Libraries as Collaborative Gaming Spaces: Engineering Academic Challenge

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Abstract

We focus on the role of libraries as collaborative game development and game playing spaces, in context of the Engineering Academic Challenge. The Engineering Academic Challenge is a five-week global game designed to hone students' digital research skills in context of NAE Grand Challenges, developed by a team of engineering students and a librarian at Drexel University on the Knovel and EngineeringVillage information platforms. Game designing and game playing empower students to engage in active learning, a constant cycle of posing questions, testing solutions, and receiving immediate feedback. To generate on-campus participation in the challenge, we organized a series of "marathon" nights in which undergraduate and graduate students gather to play the challenge. Furthermore, the challenge attracted students from outside of engineering. We observed high levels of engagement, interaction with library staff, and enthusiasm during the marathon, demonstrating how games can be used to demonstrate key functionalities of databases and library resources, and their application to research workflows.

Keywords

Information Literacy, Game-based Learning, Engineering Grand Challenges

Introduction

Engineering, science, and technology fields pose particular challenges in identifying, evaluating, and using information from diverse sources and formats, such as journal articles, technical standards, and patents[1]. The American Library Association (ALA) defines Information literacy (IL) as:

> "A set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively that information". [1]

As the basis for life-long learning, information literacy can be considered the core literacy of the 21st century, a "kernel" for all other literacies[2]. The Association of College and Research Libraries (ACRL) standards argue that "developing lifelong learners is central to the mission of higher education institutions" [3], providing the foundation for independent growth by nurturing critical thinking skills. It is well-known that freshman entering higher education tend to rely on basic Google searches[2, 10-13], overestimate their search abilities, and underutilize the tools and resources of the university library. The blame cannot be solely placed with students. Library instruction typically is performed through the "one-shot, approach", in which the university librarian is invited to a classroom to give a PowerPoint overview of the library and its services. In this passive learning approach, there is a latency created between time of instruction and usage of a library resource, requiring repeated contacts with students. [4].

The "digital natives" (applied to those born after 1990) constitute the first generation to have grown up with the Internet and various forms of digital technologies[5], living daily lives immersed in smartphones, text messaging, social media, and digital games. As the most networked generation ever enters higher education, the opportunity is ripe for transforming engineering information learning, from passive to active learning environments where students engage in meaningful dialog, interaction and exploration of various resources to address real engineering problems. Herein, we focus on developing a engineering challenges-themed game based on the Knovel [6] and EngineeringVillage[7] information platforms. The Knovel database provides an online library of science/engineering-focused content, serving over 700 customers worldwide with a collection of 3500 reference items and 90,000 interactive tables, graphs, and equations. The EngineeringVillage platform provides access to 12 engineering databases, including journal and conference articles, trade publications, patents and government reports.

Game-based Learning (GBL) for Large Scale STEM Education

STEM fields produce high attrition rates overall, with nearly forty percent of students who begin STEM degrees leaving for other field. The 1998 Boyer Commission Report *Reinventing Higher Education* [8] called for student-centered learning environments in which students "frame significant questions or sets of questions, the research or creative exploration to find answers, and the communications to convey the results" to become the standard in American research universities. Information literacy skills empower students to leverage a diverse array of information resources to formulate questions, embark on research exploration to find answers, and convey the results in a clear manner[1].

Games are the most interactive and engaging form of media available today, with global reach. Since its inception in 2004, 11 million unique players have spent six million years [9] playing World of Warcraft, rendering it the most successful massively multiplayer online role-playing game ever. Game-based learning refers to the application of game design principles to engage learners, grounded in fostering a sense of enjoyment toward the content itself [10, 11]. In his 2003 monograph entitled "*What Video Games Have to Teach Us About Learning and Literacy*" [10], Gee initiated the conversion on game-based learning, drawing parallels between game design principles and active learning principles. Good games challenge players at the leading edge of their skills, and encourage self-directed exploration of a virtual world to gain intelligence needed to advance through the game in an intensive, "flow-like" state[10]. Game tasks in many cases involve the formulation of hypothesis, experimentation, and instant feedback from decisions made, fitting recent calls at the national level [8, 12] for research or design-based active learning experiences from the freshman year.

University classes are primarily lecture-based, lack real-world connection, and do not adapt to the pace of individual learners. They are the opposite of gaming environments. Ninety-eight percent of students who leave STEM fields, and eight-seven percent of those who persist cite poor teaching as a "major concern"[13]. There is plenty of evidence demonstrating that introducing interactive learning in any form to the classroom environment (e.g. socratic methods, games, research experiences) [13] dramatically improves learning outcomes.

