Paving Digital Infrastructure: Innovation Through an Educational Video Game Database

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Abstract

We are creating an educational video game (EVG) database for university faculty and industry instructors to help them find educationally valuable video games to use in their curriculum. In recent years, EVGs have become an increasingly used tool within higher education curriculum due to their potential for improving and supporting active educational engagement. We define EVGs as video games designed to help people understand concepts and learn domain knowledge. We have two research questions we seek to answer during the development of the database. Firstly, what patterns, trends, and gaps are found within the landscape of EVGs? Secondly, what characteristics do higher education instructors want in this database to help them find EVGs? These questions allow the database to become a beneficial tool by filling the practical needs of academic faculty. Factors such as teaching style and communication take priority when gauging effectiveness, but most important are the tools the instructor selects for their course. The database created will be a collection of EVGs commonly found within university curriculum and workforce training programs to extend accessibility through ease of navigation. Creating this database has included an extensive sorting process, beginning with publishers of educational video games, and cataloging specific information such as URLs for the respective publisher, the EVG's given platform, the subject matter covered, and the total game time. Our initial search included a selection of 1,545 EVGs from 76 publishers. Of those, 120 met the requirements for higher education. We expect this number to grow significantly before presenting our work in progress. As more EVGs are used within curriculum, the creation of a useful EVG database will serve as an important resource—a tool for bolstering educational efficiency and access to resources for faculty and instructors.

Literature Review

Today's students grow up as part of the first generation of learners immersed in digital technology and are therefore more tech-savvy in how they think and learn [1]. The 2003 movement for video games in education and training, known as *serious games*, shaped the way educators approached educational instruction to meet the needs of an emerging network generation [2], [3]. EVGs have impacted various fields including firefighting [4], healthcare [5], and business [6]. EVGs are perceived mostly as a pedagogical tool with a complementary potential to curriculum teachings [7], [8], [9], and its popularity further expanded with the rise of the Covid-19 pandemic [10], [11]. For academic outcomes in engineering education, EVGs have been shown to outperform video-based learning, which has been a common educational tool used throughout the previous decade [12]. Understanding student usage directs interests towards that of educational faculties.

We sought to better understand pedagogical interest in an EVG database through the landscape of EVGs within classrooms and industries. EVGs have become increasingly common for

classroom and workplace training [13], [14]. It is widely proposed that the definite benefits of EVG usage in classrooms outweigh the potential drawbacks. Through the use of EVGs, students have experienced increased motivation and affinity with course concepts [15], [16], [17]. Despite positive gains in self-efficacy, emotional response, and engagement, EVGs remain underused throughout schools [18], [19], [15]. EVGs in higher education share many of the same factors of motivation and engagement among students in learning, offering increased opportunities and diversification among classrooms to provide a better educational experience [18], [20], [21]. These findings highlight the effectiveness of EVGS in higher academia, but understanding employer needs must also be accounted for.

EVGs increase workplace productivity and are therefore sought after by employers for training, providing the opportunity to teach workplace-essential skills like communication and problem-solving [22], [23], [24]. The use of EVGs has shown a positive correlation between employee profitability and competitiveness [25], [22]. Simulations, which can be defined as a type of electronic video game that includes curated experiences that mimic authentic situations, are prevalent in the workplace. Simulations have been proven to facilitate active learning and promote real-world application of curriculum and training [26], [14], [21].

Despite their efficacy, EVGs and simulations are especially difficult to find for use by engineering faculty and students. An efficient and comprehensive database tool for these faculty and students would help to solve this problem. Databases have been regarded as extremely helpful in sharing information, as evidenced by the continued growth of previously existing databases and the creation of new databases [27], [28], [29]. A variety of databases have been created or expanded over the years, including chemical, biological, and other scientific databases that are well utilized in their respective fields [30], [31], [15]. A successful database provides ease of access to certain information and increases the efficiency with which that information can be ascertained. By providing a systematically curated database of EVGs for university and workforce curricula, teachers will be able enabled to find possible EVGs to incorporate into their curriculum [3], [14]. As technology and databases are updated, they provide accessibility to vast amounts of information efficiently and effectively [22]. This study's purpose is to create and assess a database for teachers to find EVGs for post-secondary material.

Methodology

The creation of a higher education EVG database was divided into two parts: the collection of EVGs to be used in a functioning database and the analysis of the collected data to understand the landscape of EVGs. The creation of this EVG database was guided by two key research questions: 1) What patterns, trends, and gaps are found within the landscape of EVGs? 2) What characteristics do higher education instructors want in a database of EVGs to help them find relevant games? To facilitate searching across EVG publishers and developers, we adopted the following definition of an EVG: a video game that facilitates learning, whether intentional or incidental, inside, or outside of the classroom. We then compiled a database of higher education EVGs, documenting information from publishers' and developers' official websites.

