Gamifying a Database Management and Design Final Exam by adding a Choose-Your-Own-Adventure Twist

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Abstract

The paper presents an innovative approach towards enhancing engagement and refining learning outcomes in a database management course through gamification of the final examination. A detailed analysis of the complexity of SQL queries, student behavior in question selection, and their risk-taking tendencies is presented. The crux of this problem revolves around the potential of gamification as a powerful tool to elevate student motivation beyond traditional classroom strategies. The concept of a choose-your-own-adventure style examination, compelling students to navigate interactive narratives and tackle SQL queries of varying complexities, is introduced. A hybrid research methodology combining quantitative and qualitative elements provides an in-depth understanding of student behavior. It has been observed that complex SQL queries present notable challenges for students. There is an evident inclination towards tackling simpler questions, with only a minor section showing a preference for the more difficult ones. Interestingly, contrasting approaches have been identified: risk-averse strategies targeting partial success and risk-taking behaviors aimed at maximizing points. These findings have implications for educators and instructional designers, emphasizing the importance of addressing query formulation challenges and considering student decision-making. Engagement and learning outcomes in database courses can be enhanced by providing targeted support and designing gamified assessments. This research advances the understanding of gamified assessments, showcasing their potential to motivate students, foster SQL proficiency, and provide an engaging learning experience.

Keywords: Gamification, SQL queries, Assessment, Database management, Student engagement

1. INTRODUCTION

Gamification in education, especially Computer Science and Information Systems (CIS), has captured significant interest among information system educators to engage and motivate users over lengthy periods of time (Ozyurt & Ayaz, 2022). Gamification has become prevalent with the advent of online learning (Dichev & Dicheva, 2017; Medeiros et al., 2018; Ofosu-Ampong, 2020). The game-based elements such as points, predefined timeframe, storylines, and levels encourage the students to solve problems with realistic connections between real-world applications and

academic content. Despite the popularity, there is a lack of concrete proof for enhanced student learning, and hence, requires rigorous empirical experimentation (Dichev & Dicheva, 2017). Secondly, current literature leans towards learning processes and outcomes, with a minimal exploration of assessment methods (Morales-Trujillo & García-Mireles, 2020).

Research on the effectiveness of gamification in education has yielded mixed results, with some studies reporting positive effects on student motivation, engagement, and performance. In contrast, others have found no significant difference or even adverse effects. Despite these mixed findings, gamification remains an active research and experimentation area in education (Ozcinar et al., 2019; Ofosu-Ampong, 2020). Many educators and researchers are exploring ways to improve the design and implementation of gamified learning activities and better understand the factors that influence their effectiveness (Dichev & Dicheva, 2017; Majuri et al., 2018; Ofosu-Ampong, 2020).

Designing game-like constructs is not a straightforward process. Past works have hypothesized that this edu-gamification system requires a multidisciplinary approach comprising education, psychology, organization studies, and human-computer interaction (Dichev & Dicheva, 2017; Barber, 2021). Roadblocks in gamification adoption in higher education are potentially due to factors such as prevailing teaching culture, lack of sufficient knowledge about these methods, and the effort required for their implementation (Medeiros et al., 2018).

This article aims to design and evaluate the effectiveness of a "choose-your-own-adventure" (CYOA) based gamified final exam for the senior-level undergraduate Database course. It is derived from the popular interactive story series written by Edward Packard in the 1970s. In these books, the reader chooses sub-plots (such as left or right passageway) on behalf of the protagonist, leading to a different story ending accordingly. Similarly, the students are presented with a series of SQL queries of different levels in our exam. They can take control of the assessment process by earning points based on their perceived skill level: easy, medium, or high difficulty.

The CYOA approach incorporates more aspects of gamification than adaptive tests, where the test-taker has less control over and visibility into the difficulty level of upcoming questions. In our approach, the student can choose to continue at the same level or upgrade to the next one. In contrast, adaptive tests automatically adjust the student to the appropriate level.

This incentivized adaptive assessment approach rewards proficient students with fewer questions, each carrying higher weightage, while providing alternative paths for average or struggling students with more questions worth fewer points. By introducing game-like constructs such as points, levels, predefined timeframe, and storyline, we aim to understand student preferences as they explore different options of easy versus challenging tasks during the assessment process. From a broader perspective, our research goal is to inform the future design and implementation of gamified assessments in this field.

2. LITERATURE REVIEW

This section summarizes the existing literature on the application of gamification in educational settings, with a specific focus on database management and design assessments. Research shows that gamification's popularity surged in 2010, with the following decade seeing significant growth in the field (Dichev & Dicheva, 2017). While numerous studies have explored gamification's potential for improving student engagement, comparatively few have examined its application in assessments. A mere 11 papers delve into the intersection of gamification and SQL, primarily focusing on maintaining student involvement, *leaving a significant gap in the literature regarding gamification in assessment tools*.