Engineering challenges are increasingly complex and multidisciplinary in nature. In 2008, the National Academy of Engineering (NAE) convened a panel of worldwide experts to identify the most pressing grand challenges of engineering in the 21st century. This panel identified fourteen

interdisciplinary grand challenges that were "achievable and sustainable to help people and the planet thrive" [21]. In 2009, the NAE endorsed the Grand Challenge scholars program to pilot a new model of engineering education producing a cohort of "several thousand graduates per year" who are uniquely qualified to address the world's most pressing challenge.

We view gaming as a powerful route to expose thousands of students worldwide to the NAE grand challenges, which in turn embody the complexity and transdisciplinary nature of 21st century engineering problems. Game-based learning implementations to-date cover wide-ranging topics including immunology, numerical methods[14], algebra[15], electrostatics[16], cell biology[17], research methods[18], and entrepreneurship[19] from the middle school to collegiate levels[20].

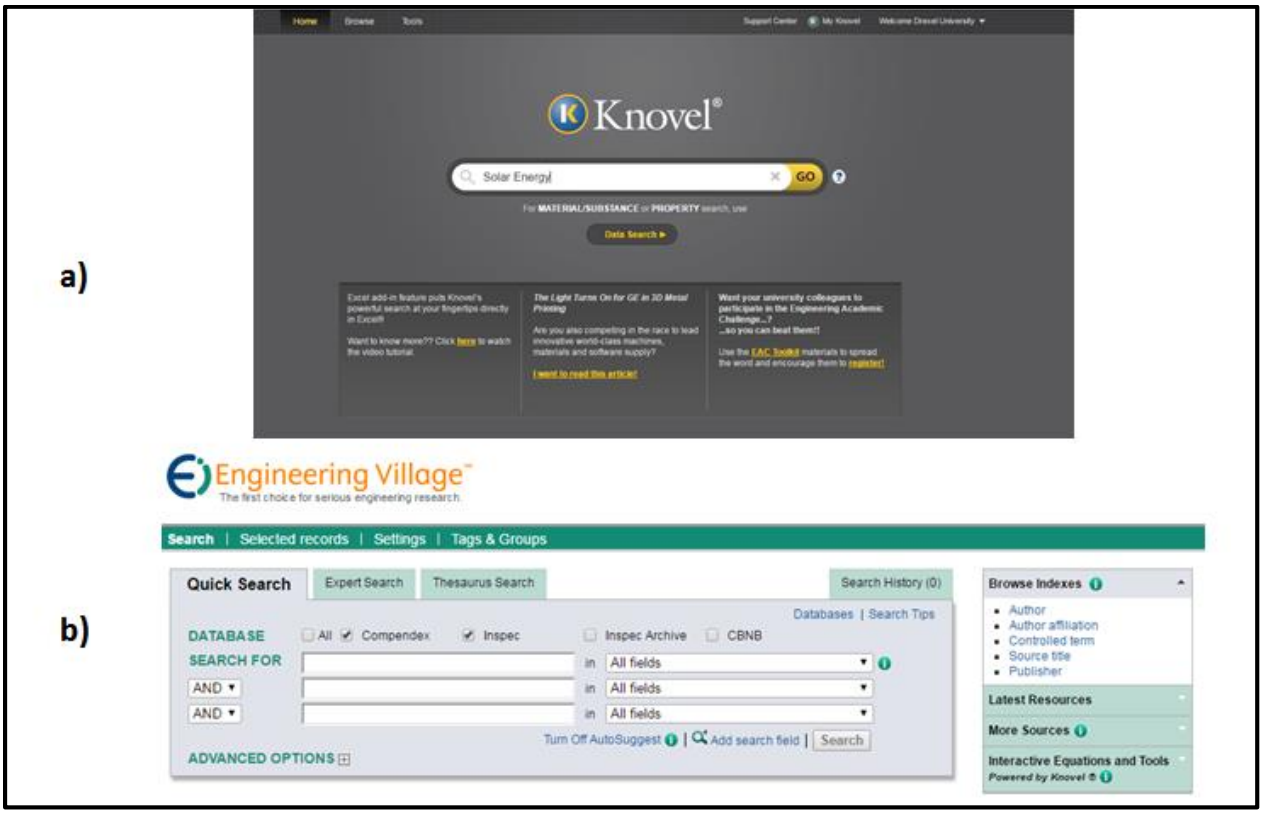

Figure 1: The **a)** Knovel and **b)** EngineeringVillage engineering information gateways

In this work, we describe how our team of students developed the global Engineering Academic Challenge[22] based on the NAE challenges, in which we integrate the Knovel and EngineeringVillage (EV) engineering information platforms (Figure 1) for the first time. Knovel provides access 3500 reference items and 90,000 interactive tables, graphs, and equations, serving more than 700 industry, academic, and government customers worldwide, including over

400 universities. EngineeringVillage indexes the two largest and oldest engineering databases, Inspec and Compendex with content dating back to 1884. This article focusing on the game development extends our prior work on the 2015 Knovel Academic Challenge [23].

