

Off-course: The Mystery of Teaching Higher Mathematics to Vocational Aeronautic Students

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Abstract: Mathematics education remains dominated by didactic, assessment-driven pedagogies that prioritise procedural competence while often failing to cultivate applied problem-solving skills relevant to professional practice. In response to growing political and educational concern regarding mathematical readiness for life and work, this study explores the potential of immersive game-based learning (GBL) to supplement traditional approaches, shifting the emphasis from knowing mathematics to doing mathematics. Grounded in John Dewey's (1916) pragmatic epistemology and principles of Joint Practice Development (JPD) (Fielding et al, 2005), the project investigates whether an educational role-playing game (RPG) can support the meaningful application of higher-level mathematics in an authentic vocational context. The research focused on the design, development, and evaluation of *Air Investigation: Numbers at the Scene*, an RPG simulation of an aviation accident investigation. The project examined how mathematical concepts could be seamlessly embedded within a narrative to encourage inquiry and reflective problem-solving beyond rote calculation. The curriculum encompasses percentages, unit conversion, trigonometry, circular measurements, and the analysis of vector components, requiring players to employ mathematical critical thinking to solve navigational and forensic challenges. User testing was conducted with 306 post-16 learners across further and higher education. Data were collected through a questionnaire, focus groups, and interviews. Quantitative analysis revealed statistically significant relationships between in-game progression and knowledge retention, and highlighted the influence of prior mathematics attainment on learning outcomes. Qualitative data revealed significant levels of learner engagement and narrative immersion. Most notably, participants reported a strong sense of authenticity that directly facilitated meaningful learning experiences. Key challenges that emerged were cognitive load impacting flow for some learners and interface design, particularly regarding calculator functionality. Consequently, the research highlights the need to balance narrative immersion with low-friction UI design. The findings suggest that RPG-based learning provides a viable and engaging supplement to traditional mathematics education. By situating mathematical reasoning within purposeful, practice-oriented scenarios, this approach supports vocational learners without compromising academic rigour.

Keywords: Higher level maths games, Game-based learning, Role-playing video games, Aeronautics, Educational theory

1. Introduction

The teaching of mathematics remains rooted in didactic pedagogy and assessment-driven practice, with learning outcomes typically measured through formal examinations. While this approach has proven effective in developing procedural competence, it often isolates mathematical problem-solving from its authentic application in professional and real-world contexts. In March 2026, the House of Lords Numeracy for Life Committee opened an inquiry into the development of mathematics education, highlighting the urgency of current political discourse in this area. However, while this discourse reflects growing awareness and intent, there remains a pressing need for testable, evidence-based solutions to improve mathematics education. This project aims to provide an alternative approach that shifts the conversation from 'knowing' to 'doing'. While the outcome of exams is currently perceived as evidence of 'I can do maths vs I cannot do maths', a more nuanced, applied, and practice approach would perhaps provide learners with a greater understanding that they 'can' do maths. Situating mathematics within applied and practice-led scenarios could provide learners with a more nuanced understanding of mathematical capability and address the systemic gap between classroom theory and real-world problem-solving.

These challenges are shaped by an educational landscape that has evolved over two decades, particularly regarding the increasing role of technology as a supporting tool for learning. Despite the proliferation of digital resources for mathematics education, their application remains constrained by didactic models that prioritise outcome-driven curricula over process-oriented learning. This emphasis risks limiting students' understanding of how mathematical thinking operates in professional contexts. While existing gamification provides valuable tools for testing competency, current Game-Based Learning (GBL) often lacks the 'cultural power' to fully reinvent how mathematics is applied and understood.

The primary purpose of this project is to test whether a more immersive GBL approach can successfully supplement traditional instruction. The goal is to supplement didactic methods while retaining the focus on measurable impact and academic outcomes. Students must still pass assessments and secure employment.

However, these requirements should not deter educators from exploring more effective pedagogies. Much like the RPG described below, the journey toward a quest's fulfilment is inherently uncertain, yet the value of the discovery lies in the exploration itself. The remainder of this paper outlines the research perspective and objectives, followed by the methodology employed, including a description of the game developed. It then presents both qualitative and quantitative findings from user testing and concludes with preliminary insights from the study.

