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Crossover Gamified Design

Learning and Assessment for Sustainable Engineering Education

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Abstract

This is a design-capture of a crossover gamified learning experience called *GreenDesigners* focused on sustainable engineering education for high school students. Located at a solar demonstration house, our design leverages the functionality of an Augmented Reality interface developed to coordinate learning of sustainable engineering design concepts and practices across real-world (informal) and classroom settings (formal). It is anticipated that such "seam-ful" (Dourish, 2001) crossover learning and assessment designs could enable a preparatory transition from informal, active learning activities to formal design-focused activities thus expanding learning opportunities for youth within STEM fields.

Introduction

This design-capture emerges from a research project called the *GreenDesigners* where we examine rich interactions in a place-dependent, gamified crossover learning design. We study how this designed learning experience equips science learners with sustainable engineering concepts and design practices to propose and create design-prototypes. Employing *Next Generation Science Standards (NGSS)*, our study is focused on High School standards in Engineering Design and inquires: *How do crossover gamified learning and assessment designs expand youth opportunities for learning discipline-specific concepts and practices in STEM fields?* Participants observe sustainable technologies across the real world site of the solar house while interacting with an Augmented Reality (AR) gamified interface on handhelds (Figure 1) and generate data as learner analytics, video-based interactions, and design prototypes.

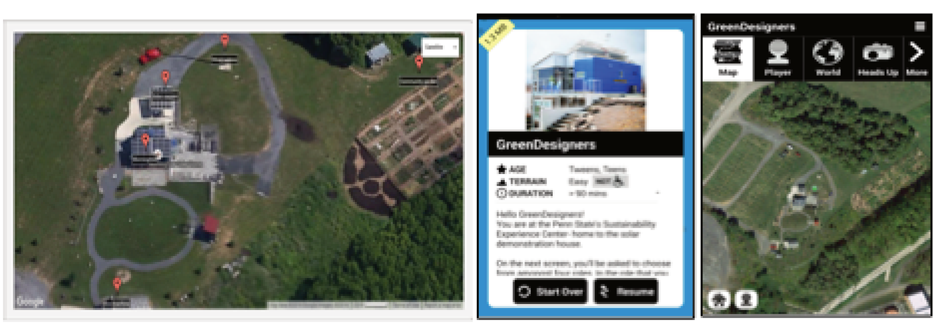

Figure 1. Mapped locations on the real-world site and AR interface GreenDesigners.

Conceptual Background

Expanding upon research on technologically-enhanced, placed-based, informal learning spaces (Dunleavy & Dede, 2014; Salman, 2014; Zimmerman et al, 2015), our study utilizes a design that coordinates STEM learning and assessment in the real world (informal) to that in the classroom (formal). Conceptually referred to as “crossover learning” (Sharples et al, 2015), this coordination promises authentic learner experience that flows as a dialogic continuum across formal and informal spaces and activities. Through our AR gamified interface, we augment learning and assessment components to address the current deficiencies in teaching and learning sustainable education (Batterman et al, 2011). Our design enables interconnections between sustainable engineering design concepts and practices for high school students through the “three spheres of activity for scientists and engineers” (NGSS Lead States, 2013).

Design Elements

Our presentation elaborated the following design elements and shared some insights from the usability testing process.

1. Place Dependence

With our focus on sustainable engineering design concepts and practices, we opted for a place-dependent learning design (Ardoin, 2006; Sobel, 2004) that leveraged the functionality of an AR game platform to augment unique design features of the *MorningStar* – Penn State’s solar demonstration house (Figure 1). Participant’s interaction with the solar house is guided by the interest-based roles they select at the onset. Progress through the physical and virtual levels of the learning and assessment tasks culminate in a design challenge where students propose sustainable design solutions based on their learning experience.