Approach

The Engineering Academic Challenge (EAC) was structured around five broad transdisciplinary themes inspired by NAE Grand Challenges [21], with one new theme per week. A table showing the mapping between EAC and NAE grand challenge themes is presented in Table 1. Each question was placed in context of a real world scenario, requiring an infusion of knowledge from Knovel or EngineeringVillage to answer successfully. The EAC was accessible to students in universities around the world subscribing to either Knovel or EngineeringVillage.

Table 1: National Academy of Engineering Grand Challenge themes incorporated in the EAC

Theme	NAE Grand Challenge(s)
Energy for a Sustainable Future	Provide Energy from Fusion, Make Solar Energy Economical, Provide Access to Clean Water, Manage the Nitrogen Cycle
Connectivity in the 21st Century	Enhance Virtual Reality, Secure Cyberspace, Advanced Personalized Learning,
The Future of Making	Enhance Virtual Reality, Engineer the Tools of Scientific Discovery, Restore and Improve Urban Infrastructure
The Future of Medicine	Reverse Engineering the Brain, Engineer Better Medicines, Advance Health Informatics
The Future of Transport	Restore and Improve Urban Infrastructure

Our team developed the game over a series of "hackathons", weekly meetings in which the student game developers engaged each other on potential scenarios for the challenge. A team leader (first author of the article) and an engineering librarian orchestrated development of the challenge and coached the team on developing scenarios and search strategies in the Knovel and EngineeringVillage platforms. Students tested each other's questions to control for quality and the engagement factor. The content was developed on a cloud-based collaborative platform, Google Drive to enable real-time collaboration and seamless sharing at any time or place. This

team itself is diverse in composition, with four cultural heritages, two female members (out of six), at least six distinct engineering fields, and freshman to 1st year graduate students represented.

This team also organizes a series of Academic Challenge marathon nights on the Drexel campus, events livened with food, giveaways, and prizes to further incentivize participation. These events were structured to create informal learning environments, e.g. "learning for fun" [24]. On informal learning, Packer called for educators to "… reject the idea that informal and formal learning should remain separated, and instead focus on empowering both spheres through facilitation, collaboration, and openness to learning from one another" [24].

Outcomes & Discussion

Engineering challenges are becoming increasingly complex and transdisciplinary in nature, reflected in the design of the EAC content. Our design team engaged on a deep level with (i) search skills, (ii) specific tools in Knovel and EngineeringVillage, and (iii) transdisciplinary concepts in order to develop the game. In a two-month period during the summer of 2016, the team produced a total of eighty original questions for the 2016 Engineering Academic Challenge. These questions were situated in wide-ranging "real-world scenarios" grounded in topics including cybersecurity, virtual reality, space exploration, urban infrastructure systems, autonomous driving, additive manufacturing, and synthetic tissues. A snapshot of the new 2016 game is shown in Figure 1, featuring questions based on the NAE Grand Challenge "Make Solar Energy Economical".