2. Incorporating Learning in a Role-play Narrative

RPG-based environments enhance motivation and problem-solving capacity (Anagnostopoulou, 2024). However, by examining available computer games designed to teach mathematics, Anagnostopoulou (2021) discovered a lack of immersive games in higher-level mathematics GBL (Figure 1). This study addresses that gap by designing a computer-based RPG that embeds advanced mathematical concepts within interactive gameplay, transitioning mathematics from abstract information retrieval to practical application.

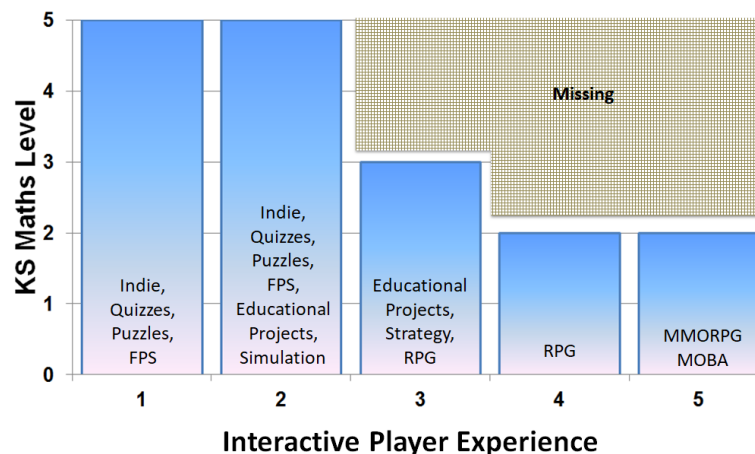


Figure 1: A gap in maths games (Anagnostopoulou, 2021).

The project adopts a pragmatic epistemological perspective, drawing specifically from Dewey's (1916) work and Joint Practice Development (JPD) (Fielding et al, 2005). Dewey conceptualises knowledge acquisition as an iterative process shaped by experience and reflection, often initiated by a 'disturbance', an interruption to routine thinking that prompts deeper inquiry. This framework moves beyond the binary 'can do/can't do', creating conditions that enable a learner to say, 'Actually, I might be able to do this'. By situating mathematical reasoning within an RPG narrative, equations are being reframed from assessment hurdles into essential tools for achieving meaningful goals. However, to ensure the experience remains "genuinely educative" rather than superficial, mathematical challenges must be rigorous and contextually grounded. For example, the game incorporates scenarios inspired by real-world events, such as the 2025 Heathrow substation fire.

The project further challenges the perceived dichotomy between vocational and academic education (Sennett, 2008, Hyland, 2017). The traditional separation of theory from practice often exacerbates students' capability to apply knowledge to real-world problems—a gap frequently identified by employers. To test the impact of "genuinely educative" simulations, this project utilises the aviation sector as a professional arena for applied learning.

Methodologically, the project employs the principles of JPD (Fielding et al, 2005), emphasising collaborative meaning-making and shared inquiry. *Air Investigation: Numbers at the Scene* was envisioned as a classroom-based tool to support JPD between teachers and students, linking specification content to applied experiences. In this way, in a classroom the game acts as a catalyst for discussion and reflection. It specifically addresses the needs of vocational learners—often underserved by traditional methods—by presenting mathematics as both an academic and vocational, practice-oriented discipline.

The curriculum underpinning the game was informed by BTEC Extended Diploma and T Level Engineering specifications. Players first apply maths concepts to locate an aircraft and subsequently investigate the cause of an incident. This approach aligns with Biesta's (2009) assertion that education must be purposeful and contextually meaningful. Accordingly, the project set out research objectives to enhance the quality of the

learning experience without compromising academic rigour, supported by intrinsic motivation theory (Malone and Lepper, 1987).

2.1 Research Objectives

1. Design and develop an educational RPG based on an aviation accident scenario to support mathematical learning for vocational aeronautical engineering students and a broader post-16 audience.
2. Investigate how embedding mathematics within an authentic simulation influences students' ability to link abstract concepts with real-world aviation problem-solving.
3. Examine the role of structured role-play as a classroom tool, focusing on how the game facilitates dialogue and shared reasoning between teachers and students.
4. Evaluate the game's educational value through playtesting with post-16 learners to assess engagement, perceived learning, and overall effectiveness in supporting mathematics education.

