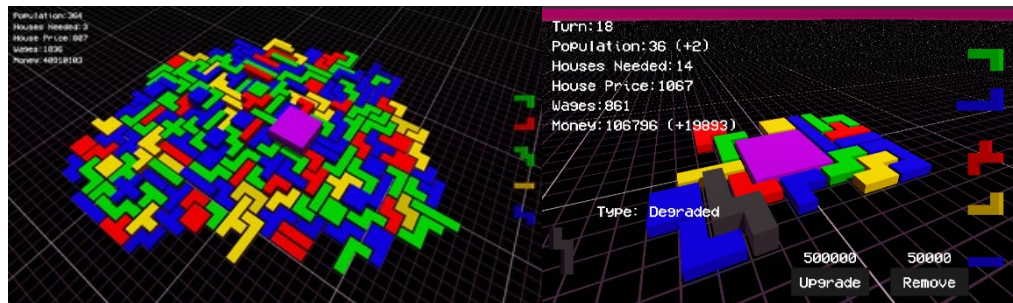
5. Outcomes

Despite some differences outlined previously in the delivery of the module over the two years of the Green Academy brief, both years resulted in several excellent student outputs. As the module allowed students to personalise their output in terms of an aspect of sustainability of their choice, the resulting prototypes were diverse in theme as well as format including for example a climate negotiation simulation, a game about a CEO seeking to contribute to sustainability before they retire and several games which involve players making decisions about alternative energy options. A number of the demonstration games have been adopted by Green Academy for use in training and events both to educate about sustainability issues and showcase how sustainability can be contextualised effectively across different academic subject areas. A selection of games are described below to illustrate the breadth and depth of student response to the brief.

- **Winterbourne Babysitter:** Based largely on Sarremejane et al's research (2021) on winterbourne chalk streams, Winterbourne Babysitter focuses on themes of Partnerships for the Goals (SDG 17) and the conservation of species, through a narrative resource-based game. The player uses time in a "non-Drought" phase to construct materials which must be used in a "Drought" phase to preserve eggs of various mythological species who have been placed in their care. Once enough time has passed, assuming the player has performed well enough, some researchers arrive to create a more sustainable future for the ecosystem. The endearing characters including various creatures and an NTU Professor from the real-life research project make for an engaging game play which educates players about a little-known aspect of UK conservation activity.



- System Sprawl:** Based on themes of Sustainable Cities and Communities (SDG 11), System Shock is an abstract puzzle game where the player is tasked with placing colored pieces, representing different zones of a growing city, into a grid such that all area types have access to other area types which they need in order to run. As opposed to an active learning approach, this design attempts to inspire the player to think about how cities are built and grown, and adopt strategies to ensure resources, especially energy and other utilities can be used effectively and efficiently. An elegant composition, the game is at once compelling for the player due to the classic puzzle aspects and also visually articulates the complex predicament of trying to allocate finite resources for a growing population.



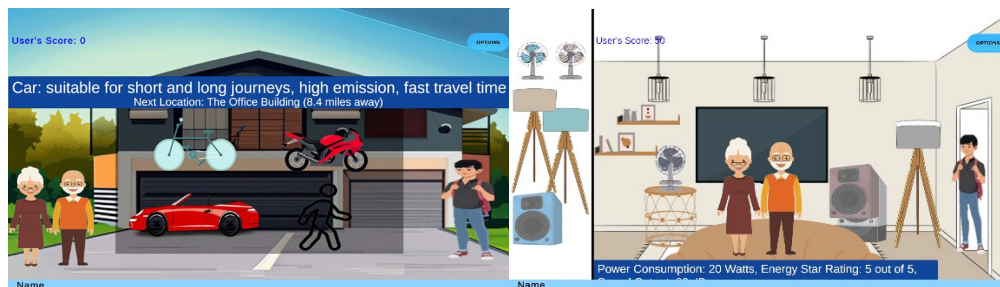
- Kobold Mining Corps:** This clicker game incorporates fantastical lizards representing low-income nations and money-eating dragons symbolising high income nations. Focussing on SDG8 – decent work and economic growth – as well as broader themes of climate justice and geopolitics, the game facilitates both short term and long-term thinking and explores how the strength of individual workers can be multiplied. This game also focused on enabling the end client to enhance and customise the game via an easily edited modular design, requiring little programming experience.