The current literature leans more toward the students' perceptions and learning experiences, leaving a crucial area of gamified assessment relatively unexplored. Despite this, the existing body of work suggests potential benefits of incorporating game mechanics into assessments, such as final exams, for boosting student motivation and engagement. Future research requires addressing two key questions: the effective application of gamification principles in final exams and the student's response to these strategies, including influencing factors on their motivation and engagement.

Gamification in Education

The popularity of gamification extends across diverse fields, such as marketing, employee management, and wellness. This review intentionally narrows its focus to its application in education. The widely recognized and frequently cited definition from Deterding et al., 2011, describes gamification as "the use of game design in a non-game context." Several review articles (Dichev & Dicheva, 2017; Majuri et al., 2018; Nah et al., 2014; Ozcinar et al., 2019;

Ofosu-Ampong, 2020) have analyzed the use of gamification gaining rapid momentum in addressing low student engagement and motivation in education.

Gamification has been implemented across numerous contexts and subjects to facilitate learning and influence associated attitudes, activities, and behaviors. These include encouraging participatory methods, fostering collaboration, promoting self-directed study, enhancing assignment completion, streamlining assessments, integrating exploratory learning techniques, and bolstering student creativity and retention (Caponetto et al., 2014).

The review (Dichev & Dicheva, 2017) suggests that while gamification in education continues to evolve, there is currently a scarcity of evidence supporting its long-term advantages, and the practice of gamifying learning has advanced faster than the research on its underpinning methods and mechanics. Additionally, the knowledge to tailor gamification to the unique requirements of specific educational contexts is lacking, thus underlining the need for methodically structured studies to verify the educational benefits and gain acceptance as a recognized instructional approach. The current trends indicate a substantial surge in research interest regarding applying gamification and game elements, specifically within CIS education (Ofosu-Ampong, 2020; Saleem et al., 2022). This trend predominantly focuses on enhancing online learning experiences, especially after the COVID-19 pandemic.

Gamification in CS and IS Courses

The review article (Ozyurt & Ayaz, 2022) states that gamification is one of the most accelerated topics in CIS education research within the last twenty-five years. Gamification in CIS education is primarily targeted toward programming (Call et al., 2021; Kasahara et al., 2019; Zhao et al., 2022), data structures (Dicheva et al., 2019; Spanier et al., 2021), and software engineering (Alhammad & Moreno, 2018; Call et al., 2021; Fraser, 2017; García-Mirelesand & Morales-Trujillo, 2020). The selection of gamification elements differs among studies, with many researchers opting for features such as a points system visualized through a leaderboard, digital badges or stamps, redeemable virtual currency or tokens, and elements fostering social interaction (Call et al., 2021; Saleem et al., 2021).

Framework for Gamified Programming Education (FGPE) project (Paiva et al., 2022) has developed an open-source, general-purpose software platform for creating and managing online gamified programming courses, addressing a significant need highlighted during the pandemic-enforced shift to distance learning. The article by Call et al. (2021) explores and evaluates a gamification strategy that leverages software engineering tools to incentivize CIS students to commence and complete programming assignments (PAs) earlier, given that starting early has been linked to better grades. The study found that while this did not significantly prompt students to start assignments earlier, it did lead to earlier completion, more frequent code commits, and higher unit test pass rates.

The gamification approach particularly appeals to Generation Y, who anticipate a blend of learning and gaming, offering both cost benefits for the institution and performance enhancements (Ofosu-Ampong, 2020). Kasahara et al. (2019) describe educational games' design and assessment targeting undergraduate and postgraduate STEM students. These games, focusing on key programming concepts, were developed to create engaging learning scenarios. The impact of these games was assessed through a combination of surveys, observations, and interviews.

Gamification in Database Course

Games involve planning and designing phases. The developer identifies the gamification subject, purpose, and users during the first phase. The designing phase involves determining game elements, rewards, and setting up analytics to monitor indicators such as user engagement. Gamification in database education is a relatively recent topic (Morales-Trujillo & García-Mireles, 2020; (Tuparov & Keremedchiev, 2020); Zorrilla Pantaleon et al., 2021).

In one of the earliest works on gamification in databases, the study performed by Santhanam et al. (2016) examines the effects of competition in a gamified training design for databases, investigating how facing competitors of different skill levels affects learning and engagement. The results reveal that facing lower-skilled competitors boosts self-efficacy and learning outcomes while facing equally skilled competitors heightens engagement; however, no single competitive structure can enhance both learning and engagement simultaneously, suggesting that the choice of competitive structure should depend on the training outcome priorities.