These objectives address higher-level mathematics, an area underserved by existing educational games, for engineering students aspiring to aviation careers. Aviation was chosen due to industry partnerships, including Boeing, and funding from the Civil Aviation Authority via the Department for Transport. These factors informed the development of *Air Investigation: Numbers at the Scene*, an educational role-playing game designed to bridge narrative mystery with practical application.

3. Methodology

3.1 The Game

Air Investigation: Numbers at the Scene is structured into two distinct operational phases within a controlled virtual environment. The narrative begins with the player acting as an apprentice investigator within the Air Accidents Investigation Branch (AAIB) (Figure 2a), tasked with locating a missing aircraft following an aviation incident. Players navigate a series of quests that require the application of mathematical techniques. Once the aircraft is located, the player transitions to the crash site for the game's forensic phase (Figure 2e). This stage focuses on environmental exploration and evidence collection. The investigation is facilitated through seven interactive components, in which players analyse physical clues and perform a series of calculations to start to determine the cause of the crash.

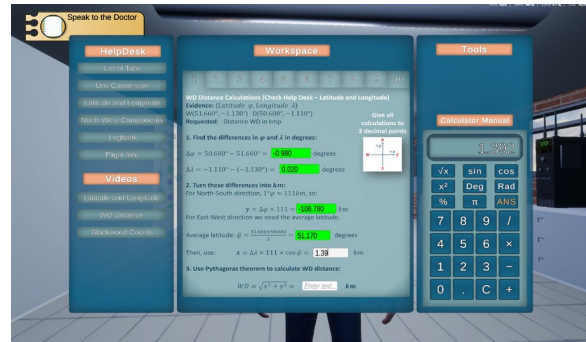
The mathematical content focuses on trigonometric principles, unit conversion, applied geometry and vector analysis, specifically tailored to the navigational and analytical requirements of an aviation investigation. To successfully locate the aircraft, players must apply trigonometric principles and circular measurements. This involves angular measurements and deconstructing flight paths into their horizontal and vertical components to determine final displacement (Figure 2c/2d). Beyond calculation, the game prioritises critical thinking and data analysis. Players are not merely provided with numbers, they must identify which pieces of information are relevant and consider the appropriate mathematical strategy to apply.

Borrowing typical RPG features, the user interface (UI) was carefully designed to facilitate active engagement with mathematical tasks. The game includes a quest log to guide progression, interactive dialogue systems, and embedded instructional videos that explain relevant mathematical principles. The experience is further supported by a combination of cutscenes, confirmatory question-and-answer tasks, and guided investigation (Figure 2f). Players use the SavviPad (Figure 2b), an integrated digital interface, to log their findings, check guidance, and perform calculations. They can enter their solutions directly into an integrated calculator and receive immediate feedback, with correct responses highlighted in green. This functionality was intended not only to support learners but also to provide teachers with insight into specific areas of difficulty, informing subsequent instructional interventions.

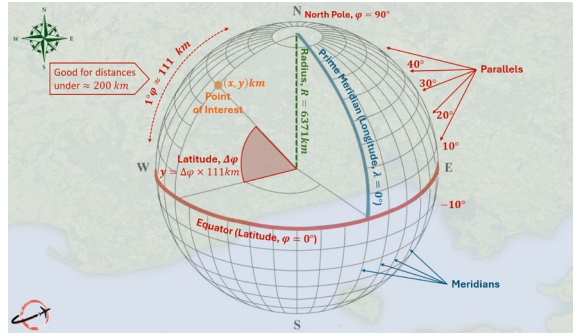
The game was developed in the Unity Engine by a designer and a developer from the Department of Informatics at the University of Sussex as part of a 12-month project conducted from April 2025 to March 2026. The design, development, and construction phases took place between April and December 2025, followed by data collection from January to March 2026. Visual assets, including the aircraft model and a 3D simulation of the Air Accidents Investigation Branch (AAIB) facility at Farnborough Airport, were created using Blender and ProBuilder, while instructional videos with voice-over narration were produced in Clipchamp.