- Environmental Vigilante:** The game is set in a climate dystopia and explores social sustainability issues connected with SDGs 1-3 – No poverty, zero hunger and good health and wellbeing. The character is presented with several tasks to complete to ensure the safety and health of local citizens. One such task revolves around a food bank (a charity food donation point); a nod to the fact that the city where our university is located – Nottingham, UK – has one of the highest uses of food banks in the country.



- **Energy Expedition:** an interesting feature of this game is that it revolves around an intergenerational conversation about sustainability issues with a prospective university student and their grandparents as the main characters. The grandparents send the student around the local town on a sustainability discovery adventure, educating them along the way about ways to be more sustainable within your individual sphere of influence, for example the student is faced with decisions about selecting the most sustainable options of electrical appliances for their move to university. The game focusses chiefly on SDG 7 – affordable and clean energy – with the wider theme of intergenerational learning which is a key tenet of our university sustainability strategy.



6. Ongoing Pedagogical Outcomes

Whilst students were very engaged throughout the year, there were a number of students who struggled with the module's apparent process on "reporting" over programming, in spite of the fact that there is no explicit requirement for programming to be taught or assessed under the module's agreed Learning Outcomes (with programming skills being assessed elsewhere on both sources). In particular, this caused a rift between the Games Technology Students, who had already had significant Unity experience in a second year module, and the Computing Students, who had not. The group who had already undergone teaching of the Unity Engine prior to the module, on average, scored 74% (SD 20%), with 8 of them (72%) attaining a 2:1 or better, whereas the group who had not, on average, scored 76% (SD 16%), with 7 of them (70%) attaining a 2:1 or better.

The appropriate test to determine if these two groups varied significantly is the Mann-Whitney U test, suited to comparing two relatively small sets of data. The U value for the Games Technology group was 53.5, and for the Computing group, 56.5. To disprove the null hypothesis that there is no impact of course on student outcomes, the lower of these would have to be less than 26 ($P < .05$). It seems relatively safe to say that the current provision enables Computing students to perform just as well as their peers in Games Technology – in fact, the statistics this year suggest that the Computing students performed better. Of course, the team is planning on monitoring this difference in years to come, especially considering how provision may be adjusted if the cohort size requires that the groups be split once more. For now, however, the balance of provision shall be left as is.

Therefore, it suggests that the purpose of the report is not strictly clear to the students, as while the report contents cover most of the learning outcomes, the report in and of itself is not, barring that for producing quality written work. Some students have explicitly expressed that the report is redundant. Furthermore, from the perspective of the final year as a whole for both modules, there are few explicit assessments of speaking skills outside of this module. Combined with very positive feedback with regards to the clients being present during their final demonstration, as well as concerns over AI use and workload, this assessment element is currently being changed to a full presentation component with a small written context document or brochure. This also has the effect of reinforcing the idea of communicating with a client in a clear manner, one of the key learning outcomes of the module.

The Playtesting Session, despite ending up being less effective than it could have been due to unexpected numbers and timetable complications, still showed great use and promise to the students. In future years, this session will be extended to a full day, with the testers being straddled throughout the day. Similarly, the structured feedback log will be maintained, as not only were students more clearly able to identify what feedback they had received and used, they were more likely to go out of their way to solicit feedback from their clients, their family and their peers.

The confusion found by the students in their first year was less pronounced this year, indicating that the extra clarifications embedded within the teaching content and the mark scheme helped students differentiate between the two briefs and create a more targeted and focused product. Whilst it's possible this could be further alleviated by mandating that students fill in a form declaring which brief they are following; it appears that this would likely inhibit the students by requiring them to commit to an idea that may not work early on.

Students fed back that they did not feel like there was enough opportunities for them to exchange ideas and help each other to work. This may be alleviated in future years by introducing sessions based on Beichner's SCALE-UP project – giving each student some time to head a roundtable discussion on their design ideas and concepts, either prior to or during the development of the student's first pitch session. (Beichner et al. 2008)

Sustainability based teaching is going to remain embedded into the module, particularly focusing on intersectionalities between equality and environmental sustainability, themes that are going to remain very relevant heading into the briefs to be used in the 2024/5 academic year. There are plans to remain in contact with Green Academy and other departments in the university to enhance teaching on the module and courses, including clear plans to resume a direct partnership in later academic years.

Going forward, the module team is attempting to work alongside their clients and their user groups in order to create highly specific briefs and goals for teaching to address gaps in their current curriculum. The module team has already been through an intensive co-design session with a local user group of SEN students and their teaching and support staff, to prepare the assessment specification and brief for the next academic year.

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