A recent study (Morales-Trujillo & García-Mireles, 2020) provided empirical evidence on the effects of integrating gamification elements like challenges, points, and leaderboards into Query Competition on student performance, motivation, and user experience in a database course. The study found that the gamified group demonstrated improved motivation, slightly better user experience, and notably, a significant enhancement in student

performance compared to the non-gamified group. The research underscores the effectiveness of gamification in enhancing student engagement and learning outcomes, challenging the current literature that is inconclusive about the improvement of student performance with the use of games in a learning environment.

According to Zorrilla Pantaleon et al. (2021), a gamification strategy was employed in two university-level database subjects to encourage study time outside of class. In the larger Databases course, which had 60 students per year, a badge and experience points system were used for questionnaires. On the other hand, the smaller Information Systems Development course, with 30 students per year, utilized a leaderboard. This leaderboard was based on scores from more involved activities like labs and design exercises. In the gamified assessment of the database course by Ab Rahman et al. (2018), 96% of students reported high engagement during lectures using Kahoot! and Quizizz.

A pilot study implemented gamified self-training and self-assessment in an online SQL course during the spring semesters of 2020 and 2021 (Tuparov & Tuparova, 2021), with generally positive student feedback. The study highlighted significant differences in achievement between groups that utilized gamified self-training and those that did not, emphasizing the effectiveness of immediate feedback and SQL query simulation in enhancing students' SQL skills and knowledge.

The article (Noh et al., 2018) explores the potential of gamification in learning database normalization, a crucial step in designing relational databases, given the limited existing studies on this topic. By reviewing literature and conducting preliminary investigations with students, the study identifies a courseware model composed of gamification features and content learning aspects that could aid in effectively teaching database normalization to computer science students.

Our research investigates the potential of gamified final exams, structured as a CYOA experience, to fill current research gaps. This paper explores using gamification principles to improve assessments beyond traditional classroom motivation techniques through an innovative design and interactive narratives. This approach is evaluated to gauge its effectiveness in enhancing student motivation and experience. The study addresses open research questions related to design, learning outcomes, student perceptions, and generalizability of gamified assessments, providing valuable insights into the potential of gamification in increasing student engagement during assessments.

3. METHODOLOGY

Gamification is a relatively new teaching and learning approach involving game elements and design principles in educational contexts. By applying game-like structures, mechanics, and feedback mechanisms to traditional learning activities, gamification seeks to increase student engagement, motivation, and performance while providing opportunities for more active and immersive learning experiences.

Digital Course Textbook

The course uses the online textbook "Database Management and Design" by MyEducator in a database course. The textbook comprehensively introduces database management and design concepts and techniques, with interactive elements such as flashcards, quizzes, audio, video, and in-line SQL exercises. The exam is open to the MyEducator Textbook, MyEducator Prior Assessments, and MyEducator Course Materials ONLY, and a physical book is allowed for ESL (English as a Second Language) students. The exam covered simple queries, extracting data from multiple tables, entering, and changing data in the database, and various SQL statements.

The e-book creatively blends storytelling with a fictitious shoe-selling business to guide readers through progressive levels of complexity. Over time, the book gradually improves the normal form of the tables in the database, guiding readers through progressive levels of complexity. The interactive nature of the e-book allows for running queries directly within the text, where new information is presented. For example, readers can practice unions in real-time when the concept of a union appears in the eBook. Immediate feedback on queries is provided in some sections, enhancing the learning experience, although this is not available everywhere in the e-book. Combining these interactive elements, such as immediate feedback, real-time query execution, and storytelling, contribute to the gamification of the material, turning the learning process into a more engaging and effective experience. Additionally, the book includes aspects related to report creation, further enriching its content.

Learning Outcomes

The gamification of the final exam is a strategy designed to boost engagement, motivation, and retention of course content. The objective is to effectively evaluate students' comprehension of core principles in database management.