a. The main quest building



b. The Savvipad, for info and calculations



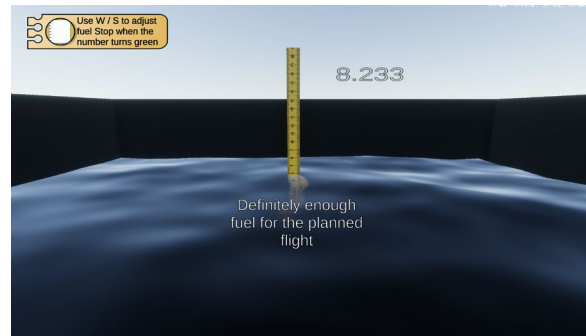
c. Learning latitude and longitude



d. Calculating coordinates



e. The crash site



f. Investigating fuel consumption

Figure 2: Screenshots of the game

3.2 User Testing

For the main testing phase, the prototype was distributed as a PC-based Unity executable. Testing was conducted directly within schools and colleges across the Southeast of England, using standard classroom computers rather than researcher-controlled environments. Sessions involved groups of further education students and undergraduate learners enrolled in foundational engineering programmes, allowing feedback to be gathered in authentic educational settings and reflecting real-world use as honestly as possible.

A total of 306 participants of diverse mathematical and gaming backgrounds, ranging from low to high in both categories, took part in the study. They engaged with the game for 30 to 90 minutes, depending on how much time each institution could allocate to student participation. The sample comprised 76% male, 19% female, 2% non-binary, and 3% preferred not to respond. A total of 13% of participants reported having special educational needs and disabilities (SEND). Following gameplay, students completed an online questionnaire to capture feedback and self-reported perceptions of learning. In addition, the project team conducted interviews and focus groups to explore participant responses in greater depth.

4. Results

The following results and accompanying findings from user testing represent an initial set of data gathered from the prototype and should be considered with appropriate caution. While they offer tentative insights that

may help inform future research and guide the refinement of this game, in particular, they are not intended to support broad generalisations. Instead, these early indications may prove useful in highlighting patterns that could resonate with developers, tutors and educational leaders working in comparable contexts.

4.1 Findings About Learning

4.1.1 Scores vs in-game progress

A One-Way ANOVA was conducted to assess whether the in-game progress stage significantly affected participants' knowledge test scores. Since the p -value is $0.003 < 0.05$, the results are statistically significant. There is a real difference in scores based on how far a player progressed. Scores generally increase as players reach the end. Group 5 has a substantially higher average score (85%) compared to the early groups. This may suggest that participants with longer play sessions were able to absorb the information more effectively than those with limited time. However, Group 3 shows a slight dip in average score compared to Group 2, though it has a very small sample size ($n=6$), which makes that mean less reliable.

Table 1: Comparing knowledge test scores across varying in-game progression

In-game progress stages	Average score	One-Way ANOVA
1. Didn't get to open the Savvipad	27% ($n=5$)	F -statistic: 4.316 p -value: 0.003 (Significant at $p < 0.05$)
2. Calculated distances and coordinates	45% ($n=41$)	
3. Collected evidence from the site	39% ($n=6$)	
4. Calculated fuel	52% ($n=13$)	
5. Reached closer to the end	85% ($n=16$)	

4.1.2 Scores vs gaming background

A One-Way ANOVA was conducted to examine the impact of prior gaming experience on knowledge test scores. The analysis yielded a statistically significant result ($F=2.534$, $p=0.048$), suggesting that gaming literacy influences a player's ability to absorb educational content within the game environment. Participants with a 'High' gaming background achieved a higher average score (63%) compared to those in the 'None,' 'Low,' and 'Medium' categories, who scored between 44% and 52%. These results align with Sweller's (1988) Cognitive Load Theory. While 'High' gamers operated with reduced extraneous load due to their established schemas for game navigation (Gee, 2003), novices likely experienced higher cognitive demands from navigation and interface interactions, leaving fewer mental resources for acquiring the target knowledge. The learning curve of the game is a common occurrence in RPGs and improves over time.

Table 2: Comparing knowledge test scores across gaming backgrounds

Gaming background	Average score	One-Way ANOVA
None	44% ($n=6$)	F -statistic: 2.534 p -value: 0.048 (Significant at $p < 0.05$)
Low	48% ($n=12$)	
Medium	52% ($n=24$)	
High	63% ($n=40$)	

4.1.3 Scores vs maths background

A One-Way ANOVA was performed to evaluate the influence of mathematical background on participants' performance on the knowledge test. The results indicate a highly statistically significant difference between the groups ($F=5.600$, $p=0.002$). Participants with higher prior maths knowledge (Group 4) performed substantially better than those with lower levels. These findings suggest that, while the game is accessible, prior mathematical proficiency strongly predicts mastery of the material, with higher-achieving students benefiting most from the educational content. The average score of 63% for Level 3 participants is a positive indicator. Given that this group represents the primary target audience, this score suggests the game is appropriately challenging without being inaccessible. It demonstrates a foundational understanding of the core concepts being taught.

