

Right Opinion: Fidelity and Learning Design in a Food Poisoning Card Game

Mario Michaelides

Brunel University of London, UK

mario.michaelides@brunel.ac.uk

Abstract: This paper presents the design and development of "Right Opinion", a competitive two-player card game created to support Key Stage 3 learners' understanding of food poisoning. It is the first prototype in a wider doctoral study asking whether the fidelity of a serious game's delivery medium affects immediate knowledge acquisition and player experience. The planned comparison spans card, board, 2D digital, 3D digital, and virtual reality formats, representing increasing technological, audiovisual, spatial, and immersive possibilities without assuming that more technology produces better learning. With learner testing yet to take place, the paper addresses how two pages of static educational material can be transformed into a card game that aims to engage and educate in equal measure. Right Opinion converts the source into 12 patient cases. Players interpret food histories and symptoms, identify *E. coli*, *Salmonella*, or *Listeria*, and select suitable treatment and prevention responses. Correct decisions earn points, while the opponent can Challenge a response and optionally provide a Second Opinion. These mechanics make commitment, confidence, disagreement, and feedback visible. Bloom's original taxonomy informed four learning outcomes at the levels of Knowledge, Comprehension, and Application. The paper traces the design from an early handwritten speed-based version to the professionally printed prototype, then examines learning alignment and the affordances and limitations of cards. The physical format offers tactile, face-to-face play, low technical requirements, portability, and rapid setup, but relies on players to manage feedback and scoring. The resulting design findings concern content transformation, pacing, and the medium-specific affordances of cards as a physical baseline for later cross-format comparison across the five delivery conditions. The planned evaluation will combine matched knowledge tests at three points with a measure of player experience, enabling immediate acquisition and learners' perceptions of competition and engagement to be examined without treating competitive scores alone as learning evidence.

Keywords: Serious games, Game-based learning, Delivery fidelity, Card games, Game design, Key stage 3

1. Introduction

Game-based learning can use challenges, rules, goals, rewards, feedback, and a spirit of play to offer active, experiential learning (Whitton, 2014). Adding points or competition to static material does not, however, ensure learning; player actions, educational content, and feedback must work together (Garris, Ahlers, and Driskell, 2002; Plass, Homer, and Kinzer, 2015).

The wider doctoral study asks whether delivery fidelity affects immediate knowledge acquisition and player experience. It compares five prototypes sharing one topic and four learning outcomes: card, board, 2D digital, 3D digital, and virtual reality. Each uses the opportunities of its medium rather than reproducing the same game. The sequence reflects increasing audiovisual, spatial, automated, and immersive possibilities without assuming that more technology produces better learning. *Right Opinion* establishes the card condition at the lowest level of delivery fidelity.

The practical design problem is how two pages of static educational material can become an engaging and educational card game. Food poisoning was selected because it is relatable and its causes, symptoms, treatment, and prevention translate into rules and choices. *Plague Inc.* showed how disease-related subject matter could be made accessible through play (Ndemic Creations, 2012), although *Right Opinion* differs in purpose, audience, and mechanics. The aim was not to reproduce source text on cards but to make its relationships playable. Food poisoning is therefore the content through which the design problem is explored, not the paper's principal contribution. It also connects with Key Stage 3 learning about unicellular organisms, nutrition, digestion, and health (Department for Education, 2013; Department for Education, 2015).

Research on game-based learning has focused mainly on effectiveness and evaluation, but studies differ in their games, learners, settings, and methods. A meta-analysis of games in primary and early secondary STEM education found overall cognitive, motivational, and behavioural benefits, although effect sizes varied substantially (Arztmann et al., 2023). Reviews likewise report cognitive, affective, and motivational outcomes alongside variation in design, implementation, and measurement (Connolly et al., 2012; All, Nunez Castellar, and Van Looy, 2013; Wouters et al., 2013). Board-game interventions show similar potential and evidential limitations (Noda, Shirotaki, and Nakao, 2019). Design frameworks explain how learning and game mechanics may be aligned (Plass, Homer, and Kinzer, 2015; Arnab et al., 2015), but outcome-focused literature gives less attention to documenting how a shared instructional core is transformed across medium-specific games.