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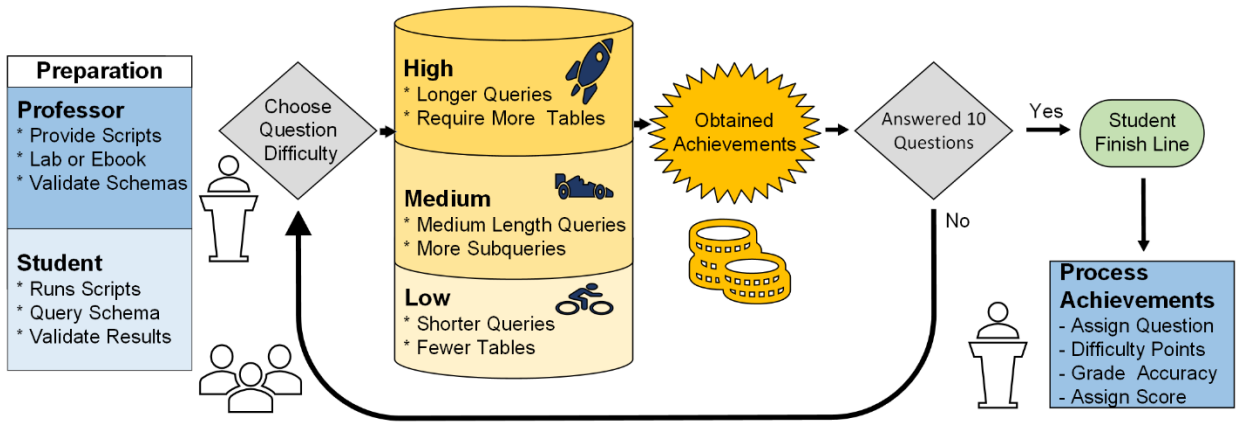

Figure 1: Proposed Workflow for Exam Gamification

The gamified examination aligns with program-level outcomes, primarily the ability to dissect complex computing problems and leverage pertinent disciplines to derive solutions. This format requires students to tackle intricate database management issues, thereby refining problem-solving capabilities and offering practical real-world preparedness. At the *course level*, the gamified final exam addresses several learning outcomes related to SQL query proficiency. Students must design and execute SQL queries of varying difficulty, ranging from simple to complex. They show they have developed proficiency in constructing queries that retrieve data from a database based on specific criteria.

An additional component gauged by the exam includes understanding and applying multi-table joins in a query. Students learn how to connect related data from different tables, enabling them to retrieve comprehensive information for analysis and decision-making. This skill is essential for effectively working with relational databases and extracting meaningful insights. *Aggregate and built-in functions* represent another key learning outcome evaluated by the gamified final exam. Exposure to various aggregate functions like SUM, AVG, and COUNT equips students with the ability to execute calculations on data.

The gamified examination also emphasizes the importance of understanding and implementing the "Group By" and "Having" clauses with aggregate functions. Exercises help students group data based on particular attributes and apply filters to the grouped data using aggregate conditions. This acquired skill empowers students to generate meaningful summaries and conduct advanced data analysis.

Choose-Your-Own-Adventure (CYOA) Exam

This section begins with comprehensive guidelines that the students receive for grading rubrics, grading expectations and even extra credit information in the pre-exam information section (see Appendix 1 - Final Exam Pre-Information for additional details). The final exam will require students to interact effectively with a product sales database. The expectations during this interaction include the capability to execute basic queries that can effectively filter products, customers, or employees according to a range of pre-defined criteria. These may include, but are not limited to, considerations such as product price range, availability, and others.

The CYOA exam format is meticulously structured with queries characterized by three distinct difficulty levels, designated as 10-, 15-, and 30-points. The (easy, medium, and hard) categories represent the query complexity and, thus, the technical skills/exam-readiness students will require to complete the task. Harder queries often require data from multiple tables and a longer SQL statement to return the correct information requested. Queries that are not as complex are often shorter and require fewer tables to return the correct information.

Each category has a specific number of questions, and students must select no more than ten queries to answer. The 10-point category included five options, the 15-point category included six options, and the 30-point category included six options. The queries selected for answering will be graded based on the correct number of rows, columns, and the validity of the items within. These queries must run and are adaptable to future datasets.