For each EVG, we extracted data across several categories, including study details (e.g., author, year, design), characteristics (e.g., subjects, game type, genre), the intended group (e.g., college, industry, training), and accessibility/platform.

Our initial search began by identifying the first 75 publishers of educational video games, serious games, or training games on Google. This produced 1,545 EVGs, which were then organized into a MongoDB database through data filtration. This data filtration process included removing duplicates, non-educational, or discontinued video games. Next, we categorized the key findings and trends from the collected data with a focus on the two key research questions. The categorized data will allow us to determine the landscape of EVGs in the market. Following this, we plan to gather data from teachers on the features needed in such a database tool. Currently, we are working towards the development of the final database product to be used by teachers, faculty, and students.

Exclusion Criteria

The categories of games that did not meet the criteria are summarized below.

Primary Education Games: It quickly became apparent that most EVGs found were designed for younger audiences, mostly spanning from kindergarten to 12th grade. A considerable number of the games we encountered from this category met our expectations as EVGs. However, despite their alignment with that criterion, the exclusion of these games was necessitated by their lack of applicability to higher education.

Simulation/Interactive Experiences: A notable observation that quickly surfaced was the prevalence of simulations and interactive experiences. The challenge with simulations/interactive experiences was whether they could be classified as a game. The uncertainty surrounding those types arose not only from the type of content but also from the duration of "gameplay." Many simulations and interactive experiences often showed characteristics like watching an informative slideshow or video. This intricate interplay of factors heightened the complexity of categorizing such content within our EVG database for higher education. This subsequently caused confusion regarding the precise definition of EVGs. The line between true EVGs and other interactive educational content appeared to be blurred, prompting the need for a more refined and clarified distinction in our categorization process. Consequently, the decision was made to exclude both simulations and interactive content from the analysis. Simulations provide educational benefits, therefore, we concluded that they will be included in the higher education database [17], [23], [12]. Lastly, there were gamified learning tools that turned out to be solely quiz-based, without substantial game structure, functioning more as quiz platforms rather than offering an educational gaming experience.

Non-educational Games: Some of the video games (n = 103) were identified as falling short of meeting a sufficiently high educational standard of potential learning. There were cases where games claimed to teach a particular subject, but the educational aspect was only a minor consequence of the game's existence. This was particularly prevalent in games related to the subject of economy, where the presence of in-game currency was often used as a promotional claim to suggest that the game was imparting economic knowledge on its players. Moreover, there were instances where a webpage would promote math or science video games, but upon closer inspection, most of the games lacked educational value.

Results

While a collection of 1,545 EVGs was initially gathered, only 120 of those met the criteria to be included in this database. An example of an EVG included in the database is *Variant: Limits*, an EVG dedicated to teaching concepts of calculus to students. The most common reason for exclusion was that the game was not intended for post-secondary education. As found when conducting the literature review, there are far more EVGs with a target audience of K-12 education level (n = 630) than EVGs with a target audience of those a part of a university/workforce. Overall, there are 279 simulation games collected in the data; we found it difficult to identify and access EVGs due to the lack of updated databases and publishers. Due to the lack of an existing database for higher education, the need for an effective and updated database is shown. In *Figure 1*, we analyze the games included in the database, the percentage of included entries passing the criteria of an EVG were 13.4%. There are also more games that cover university curricula than those that cover workforce training.

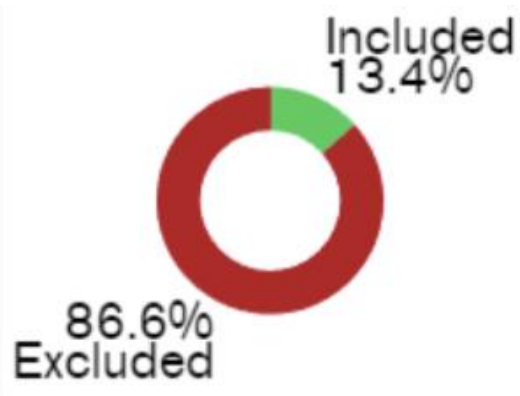

Figure 1: Percentage of Included and Excluded Entries

Out of the games included, there were only a few (n = 4) that were clearly indicated as multiplayer games. This could be explained by the ease of developing single player versus multiplayer games.

The most prominent platform within our database was PC, with Android and IOS being second and third respectively. These three platforms enable increased accessibility due to educational, corporate, and other career institutions usually already having access to PCs, and most global individuals have access to smartphones.

There is a focus on mathematics and sciences within higher education video games, with biology being the most common category (see *Figure* 1). This leaves a need for more available games outside of these disciplines. A lacking spread of disciplines across EVGs could lead to educational gaps, potentially putting students of respective disciplines behind their peers of other majors/professions.