Without transparent design accounts, later differences in learning or experience are difficult to interpret. The specific gap is the design of a physical card baseline for a five-format fidelity comparison. The paper asks: how can bounded educational content be transformed into an engaging card-based serious game in which learning outcomes, player actions, and feedback are aligned?

2. Design Framing

2.1 Learning Mechanics and Alignment

I designed *Right Opinion* backwards from four learning outcomes, using Bloom's original categories of Knowledge, Comprehension, and Application (Bloom et al., 1956). Constructive alignment (Biggs, 1996), the Learning Mechanics–Game Mechanics (LM-GM) model, and the Interactive, Constructive, Active, and Passive (ICAP) framework are used here to examine the finished design, rather than to claim that every framework was formally applied to the first prototype. The important point is that players do more than recognise information: they interpret a case, commit to a response, and receive feedback.

The Learning Mechanics–Game Mechanics model asks how a game action performs a learning function (Arnab et al., 2015). In *Right Opinion*, card selection is not decoration around a quiz: players classify and match information, then place a response where the opponent can inspect it. Challenge adds peer critique and a judgement of confidence. Within ICAP, selecting and comparing cards is active engagement, while the rule requiring players to justify a Challenge supports constructive or interactive engagement (Chi and Wylie, 2014).

2.2 Fidelity as Delivery Medium

In this study, delivery fidelity describes differences in how each serious-game condition presents and mediates learning. The conditions are ordered as card, board, 2D digital, 3D digital, and virtual reality, reflecting increasing capacity for audiovisual representation, spatial environments, automation, and immersion. *Right Opinion* comes first because its information, state, and feedback depend on printed cards and manual player action.

This definition is specific to my study and does not mean that every digital game is more faithful or educationally valuable than every physical game. The media effects debate distinguishes medium from instructional method (Clark, 1983; Kozma, 1994). Immersive and desktop comparisons also give mixed results: immersion can increase presence and interest while adding distraction or cognitive load (Parong and Mayer, 2018; Makransky, Terkildsen, and Mayer, 2019). The question is whether delivery fidelity makes a difference, not whether more must be better.

Delivery fidelity is the comparative variable, not a measure of technological or production quality, realism, design quality, or educational value. Prototype maturity concerns resemblance to the intended product; content accuracy concerns the validity and scope of its information. Greater polish or more content does not alter *Right Opinion's* position at the lowest level of delivery fidelity.

3. Design and Development of Right Opinion

3.1 Source Content and Design Method

This practice-based account treats the artefact and documented making process as the basis of the contribution (Candy, 2006). The process comprises six stages: (1) defining the audience, learning outcomes, subject scope, and card format; (2) analysing the source; (3) translating content into mechanics; (4) building a prototype; (5) designer play-throughs examining alignment, clarity, pacing, and balance; and (6) iterative refinement. Successive prototypes, rulesets, and photographs document the process; play-throughs are design evidence rather than learner data. The starting point was the two-page 'Food poisoning' spread in Brian Ward's *Epidemic* (2000, pp. 18–19), selected as source material for Key Stage 3 learners. It provided a general overview and a focus on *E. coli*, *Salmonella*, and *Listeria*. NHS guidance supplied the additional symptoms, treatment, and preventive advice needed to create cases and response choices (NHS, 2023; NHS, 2024; North Tees and Hartlepool NHS Foundation Trust, 2026; Royal Berkshire NHS Foundation Trust, 2024).

The material was then made playable. I broke it into relationships between bacterial cause, exposure, symptoms, treatment, and prevention, then reconstructed these as patient histories and response cards. A statement became an uncertain case, a category became a player choice, and a printed answer became hidden feedback. The book's one-way presentation was therefore turned into interpretation, commitment, peer challenge, and feedback.

The three bacteria bound the game rather than offering a comprehensive account of foodborne illness. I expanded food and exposure cues for case variety while keeping the structure modular, so cases, answers, and categories can be revised without changing the interaction. The approach could apply to other bounded curriculum material.

Table 1: Transformation of source content into game mechanics

Source Content	Design Transformation	Learning
E. coli, Salmonella, and Listeria.	Three diagnosis-card categories.	Recognition and classification (LO1).
Food, symptom, and bacterial relationships.	Patient histories requiring interpretation.	Association and application (LO2).
Treatment information.	Treatment cards.	Matching an appropriate response (LO3).
Preventive advice.	Prevention cards.	Selecting a context-relevant prevention measure (LO4).
Explanatory answers.	Answers and explanations on the reverse of Patient cards.	Immediate corrective feedback across LO1–LO4.
Case information and possible alternative responses.	Challenge and optional Second Opinion before the answer is revealed.	Opportunity for peer evaluation and discussion.