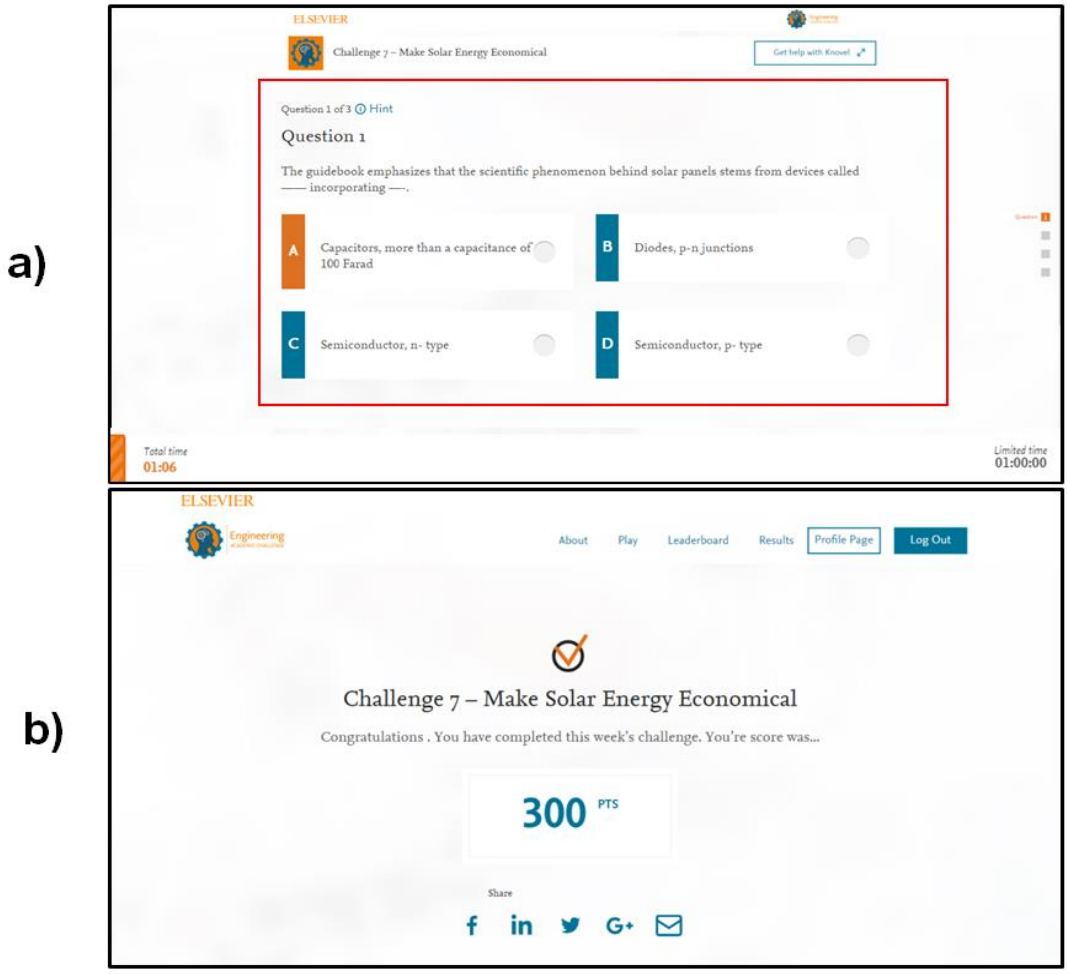

Figure 2: a) The 2016 EAC platform provides players hints, a timer, and direct link into the Knovel or EngineeringVillage platforms **b)** Players can share wins with friends via social media

Figure 3*:* Links to related NAE Grand Challenges are provided directly within the game, to provide students the opportunity to discover interests in engineering

The game was developed in a top-down process, meaning the students would begin with a grand challenge, and search the Knovel or EV platforms to find relevant content to produce interesting questions. After each week of the challenge, players will be given live links to NAE Grand Challenge themes for deeper, self-directed exploration (Figure 2). The most challenging element for the design team was formulating realistic, contemporary challenge questions from divers, transdisciplinary themes of energy, connectivity, making, medicine, and transportation. The questions forced the developers to delve into grand challenges, current events, and even science or technology fiction for inspiration, and locate relevant content in the Knovel and EngineeringVillage databases.

Universities are evolving from the traditional model to an unbundled "information supermarket" [25] where students can customize their learning experiences and pull information "just-in-time". Libraries have an essential role to play in this transformation. As the "heart" of any vibrant research institution, libraries represent a scholarly commons where learners from all fields can intermix, a reflection of the interdisciplinary nature of information. We created informal learning environments (Figure 3) in the format of Engineering Academic Challenge marathon nights, in which diverse students from all colleges and departments could collaboratively play the challenge as a Drexel "team".

Games are the most engaging and interactive form of media known today. Gaming enables new levels of continuous assessment, such as the ability to track "in-situ" sequences of player actions and relate these to performance [26]. Games have excellent potential to become large-scale research platforms for STEM learning. Metrics including persistence throughout the five weeks, time-to-correct answer, and attempt frequency can be monitored to assess higher order problem solving skills. We are currently exploring some of these options in the 2016 Engineering Academic Challenge.