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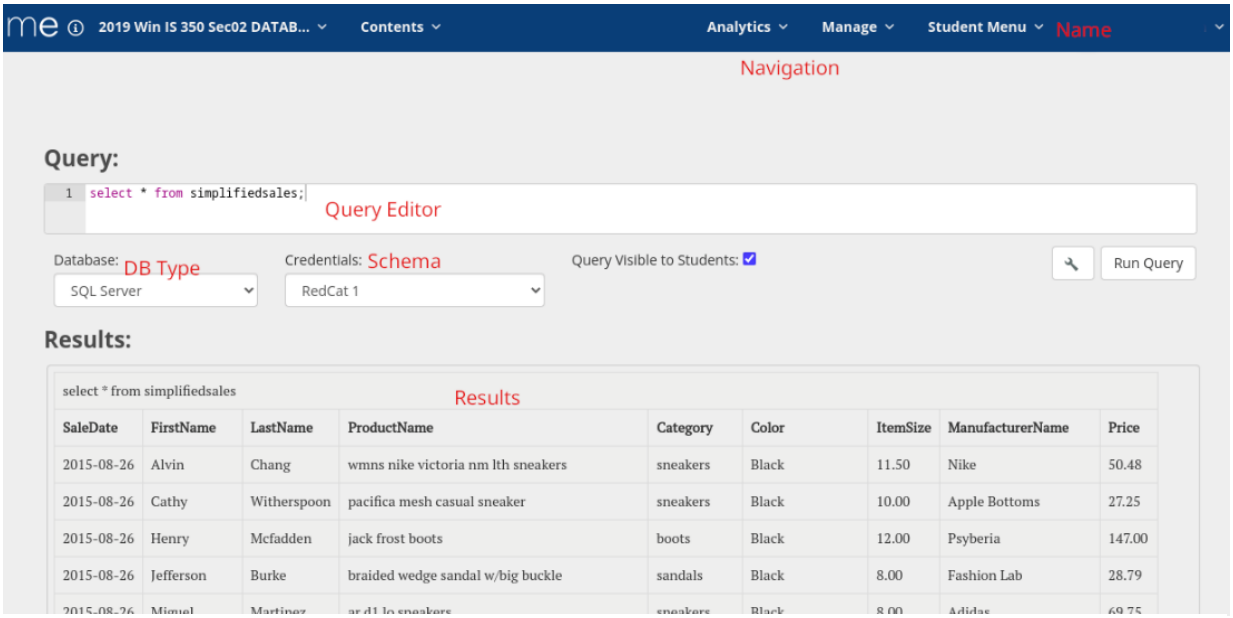

Figure 2: Annotated Exam Page

As a guideline, the students are advised to choose two 10-point questions, four 15-point questions, and four 30-point questions (2x10=20, 4x15=60, 4x30=120, 20+60+120=200), where 200 is the maximum points. This requirement is in place to encourage a sense of balance in their selections between the categories, ultimately aiding them in achieving full credit. However, the students can choose any permutation and combination of the diverse category to maximize their score beyond 200 points, as long as they stay below ten questions. For example, if a student chooses five 15-point and five 30-point questions, they could end up with (5x15) + (5x30) = 225 points out of 200 if the answers are correctly answered. A visual representation of the entire workflow is shown in Figure 1.

An essential aspect of this exam format is the customizable difficulty level. This feature is tailored according to the individual choices made by students and allows the exam to adapt to their personal *exam-readiness, attempt strategy, and time management* skills. By offering a range of difficulty levels within the questions, students can select queries that are most appropriate for their current level of knowledge while also challenging themselves to learn and improve. Additionally, the point system incentivizes students to attempt queries that require a deeper level of understanding by rewarding them with more points for completing these more complex queries.

Regarding submission format, it is essential to note that the examination process is fully digital and takes place on the Canvas learning management system (Figure 2). Each point category is represented as a separate question within the system. Students must input their responses to these exam questions through the essay input field of the Canvas quiz. This feature streamlines the process and allows for efficient data collection and an effective method for subsequent analysis. For transparency, the institutional review board has approved the release of this collected data specifically for research and analysis purposes.

Imbibing Elements of Gamification

To run queries, gamified systems can utilize various utility programs, such as a command line or graphical user interface (CLI/GUI). However, this does not encompass all gamification aspects like levels or storylines. Some GUI tools may resemble specific database browsing tools, which along with other similar tools, can be employed in gamification. Some tools are restrictive about click-and-run queries. Instead, it is tailored for students to manually write and execute SQL queries, with the ability to set up auto-grading and validate results. There are nuanced aspects to various database GUI warrant further explanation, and we plan to explore these without detracting from the paper's main focus.

In CYOA approach, the gamification elements of points, time restriction, story, and level were employed to create an engaging and realistic simulation of a work environment where individuals collaborate in a realistic work environment and divide the various database report requests. The "story" component outlines a scenario where individuals support a system and address reporting requests. It is emphasized that work can be distributed within a

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team, each member selecting ten queries for completion. This scenario offers a contextually relevant, meaningful backdrop to the examination, simulating challenges associated with real-world system support.

The "points" attribute assigns a numerical value to each question, where higher points correspond to increased complexity. This structure incentivizes high performance and engagement during the examination. Time restriction brings a vital element of urgency, necessitating effective time management and question prioritization. This feature mirrors real-world situations, instilling the need for thoughtful time allocation and critical decision-making. The "level attribute" introduces an element of graded complexity, offering questions of different difficulty levels. This feature allows individuals to opt for questions that align with their skill level while nudging them to take on more challenging queries.

Overall, these gamification elements *collectively create* a dynamic and challenging examination environment. The scenario simulates real-world conditions, encouraging the application of database management skills and knowledge in a competitive setting.

4. EVALUATION

This section focuses on three primary areas. The first part highlights the methodologies employed for data collection and analysis. The second part delves into the design considerations for the exam structure, concentrating mainly on the interplay between the length of SQL solutions and related questions. The final part investigates student behavior regarding their choice of questions, providing valuable insights for future assessment strategies.