The interaction forms a four-stage loop: draw a Patient card, submit a response, allow a Challenge, then apply the result before the next case (Figure 1). In the diagram, 'Diagnose' is shorthand for the complete Diagnosis, Treatment, and Prevention response. Section 3.4 explains the full turn.

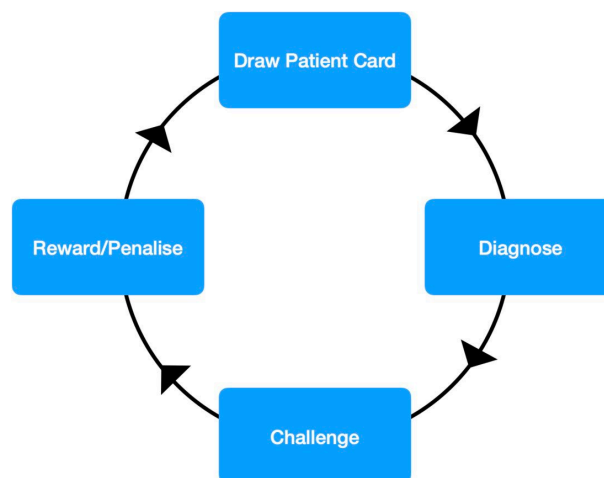


Figure 1: Core gameplay loop of Right Opinion. 'Diagnose' encompasses the diagnosis, treatment, and prevention responses

3.2 Prototype Evolution

The four prototype stages are shown in Figure 2.



Figure 2: Development of Right Opinion: (a) vertical prototype; (b) horizontal prototype; (c) laminated pre-production prototype; and (d) professionally printed version (author's photographs)

The first handwritten version used a quick-response interaction similar to Snap. Designer play-throughs showed that the case information did not suit speed because players reacted before interpreting it. As this conflicted with the intended learning, the mechanic was discarded. This was a design finding, not participant evidence.

Four prototype stages developed through a playcentric cycle of play, reflection, and revision (Fullerton, 2014). The vertical prototype tested the core loop, the horizontal version expanded the card types, and the laminated version refined readability and handling before professional printing. Play was slowed so responses were committed before answers were revealed; Challenge and Second Opinion then made disagreement and answer checking part of the interaction.

I created 12 Patient cases, four for each bacterium. Challenge requires an opponent, making the prototype explicitly two-player. Games are intended to last 10–20 minutes, a design judgement still to be tested.

3.3 Design Requirements and Components

This paper analyses the professionally printed prototype and Ruleset Version 1.17, dated December 2025. I designed a short, replayable physical experience for 11–14-year-olds that requires no device or account and resets quickly. These qualities make the prototype classroom-ready in design terms, although appropriate testing with learners and teachers is needed to establish classroom readiness in practice.

The 34-card set contains 12 Patient cards and 11 response cards for each player: three Diagnosis, four Treatment, and four Prevention cards. Diagnosis covers *E. coli*, *Salmonella*, and *Listeria*. Treatment covers hydration, rest, and antibiotics, including water and rest combined. Within this closed model, the Antibiotics card is the only accepted treatment for *Listeria*. A Patient front presents a character, food or drink history, and symptoms; the reverse gives the accepted answers (Figure 3). More than one Treatment or Prevention card may be allowed, but every submitted card in that category must match the reverse. Figure 4 shows the shared Patient deck and Outpatients pile between the two response areas.