The significantly higher scores seen in Level 4+ participants (89%) compared to Level 1 (31%) suggest a correlation between mathematical background and knowledge retention. Since the final assessment focused on game knowledge rather than maths skills, this discrepancy may stem from differences in Cognitive Load. For participants with high mathematical fluency, the game's calculations were likely more familiar. This allowed them to dedicate more of their cognitive capacity to the narrative and gameplay mechanics. Conversely, participants with lower math levels likely experienced higher cognitive load, as they had to exert more effort to manage the mathematical tasks and had fewer mental resources available to absorb and process the game's broader educational content.

Table 3: Comparing knowledge test scores across mathematical backgrounds

Mathematical background	Average score	One-Way ANOVA
Entry level	31% ($n=7$)	F -statistic: 5.600 p -value: 0.002 (Significant at $p < 0.05$)
Level 1-2	52% ($n=42$)	
Level 3	63% ($n=26$)	
Level 4+	87% ($n=7$)	

4.1.4 The use of calculators

Much of the user feedback centred on the in-game calculator. Intended to standardise responses and ensure accuracy, it instead caused confusion and frustration because many users ignored the provided guide. Some preferred their own calculators, suggesting the imposed tool hindered engagement rather than supporting learning. The calculator was intentionally designed to function without features like parentheses to force users to apply basic operational rules, such as resolving double negatives mentally. The observation that even higher-level students produced errors, e.g., $-1.110^{\circ} - (-1.130^{\circ}) = -2.240^{\circ}$, without challenging the logic of the result, supports the observation that reliance on early-year calculators can curtail mathematical intuition.

It was essentially demonstrated that removing the functionality of a standard calculator increased the extraneous cognitive load for students who have become dependent on algorithmic input rather than on conceptual understanding. Consequently, the tool did not just measure their ability to solve the game's problems but may also have exposed a fundamental disconnect in their number sense. This is significant because, in the transition from study to the workplace, graduates may face greater demands to draw on their mathematical intuition in practice. This includes being able to judge whether results produced using a calculator are reasonable, or whether errors may have occurred during data entry. These findings suggest that games such as this may play a role in shaping how knowledge is applied in real-world contexts, supporting the development of deeper thinking beyond simple memory retrieval. Additionally, this may also support the need for further exploration of cognitive load in educational RPGs, as well as more careful consideration of how game-based learning experiences are designed with these factors in mind.

4.1.5 Joint practice development and guided mathematical reasoning

Classroom observations showed JPD occurring naturally during gameplay. As mathematical and conceptual challenges arose, unscripted teacher-learner interactions emerged in response to the students' experiences. This aligned with JPD principles by being situated and practice-based rather than prescriptive. In some cases, guidance was highly subject-specific, such as clarifying coordinate systems, interpreting negative values in aviation contexts, or reasoning about fuel calculations. In other instances, teachers offered reminders of foundational mathematical principles, such as the order of operations, estimation, or checking the plausibility of numerical results.

Importantly, these interactions were often dialogic rather than corrective. Teachers prompted learners to articulate their thinking, question unexpected results, or reflect on how a calculation related to the in-game scenario. Rather than resolving tasks for learners, teachers supported them in navigating uncertainty, allowing misconceptions to be surfaced and addressed through shared reasoning. From a cognitive perspective, such guided interaction may have played a role in managing intrinsic and extraneous cognitive load and this may also need to be explored more in the future.

4.2 Perception and Satisfaction

While the ANOVA results showed that learning was informed by background, Figure 3 suggests that the engagement and usability were successful across the board. Over 80% agreed they understood the game and

could find in-game information to solve the tasks, indicating they did not feel confused while playing. Therefore, if some people scored lower on the test, it was not because they felt lost in the game, but likely because the educational content itself was challenging. Around 62% of respondents found the storyline interesting and would welcome a follow-up, while disagreement was limited to 10%. This result points to the creation of an intrinsic motivation environment in which players were not just playing because they had to, but were invested in the gameplay.