Data Collection and Analysis

This study collected data from final exams during senior-level undergraduate Database courses in 2018 and 2019 at Brigham Young University – Hawaii. A total number of 108 students took the final exam. The Institutional Review Board (IRB) approved the release of this data for this research, ensuring that ethical considerations were considered in handling the data. The data was collected from Canvas, a Learning Management System commonly used in educational institutions.

Designing the exam questions

In the proposed exam format, students choose from a set of queries to solve, divided into three categories based on the difficulty level and the corresponding point value. Each category includes a specific number of options, and students must select no more than ten queries to answer. The first category, worth 10-points each, includes five options. The second category, worth 15-points each, includes six options. Furthermore, the third category, worth 30-points each, includes six options. The point system encourages students to balance their selections between the categories to achieve full credit.

Two notable trends emerge here. Firstly, it was observed wherein students encounter substantial challenges when formulating queries that demand longer SQL responses. The complexity of constructing longer queries is regarded as significantly more laborious and taxing than the formulation of queries that necessitate shorter SQL responses. Figure 3 visually represents this correlation by demonstrating the length of solutions with respect to each difficulty level. A majority of the 10-point questions predominantly fall under 100 characters. In contrast, all 15-point questions mandate more than 100 characters for accurate response, with the most extended, Question 5, necessitating up to 270 characters. Furthermore, the 30-point questions uniformly demand over 240 characters for a correct response, with the lengthiest one, Question 3, requiring up to 470 characters.

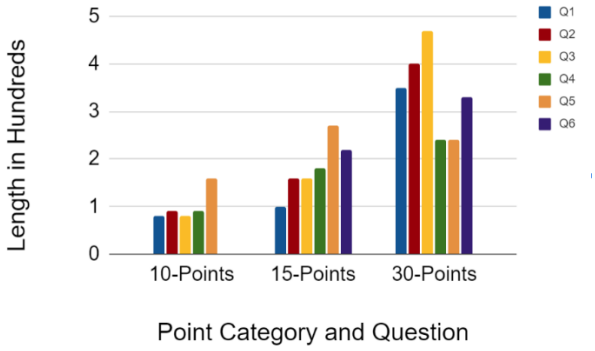

Figure 3: Length of Correct SQL Query Based on Question Category

Secondly, a correlation between question complexity and the need for data from multiple tables has been observed. More challenging queries often require the joining of multiple tables, employing an increased number of aggregate functions, usage of the group by and/or having clauses, and subqueries to retrieve the desired information accurately. Conversely, simpler queries tend to be shorter and require fewer tables. Examples of each difficulty type are presented for reference in Appendix 2, titled 'SQL ANSWER COMPLEXITY'. This comprehensive analysis facilitates a clearer

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understanding of the correlation between the length and complexity of SQL queries and their respective difficulty levels in the examination structure.

Understanding student behavior from question selection

The exam required the students to select a max of 10 questions from three distinct categories: 10-, 15-, and 30-points. These categories correspond to difficulty levels of easy, medium, and hard, respectively. It is suggested that a balanced selection of two queries from the 10-point category, four from the 15-point category, and four from the 30-point category should be made to exploit the breadth of all categories.

Upon inspecting the student trends in category selection, as shown in Figure 4, slight deviations from this recommended advice were observed. The advice to students was to opt for two 10-point questions, four 15-point questions, and four 30-point questions. However, on average, the selections comprised 2.97 10-point questions, 3.69 15-point questions, and 2.54 30-point questions. Moreover, the mean number of questions selected was 9.2, slightly less than the expected ten.

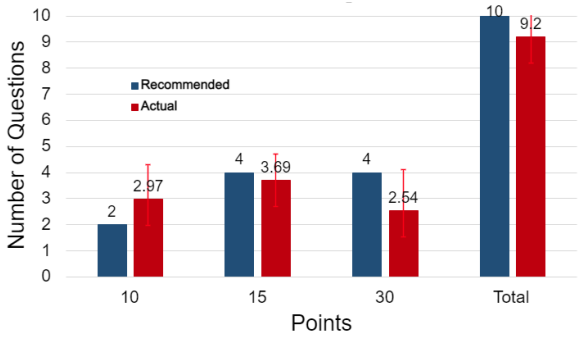

Figure 4: Deviation of Student Question Selection from Advised Distribution

Insights derived from these observations suggest *a propensity among students to attempt more challenging questions, potentially requiring a more significant investment of time and consequently leading to fewer overall questions attempted*. An attempt rate was calculated to evaluate this deviation from the suggested advice. It was observed that students attempted 148.5% of the advised 10-point questions, 92.3% of the advised 15-point questions, and only 63.5% of the advised 30-point questions. This offers a quantifiable understanding of student strategy in examination selection and time management.