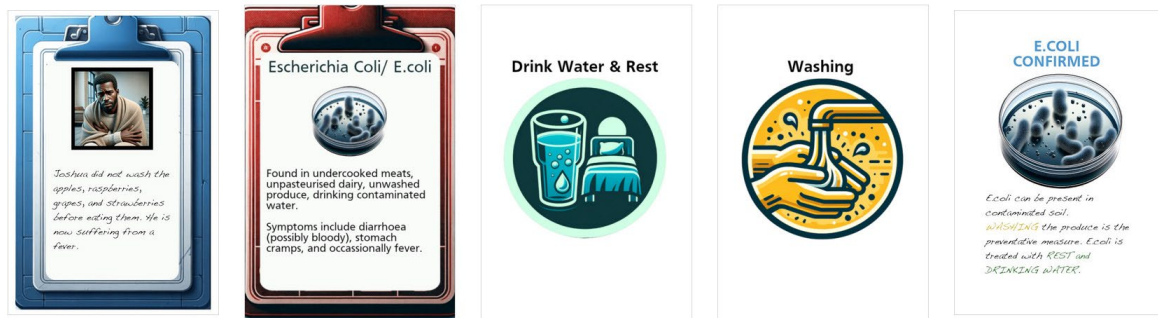


Figure 3: Representative gameplay components: (a) patient case; (b) diagnosis; (c) treatment; (d) prevention; and (e) answer back (author's prototype; illustrations generated with DALL-E through ChatGPT, July 2024)

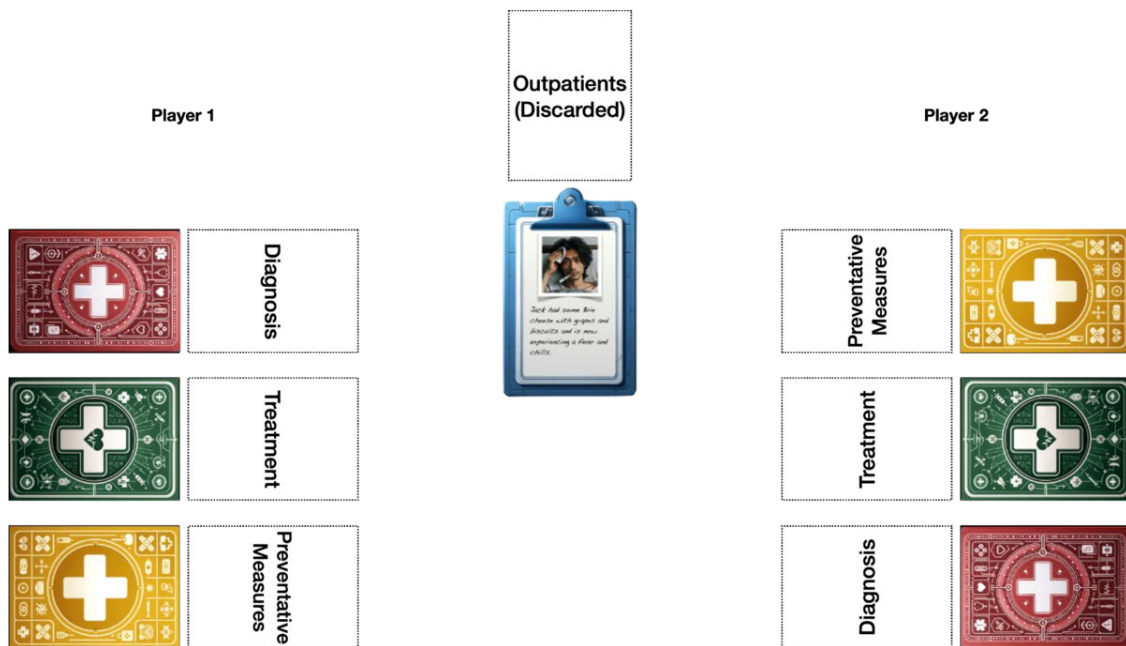


Figure 4: Recommended two-player tabletop setup for Right Opinion

3.4 Turn Sequence, Feedback, and Competition

Figure 1 summarises play. The shuffled Patient deck is placed case-side up, and the active player reads the top case without lifting it. They submit one Diagnosis card and the Treatment and Prevention cards they judge appropriate. Before the answer is revealed, the opponent accepts or Challenges the response. A Challenge states that at least one category is wrong; the opponent may also submit a complete Second Opinion that differs in at least one category. The Patient card is then turned over, outcomes are scored, and it moves to Outpatients. Roles alternate through all 12 cases, so each player leads six. The highest competitive score wins. Figure 5 shows the full resolution.