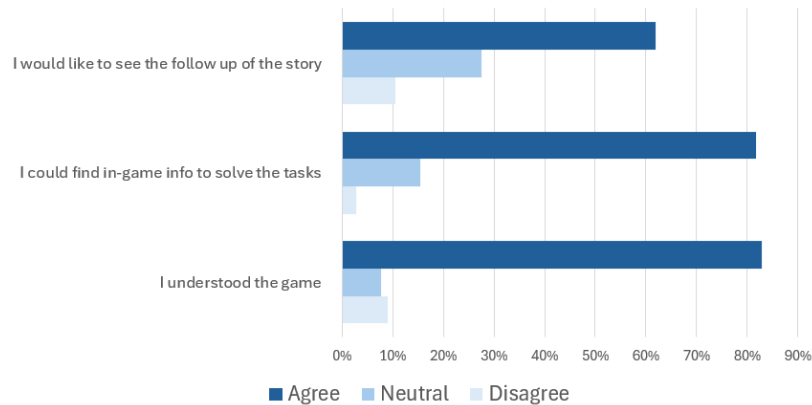


Figure 3: Likert feedback about the gameplay

Figure 4 highlights the successful contextualisation of the subject matter, with 75% of participants agreeing that the game improved their awareness of problem-solving within the aviation sector. The 'relevance to needs' category shows the highest level of disagreement. This is largely due to the participants' diverse backgrounds, many of whom were pursuing careers outside the aviation sector. However, more than 60% of the aeronautical students found the game relevant to their needs. The moderate recommendation scores, despite high enjoyment, reinforce this idea. Despite the content's specific professional focus, player motivation and engagement remained remarkably high. The fact that 70% of players enjoyed the overall experience suggests that the game's mechanics and narrative were strong enough to sustain interest and deliver educational value, even for those for whom the subject matter was not a personal or professional requirement.

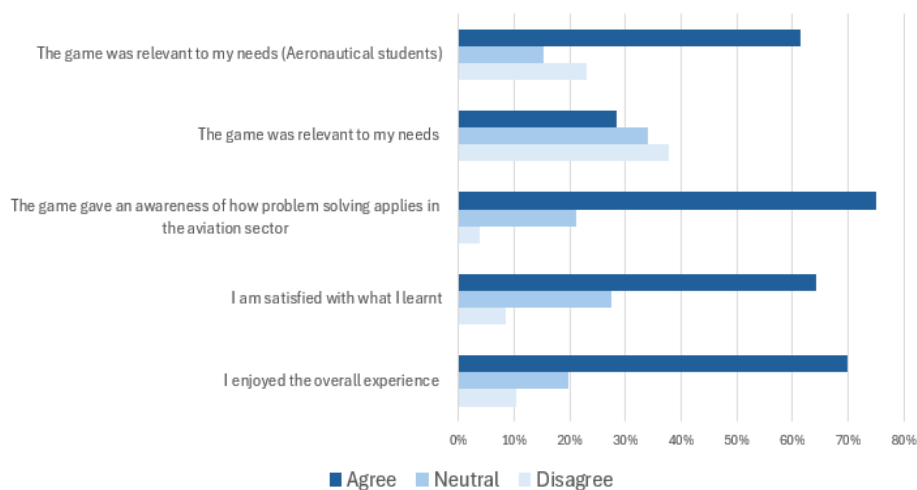


Figure 4: Likert feedback about satisfaction, perception, and motivation

4.2.1 Maths background vs enjoyed the overall experience

The game was designed for Level 3 learners and above, drawing on higher-level mathematical application. However, focus group discussions revealed that some Level 2 learners and below still reported enjoying the experience, largely because it offered something different from their usual learning activities. While not unexpected, the findings summarised in Table 4 below are nonetheless informative. It is notable that over half of the participants reported overall enjoyment. These findings suggest that the current design may be appropriately pitched for Level 3 learners, but potentially mathematically demanding for some at Levels 1–2.

The challenge might be less enjoyable because students are being stretched outside their comfort zone. Future iterations could improve accessibility and manage cognitive load by offering multiple entry points. For instance, allowing learners to start with the forensic crash site scenario, which contains less advanced maths, would make the experience more inclusive.