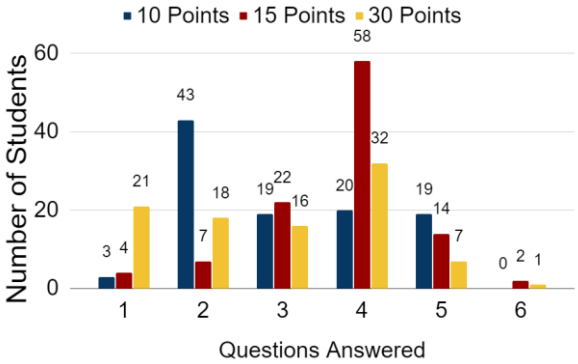

Figure 5: Distribution of Student Responses Across Questions in Different Point Categories.

A deeper analysis of the attempt rate and student question preference presents interesting insights. Figure 5 shows the count of students addressing each question within each category. For instance, in the 10-point category, the first question saw one student's response, whereas the second question attracted attempts from two students, and so on.

In the 10-point category, it was found that all students chose to answer at least the recommended two questions, with the average response being 2.972 questions. It was also noted that 43 students opted to answer only two of these questions. Regarding the 15-point questions, students were advised to answer four questions. However, the average number of questions answered was 3.6851. Of all participants, 58 responded to four 15-point questions, and 16 ventured to answer more than four. In the 30-point category, the suggested response was four questions, but the average response dropped to 2.5370. Only 32 students followed this recommendation, and a handful, eight in total, chose to attempt more than four.

It was also noted that the median test duration was 2 hours and 45 minutes, near the total allotted time of 2 hours and 50 minutes. The average time spent on the test was 2 hours and 35 minutes, measured from the start of the exam until submission, excluding the preliminary period of welcoming the class and distributing the test code. This observation suggests that most students used most of the allocated time, presumably working on questions until the last moments, possibly not completing their final selection.

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Table 1: Perceived Risk-Taking Tendencies vs Final Score

Risk Appetite Level of the Students	Average Score	Standard Deviation	Max Score	Percentage of student population	Average number of questions attempted for each point category		
					10-point questions	15-point questions	30-point questions
High (high-performing)	94%	0.281	120%	9.3%	1.1	3.90	4.90
Normal	66%	0.240	100%	37.0%	1.95	3.95	3.40
Low (risk-averse)	43%	0.220	95%	54.7%	4	3.50	1.55

Discussion

The examination results offered intriguing insights into student behavior and risk-taking tendencies. The majority, approximately 54.7%, of students demonstrated a risk-averse approach. This is shown in the third row of Table 1. Their chosen path was not necessarily designed to earn them full points but rather to secure a good score, highlighting *a preference for guaranteed partial success over uncertain total success*. This approach reflects a pragmatic strategy, likely adopted to avoid the potential disappointment or academic consequences of failing to gain any points. Contrastingly, a smaller portion of students, accounting for 12.04%, showcased more risk-taking behavior. These students aimed to earn more than the full score by attempting a more significant number of the most challenging questions. This risk-taking approach could be linked to higher confidence in their SQL capabilities or a competitive desire to outperform their peers.

Interestingly, high-performing students (first row of Table 1) did not necessarily finish the exam early; instead, they utilized the full allotted time to gain as many points as possible. This pattern was observed even amongst students who had not exceeded course expectations, implying a general tendency to maximize the score, regardless of their overall course performance. Only a tiny fraction of students concluded their exam significantly early, indicating a widespread commitment to make the best use of the allotted time. The most significant variability in points earned was noted in the 30-point category, which may be attributed to the higher difficulty level of these questions and a possible variation in the students' preparation levels.

A subset of students opted for an ascending order strategy, starting with lower-point questions and moving to higher ones. This methodical approach, however, could have resulted in some students running out of time before reaching the high-point questions. A smaller group first opted to tackle the high-point questions, reserving the lower-point ones for the remaining time.

Despite these fascinating insights, these observations should be seen as preliminary. They provide a foundation for future detailed analysis to understand the risk-taking behaviors in exam scenarios better. The apparent risk-averse trend among most students and the contrasting risk-taking behavior among top performers could be fertile ground for future research. This can lead to a more nuanced understanding of student behavior and potentially guide the design of assessments to better cater to varied risk-taking tendencies.