Challenge and Second Opinion are scored separately. A player can recognise a possible error without supplying an alternative, while a Second Opinion adds risk. I intend this to discourage passive agreement, keep both players attentive, and make confidence visible. The risk is that points may become more important than explanation. As classroom goal structures can affect cognitive, metacognitive, and affective outcomes (Ke, 2008), the study protocol will request a brief reason for a Challenge. The pilot will check whether this requirement is clear and workable; the formal measure of player experience will examine learners' perceptions of whether competition supports or distracts from their reasoning.

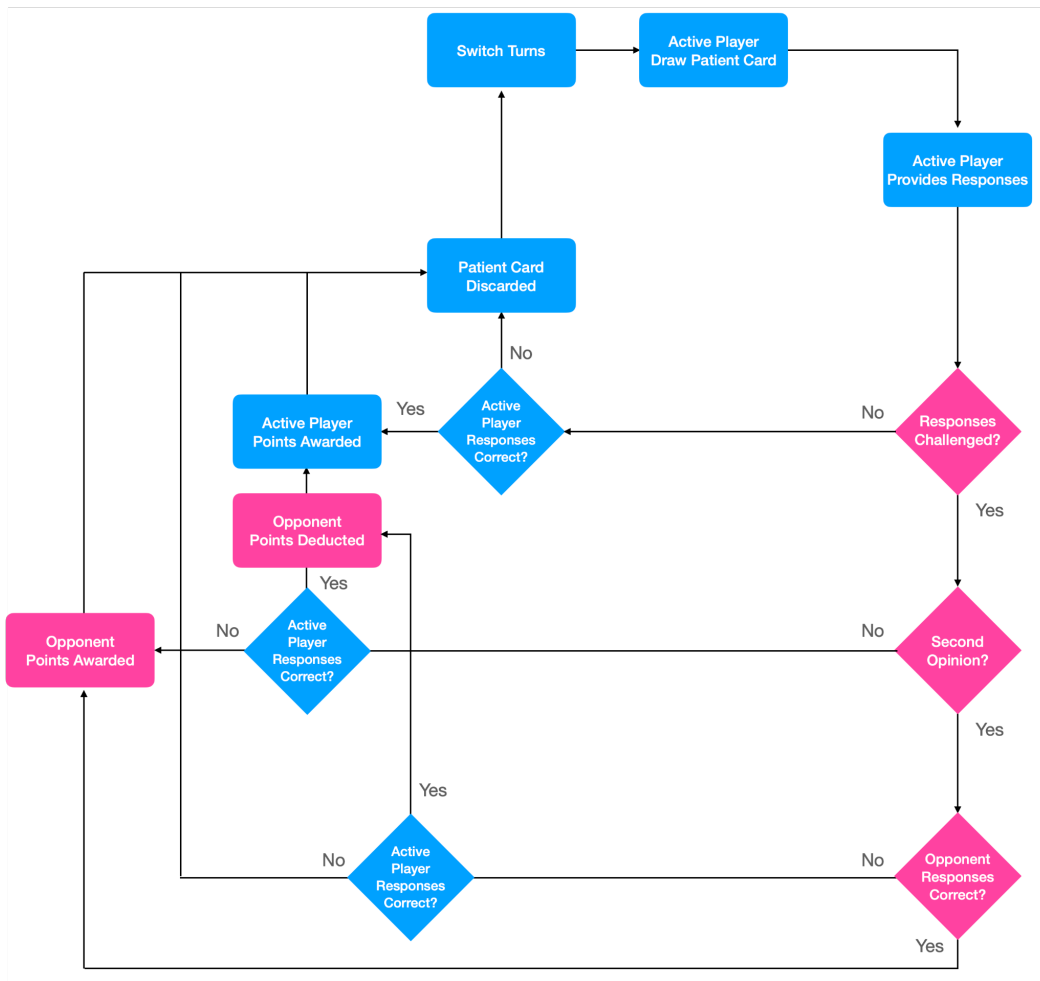


Figure 5: Detailed turn-resolution loop showing the active player's response, the opponent's Challenge, and optional Second Opinion, scoring, and the transition between turns

3.5 Scoring Model

The scoring model rewards accuracy while making Challenge and Second Opinion meaningful risks (Figure 5):

Each correct response category - Diagnosis, Treatment, and Prevention - earns the active player 2 points, to a maximum of 6 points per patient. Where multiple cards are permitted, every card must match the accepted answers, but the category remains worth a maximum of 2 points.

If the response is not challenged, the active player receives 2 points for each correct category.