Table 4: Enjoying the overall experience across mathematical backgrounds

I enjoyed the overall experience				Chi-square
Maths Background	Disagree	Neutral	Agree	Chi-square statistic: 11.76 Degrees of freedom: 6 p -value: 0.057 (Marginally Significant at $p > 0.05$)
Entry Level	0	2	5	
Level 1-2	10	16	36	
Level 3	1	2	26	
Level 4+	0	1	6	

4.2.2 Game background vs enjoyed the overall experience

Unlike the maths data, Table 5 below shows consistency across the board. For example, in the ‘Agree’ column, the percentages are very similar across backgrounds (None: 71%, Low: 78%, Medium: 65%, High: 70%). This demonstrates that the gaming background had no significant impact on the overall experience, which suggests that the game is accessible. Whether someone is a hardcore gamer or has never played any game, they have a statistically similar experience. Therefore, the game does not require gaming literacy to be enjoyed.

Table 5: Enjoying the overall experience across gaming backgrounds

I enjoyed the overall experience				Chi-square
Gaming Background	Disagree	Neutral	Agree	Chi-square statistic: 2.85 Degrees of freedom: 6 p -value: 0.83 (Not Significant at $p > 0.05$)
None	1	1	5	
Low	0	3	11	
Medium	5	6	21	
High	5	11	37	

Qualitative analysis indicated that participants largely perceived the prototype as a legitimate gaming experience, rather than a purely instructional tool, while remaining aware of its educational purpose. Many participants explicitly stated that the prototype “felt like a game” or contained “most of the game components,” often referencing familiar genres such as RPGs or adventure games. Several responses framed the experience as a “playthrough,” an “RPG game,” or an “indie” title, suggesting that participants evaluated the prototype using established gaming conventions rather than classroom expectations. This perception was reinforced by comments noting that the game “didn’t feel like its only purpose was education,” indicating successful separation from traditional didactic formats.

Engagement emerged as a second key theme. Participants frequently described the experience as “very engaging,” “interesting,” or “insightful,” with some expressing a desire to continue or replay the game. These affective responses suggest that the gameplay sustained attention and interest. Engagement was often linked to active participation rather than passive consumption, aligning with core principles of game-based learning.

Narrative structure was repeatedly identified as a strength. Participants referred to a “questline,” “story,” and “mystery,” emphasising investigation and progression as central to the experience. Some highlighted that “there was a questline, narrative, a mystery,” while others described solving a problem or uncovering information as motivating elements. These comments indicate that narrative framing played a significant role in contextualising aviation-related tasks and sustaining player curiosity. Participants also commented positively on interactivity and mechanics, character interaction, and task-based progression. Such elements contributed to a sense of agency, reinforcing perceptions of the game as interactive rather than a static learning activity.

4.3 Graphics Fidelity Matters

4.3.1 game background vs graphics

There was a conscious effort to develop the game using Unity HDRP in order to deliver a higher level of visual fidelity. However, testing within schools and colleges revealed a practical limitation: even with optimisation,

this level of graphical demand could not be consistently supported across all classroom hardware. In some cases, institutional machines lacked dedicated graphics cards, making reliable performance difficult to achieve. This highlights a key challenge.

A Chi-Square test (Table 6) showed no significant relationship between gaming background and perception of graphics. This suggests that the game's visual style was equally accepted across all levels of gaming experience.

However, a classic expert-vs-novice perception gap can be observed. The None/Low groups seem to have found the graphics attractive, while the Medium/High group are much more critical. From interviews and participant feedback, this result is enforced, as the medium and high players are seeing technical flaws that the others are not. About 30% of the respondents found the graphics less attractive. Such a result is expected, as players with a high gaming background have likely seen high-budget, triple-A graphics, so their standard for what is attractive is much higher.

Table 6: Graphics experience across gaming backgrounds

The graphics were attractive				Chi-square
Gaming Background	Disagree	Neutral	Agree	
None	0	1	6	Chi-square statistic: 7.13 Degrees of freedom: 6 p -value: 0.3 (Not Significant at $p > 0.05$)
Low	3	4	7	
Medium	11	9	12	
High	16	17	20	

While some participants expressed a preference for higher-end visuals, the technological constraints of real-world educational environments limit the feasibility of consistently delivering such experiences. Balancing visual quality with accessibility remains an important consideration for future development.