5. CONCLUSION

This paper examines the potential of gamified final exams in enhancing student engagement and learning outcomes in an undergraduate database management course. It analyzes the complexity of SQL queries, student selection behavior, and their approach to risk, providing vital insights into the design and effects of gamified assessments. The investigation utilized a choose-your-own-adventure exam style to stimulate student engagement in tackling complex computing problems. The comprehensive exam data analysis revealed student preference for challenging questions, thereby identifying the need for extensive support in solving complex SQL queries. Furthermore, contrasting student strategies, focused on partial success or maximum points, were observed, indicating diverse risk-taking behaviors.

This study serves as a steppingstone toward understanding the impact of gamified assessments in database courses, supplying actionable insights for educators and instructional designers. It suggests the efficacy of gamification in promoting engagement, enhancing SQL proficiency, and creating an interactive learning environment. Further exploration is encouraged, particularly into the dynamics of risk-taking behavior to design tailored assessments that align with students' learning styles and

preferences.

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Appendices and Annexures

APPENDIX 1 - FINAL EXAM PRE-INFORMATION

Please choose queries to answer from every group. In canvas paste your SQL as well as the number of rows. If less than 10 rows are returned also put the rows in the canvas quiz. **The max queries you can choose is 10. Do not do more.**

With reports please understand that when someone asks for a product they usually want the product **name, not** the product **number**. Same with customers, employees, etc. The exception to this is if it is from a programmatic interface or no good named item is available. In general, and for this test, you should return name/description, not the numerical key. The output should be sorted if more than a few rows are returned and if you are asked to return a calculation you often need to return something it is tied to. **Reports should be able to be run in the future or with different data sets and still be correct for the other data set.**

Example: How much does each employee make in a year?
The answer should return employeeName and the calculation that calculates how much earned in a year. This would likely be sorted by employeeName. If you were looking for the top or bottom earners you would sort by the calculation. It may also be good to name the calculation something like yearlyEarnings.

Points will be given as follows.
Correct # of rows 50%(*For single row returns this will be moved to the validity check), **Correct columns returned 20%**. Do not select * unless asked for, Check for **validity of items returned 30%**. Include the result set up to the first ten rows.
Please include the number of rows by surrounding your query in "Select count(*) from (YOUR QUERY GOES HERE) sq" *You may need to name aggregate columns and order by removed.

The max queries you can choose is 10. You are advised to choose them according to the points allocated. One of the queries is considered worth the points of two. You can choose to do another query or not and use the extra potential points as extra credit.

For minimal credit, you can also do all of the lower point queries up to the 10 queries. If you get them all correct you only get the points allocated. Example if you did 5 10 point queries and 5 15 point queries **your score would be 125 out of the total points possible or 62% if you get 100% correct on all of the queries you choose.**

For maximum credit, you could do all of the 30 point questions and as many 15 point questions as possible. **This would give you 240 out of 200.** They are more difficult. Be careful when choosing your queries.

The test is open MyEducator Textbook, MyEducator Prior Assessments, and MyEducator Course Materials ONLY. I will allow a physical book for ESL students. Example English to Tongan and Tongan to English.

A few notes on definitions
On-Hand is similar to inventory in stock
An account representative is also a Sales Representative (Item in the customer table linking to the employee table)
OrderValue should be tied to priceEach, not msrp. OrderValue does not equal priceEach. OrderValue is priceEach*quantityOrdered summed by all things ordered

To help remove the fears of the past exams I have chosen only questions that do not need distinct. Please do not put distinct in your query. It should not matter at all unless you are grabbing the data from the wrong table.

APPENDIX 2 - SQL ANSWER COMPLEXITY

Points	SQL Structure
10	SELECT FROM WHERE SELECT FROM WHERE (complex conditions) SELECT FROM ORDER BY SELECT (aggrigate function) FROM GROUP BY SELECT FROM (complex operations) GROUP BY
15	SELECT FROM WHERE (complex conditions) (subquery) SELECT (aggrigate function)(added complexity) FROM GROUP BY (complex conditions) SELECT FROM (complex operations) SELECT FROM WHERE (complex conditions) (subquery) SELECT (aggregate function)(added complexity) FROM (complex operations) WHERE SELECT (aggregate function)(added complexity) FROM (complex operations) GROUP BY ORDER BY
30	SELECT (aggregate function)(added complexity) FROM (complex operations) GROUP BY HAVING (complex operations) SELECT (added complexity) FROM (complex operations) WHERE (complex operations)(subquery) HAVING (complex operations)

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	ORDER BY SELECT (added complexity) FROM (complex operations) GROUP BY (complex operations) ORDER BY (complex operations) SELECT (added complexity) FROM (complex operations)(subquery) SELECT FROM WHERE (complex operations)(subquery) ORDER BY (*Removed halfway in to 2019) SELECT (added complexity) FROM (complex operations) WHERE ORDER BY (*Added in the beginning of 2019) CREATE VIEW (From a 15-point query that you have not yet done)