2. Gamified Curriculum

Our design draws upon the NGSS’s Engineering Design standards for high school [HS-ETS1-1, HS-ETS1-2, HS-ETS1-3]. Focal concepts for our study include: (a) active and passive solar designs (b) geographical design considerations- position of sun/natural light and wind direction (c) heat mapping in active & passive solar designs (d) insulation & thermal mass in the choice of materials (e) conductors vs. insulators. We present these as augmented images, videos and embedded assessments overlaid on the physical design features of the solar house (Figure 2). Focusing on engineering practices, these videos feature real life architectural engineers explaining the design decisions and trade-offs that went into the unique design of the solar house. Our gamified interface *GreenDesigners* (the game) is developed on an open sourced, visual programming, AR game platform developed by the MIT-STEP lab that allows the learning path to unfold and evolve with the learners’ self-driven role-based progressive interaction with the physical and digital artifacts. In this way, the interface leverages game elements such as: (a) scene setting (b) role-based player control (c) progress mechanics (d) collective intelligence response, (e) final challenge. Participants earn digital badges upon completion of learning levels. Our interface affords deeper insights into learners’ experience of the performance assessments through real-time learner analytics (Figure 2).

Figure 1. Mapped locations on the real-world site and AR interface GreenDesigners.

3. Seamful Crossover Learning & Assessment Design

The learning process is connected by means of engineering design concepts and practices across the outdoors, informal space and the indoors, formal classroom. The design is a "seam-ful" (Dourish, 2001) crossover of physical-digital, formal-informal where learners are made aware of the transitions spread over:

- the gamified trail across the real world site of *MorningStar*, the solar demonstration house
- the AR gamified interface of *GreenDesigners* (game played on handhelds)
- the embedded assessments at each content-spot
- the design-capstone task in the classroom

Research Methods and Study's Significance

Within Design-based Research (Sandoval & Bell, 2004), non-experimental and qualitative methods are employed. Video based interaction analysis examine interactions as the learners engage with digitally augmented learning and assessment activities as they move through the real world site. Our study contributes to the development and research on digitally augmented crossover learning that is being seen as an impactful design for discipline-specific learning across real-world and classroom settings (Sharples et al, 2015). We anticipate that such designs will expand youth opportunities in the form of preparatory learning transition from a less formal to a formal learning space so that all learners capitalize on their STEM interests and skills.

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https://coil.psu.edu/blog/greendesigners-augmented-reality-learning-experience-for-sustainable-engineering-design/

References

Ardoin, N. M. (2006). Toward an interdisciplinary understanding of place: Lessons for environmental education. Canadian Journal of Environmental Education, 11, 112–126.

Batterman, S.A., Martins, A. G., Antunes, C. H., Freire, F., and M. Gamerio de Silva. 2011. Development and application of graduate programs in energy and sustainability. Journal of Professional Issues in Engineering Education and Practice, October 2011, 198 – 207.

Dourish, P. (2001). Where the action is. Cambridge, MA: MIT Press.

Dunleavy, M., and Dede, C. 2014. Augmented reality teaching and learning. In J.M. Spector et al. (eds.). Handbook of Research on Educational Communications and Technology. 735-745. Springer: New York.

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC.

Salman, F. H., Zimmerman, H. T., & Land, S. M. 2014. Collective engagement in a technologically mediated science learning experience: A case study in a Botanical Garden. Proceedings of the 11th Int Conference of the Learning Sciences. 1, 378–385.

Sandoval, W., & Bell, P. 2004. Design-based research methods for studying learning in context. Educational Psychologist. 39, 4: 199–201.

Sobel, D. (2004). Place-based education: Connecting classroom and community. The Orion Society (4th ed.,Vol. 4). Great Barrington, MA: The Orion Society.

Sharples, M., Adams, A., Alozie, N., Ferguson, R., FitzGerald, E., Gaved, M., McAndrew, P., Means, B., Remold, J.,Rienties, B., Roschelle, J., Vogt, K., Whitelock, D. & Yarnall, L. (2015). Innovating Pedagogy 2015: Milton Keynes: The Open University.

Zimmerman, H. T., Land, S. M., McClain, L. R., Mohney, M. R., Choi, G. W., & Salman, F. H. 2015. Tree Investigators: Supporting families' scientific talk in an arboretum with mobile computers. International Journal of Science Education Part B. 5, 1: 44-67.