5. Conclusion and Next Steps

At its core, this project explored the extent to which educational experiences could move beyond didactic instruction by introducing an RPG that offered learners opportunities to understand how mathematical knowledge is applied in practice. The project demonstrated that the pedagogical principles underpinning its design resonated meaningfully with learners. Participants responded positively to both the concept and the implementation of the game, recognising the value of applying mathematical knowledge in an interactive, role-based environment, with JPD still at its heart.

The prototype demonstrated that practical application is engaging and enjoyable for most students. Notably, longer gameplay correlated with improved understanding and retention. However, GBL must align complexity with learner capability to prevent disengagement, and designs must remain accessible regardless of prior gaming experience.

The primary limitation was learner interaction rather than mathematical content. Managing the UI imposed a cognitive load that reduced both learning impact and narrative engagement. Specifically, the calculator was cumbersome and lacked standard features. Furthermore, participants noted that solutions were often presented rather than discovered, progression felt predetermined rather than earned, and there was little sense of risk or consequence.

A range of constructive design recommendations emerged. These included the potential introduction of a timed element, in which learners must complete calculations within a set period to reach the plane and 'save the pilot', thereby increasing urgency and engagement. Another suggestion was to integrate an adaptive or AI-driven interface into the SavviPad to support variable datasets, ensuring that each playthrough yields different numerical values and solutions. Participants also proposed restructuring the gameplay sequence, for example, by introducing non-linear progression, such as starting with the crash scenario before moving on to more advanced mathematical challenges.

Ultimately, the real-world application of mathematics extends beyond the structured constraints of examinations. Future developments must continue to focus on strengthening mathematical resilience and the ability to adapt knowledge to context, ensuring that learners feel empowered to say not just 'I know this', but 'I can do this'.

Ethics Declaration: The University of Sussex requires mandatory ethics approval for research involving human or animal subjects. This project has been approved by the F-REC Science, Engineering, and Medicine: reference 218.

AI Declaration: No artificial intelligence tools were used in the preparation of this manuscript.

References

- Anagnostopoulou, E. (2021) "Identifying the Lack of Immersive Games in Higher Level Mathematics Game-based Learning", *Proceedings of the 15th European Conference on Game Based Learning ECGBL*, University of Brighton, UK 24-25 Sep 2021, pp 801-808.
- Anagnostopoulou, E. (2024) *The Red Circle: Immersive Adventures in Learning. Leveraging the Potential of Educational Role-Playing Games for Teaching Higher Level Mathematics*, PhD thesis, University of Sussex, Brighton.
- Biesta, G.J.J. (2010) *Good Education in an Age of Measurement: Ethics, Politics, Democracy*, Routledge, London.
- Dewey, J. ([1916] 1940) *Democracy and Education: An introduction to the philosophy of education*, Macmillan Company, New York.
- Fielding, M., Bragg, S., Craig, J., Cunningham, I., Eraut, M., Horne, Gillinson, S., Horne, M., Robinson, C. and Thorp, J. (2005) *Factors Influencing the Transfer of Good Practice*, Department for Education and Skills, London.
- Gee, J. P. (2003) *What Video Games Have to Teach Us About Learning and Literacy*, Palgrave Macmillan, London.
- Gregson, M. and Nixon, L. (2015) *Readings for Reflective Teaching in Further, Adult and Vocational Education*, Bloomsbury, London, pp 232-236.
- House of Lords Numeracy for Life Committee (2026) *Corrected oral evidence: Numeracy for Life*, 5 March, Evidence Session No. 1. Available at: <https://committees.parliament.uk/oralevidence/17304/html/>
- Hyland, T. (2018) 'Craftwork and the "Hard Problem" of the Vocational/Academic Divide' Presentation based on T. Hyland Craft Working and the "Hard Problem" of Vocational Education and Training, *Open Journal of Social Sciences*, Vol 5, pp 304-325.
- Malone, T.W., and Lepper, M.R. (1987) "Making learning fun: A taxonomy of intrinsic motivations for learning". In Snow, R.E. and Farr, M.J (Eds.) *Aptitude, learning, and instruction volume 3: Conative and affective process analyses*, Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers, pp 223-253.
- Sennett, R. (2008) *The Craftsman*, Allen Lane, London.
- Sweller, J. (1988) "Cognitive load during problem solving: Effects on learning", *Cognitive Science*, Vol 12, No.2, pp 257-285.