Discussion

While EVG developers do not generally have the production time constraints that many established game development companies face, we hypothesize that educational game developers sometimes lack the resources, hardware, or programming to take on the complexities within multiplayer implementation. This is especially true within the conversation of online multiplayer. A single-player experience also enables complete control of the student's pace of learning. Collaborative learning allows external perspectives and uniquely deep understanding. However, isolated learning does not bear the potential consequence of a teammate being outpaced in the learning process.

It is natural that as technology advances, so too should the ability to utilize that technology. As the world increasingly turns towards digital resources, an EVG database enables those seeking supplemental material to locate relevant resources more efficiently [6], [8], [22]. By centralizing existing learning aids in an individual location, an EVG database minimizes the laborious and sometimes nearly impossible process of locating relevant EVGs for use in the classroom [9], [13]. Rather than searching an unknown quantity of discrete locations for an unknown amount of time, a well-maintained centralized location allows more confidence in a significantly shorter time [10], [15]. Improvements to ease access and confidence in technology build a key foundation for innovation.

While a quick search on Google for "educational video games" yielded millions of results and suggests that EVGs are prevalent, educators find it a challenge to identify only the most relevant search results. There is currently no known all-encompassing EVG database solely for university curriculum and workforce training programs. General game databases, such as Steam and Google Play, lack specifics within their search criteria when dealing with EVGs. Our database is exclusively for higher education/training EVGs, with implemented searches via price, reviews, popularity, developer, publisher, release date, genre, accessibility features, play duration, and related links. Further research and development of EVG databases must continue enhancements in criteria. Working directly with faculty, collecting feedback, and continuous monitoring of the database landscape itself can aid in improvement.

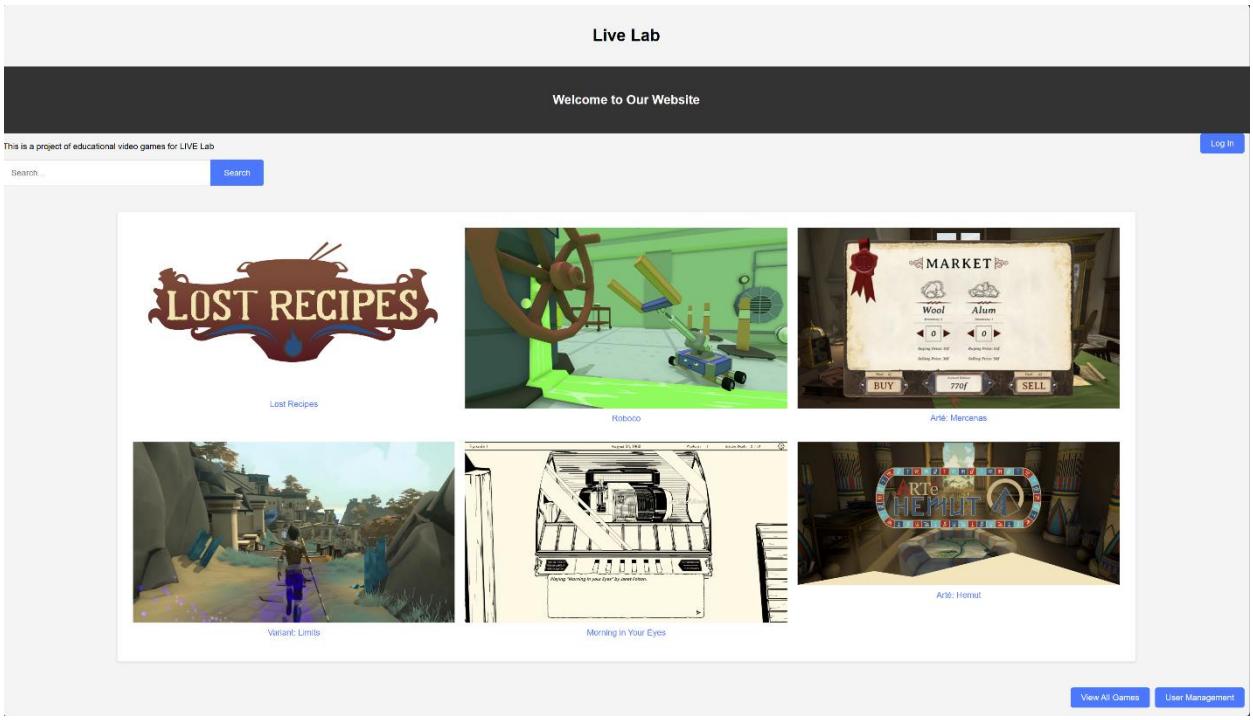

Figure 2: Early Development of Computer Science Team's Website for Database

Our team will continue to develop a database dedicated to higher education/training EVGs under the expectation to add to the collected number of entries. With the recent addition of having a team of Computer Science Graduate students working on the development of a refined database website to be published. The current stage of early development from the Computer Science team is shown in *Figure 2*. Changes continue to be made as emerging research ensures that the database is best suited for efficient retrieval of educationally valuable games. This database will serve as an educationally valuable resource and tool for both higher education and industry.

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