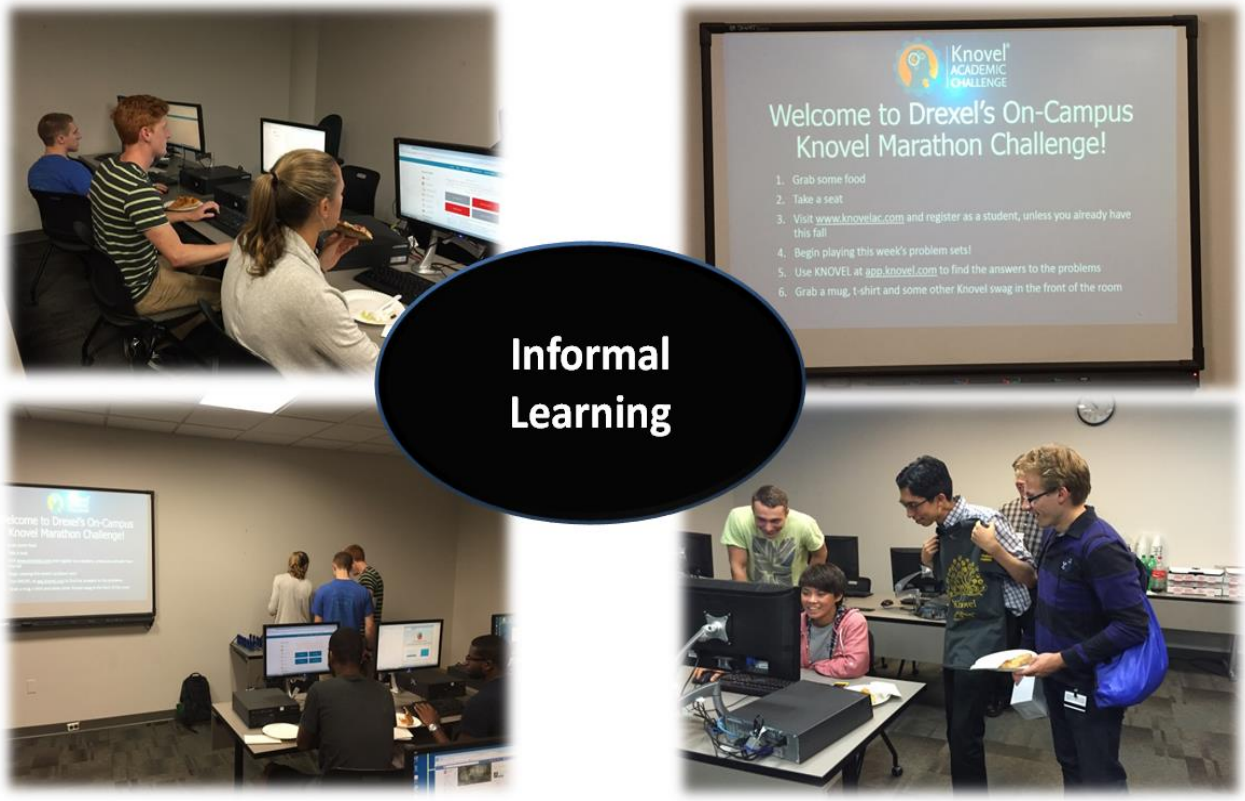

Figure 4: Students playing the 2015 Knovel Academic Challenge for prizes, food, fun, and excitement

At the time of writing, the 2016 Engineering Academic Challenge has not yet launched. Therefore, we briefly show some student testimonials (Tables 2 and 3) from the former Knovel Academic Challenge.

Table 2: Players report the elements they liked about the 2015 Knovel Academic Challenge

Please tell us what you liked about the Knovel Academic Challenge.
I liked the fact that it offered interesting facts about real world problems
The questions were varied and allowed me to explore/learn about many different subjects/topics
I liked the variety of questions
Some questions were fun to answer
Learning different things and searching different fields of engineering
It was a fun challenge to look up solutions to problems which I might never otherwise encounter and learn new things from it
I loved the challenge. It made me work
Challenging to find the answers

Table 3: Players describe their perceived learning from the Knovel Academic Challenge

Please indicate what you feel the Knovel Academic Challenge has taught you.
How to make better searches
interactive methods to problem solving
How to use Knovel as a tool
That Knovel is a great tool
How to refine search terms when looking for a specific phrase, concept
We want more challenges!
Capabilities of Knovel
Ability to search and re-search
Not afraid to make mistakes while searching for solutions

Concluding Remarks

Students can and should become co-creators of their learning experiences, alongside faculty and professional staff. The Engineering Academic Challenge is produced by a small, diverse team of students, for students around the world. As the digital natives enter higher education, libraries and librarians have a key role to play in the transformation from student to professional, especially in STEM fields given the highly specialized nature of information. The need for engaging, student-centered pedagogical approaches cannot be understated in STEM fields, with just under two-thirds of students who begin STEM degrees completing them. Gaming in education remains in its nascent stages, requiring further exploration to become an established part of the STEM education landscape in an information age.

Acknowledgements

The authors would like to acknowledge the team of professionals at Elsevier for their support and collaborative efforts to make the global Engineering Academic Challenge a reality.

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