If a challenge succeeds because at least one active-player category is incorrect, the active player receives 0 points for the patient and the opponent receives 6 points.

If a challenge fails because all three active-player categories are correct, the active player receives 6 points and the opponent loses 6 points.

A Second Opinion must be a complete alternative that differs from the active player's response in at least one category. It is scored independently: a correct alternative earns the opponent 6 points, while an incorrect or incomplete alternative loses the opponent 6 points.

If the active player's response is incorrect and the opponent's Second Opinion is also incorrect, both players score 0 for that patient. The opponent's 6 points for a successful Challenge are cancelled by the 6-point penalty for the incorrect Second Opinion. The Patient card is then discarded.

Each player leads six cases, so perfect primary-response accuracy is 36 points. Adding the maximum 12 points on all opposing turns gives a theoretical competitive maximum of 108; six failed Challenges with incorrect Second Opinions produce a minimum of -72. Primary accuracy (0–36) will be recorded separately from competitive score (-72 to 108).

3.6 Learning Outcomes and In-game Evidence

The four outcomes define what the game rehearses. LO1 is recognition of the three bacterial categories. LO2 associates food history and symptoms with the most likely category in the closed set. LO3 matches treatment, while LO4 matches prevention to the route in the case. 'Within the closed set' is important: the cards do not support real-world diagnosis, where symptoms overlap and clinical or laboratory assessment may be needed.

Table 2: Alignment of learning outcomes, player activity, and feedback

Learning Outcome	Required Player Activity	Learning Mechanism	Evidence Generated in Play
LO1: Recognise E. coli, Salmonella, and Listeria.	Select one diagnosis card after reading a patient case.	Knowledge: recall, recognition, and classification.	Selected Diagnosis card is checked against the answer on the reverse of the Patient card.
LO2: Associate food history and symptoms with a likely cause.	Integrate the food cue and symptom description before committing to a diagnosis.	Comprehension and Application: interpret and apply case cues within a constrained problem space.	The selected Diagnosis card is checked against the answer on the reverse of the Patient card; a Challenge additionally requires the opponent to give a brief reason for disputing the inference.
LO3: Match an appropriate treatment response.	Choose the treatment card or permitted combination linked to the diagnosis.	Comprehension and Application: associate and retrieve an appropriate response.	Selected Treatment card or combination is checked against the answer on the reverse of the Patient card, providing immediate corrective feedback.
LO4: Match a context-relevant prevention measure.	Choose one or more prevention cards for the route represented in the case.	Application: discriminate between alternatives and apply prevention to context.	Selected Prevention card or combination is checked against the answer on the reverse of the Patient card; scoring distinguishes a contextually correct response from a generally plausible one.

Challenge and Second Opinion support the four learning outcomes; they are not additional outcomes. They require players to evaluate responses linked to LO1–LO4 and make errors visible through peer challenge and immediate feedback.

Table 2 shows the evidence created by player decisions. Game points are not a validated learning measure because they combine knowledge, confidence, Challenge strategy, and case distribution. I will assess the outcomes independently through pre-test, midpoint test, and final test.

4. The Card Medium as a Fidelity Baseline

4.1 Position of the Card Condition

Right Opinion is the study's card baseline, representing the lowest level of delivery fidelity. Its game world uses static images, printed text, and coloured categories, with no animation, simulated space, audio, automation, adaptation, or computer-controlled characters. Players create game state by selecting, placing, revealing, and discarding cards. This provides a starting point for examining whether technologically and representationally richer formats alter learning or experience.

Low delivery fidelity does not mean low design complexity or educational potential. Cards make choices tangible, hide answers, and make commitment and peer challenge public without software. They do not reproduce clinical practice; they make the intended knowledge relationships playable.

4.2 Game World, Consequences, and Physical Affordances

The tactile nature of *Right Opinion* is a key affordance. Handling, arranging, and revealing cards gives decisions a physical presence that digital interfaces do not provide in the same way. Face-to-face play also makes the social element visible as players announce and respond to decisions. The shared table keeps categories open to inspection, while hidden answers allow prediction followed by feedback.

The format also has low logistical and technical requirements: a small tabletop, with no computer, headset, electricity, or account. It is portable and quick to set up or put away, allowing several classroom pairs to play. Information is static, feedback and scoring are manual, and errors cannot be recorded automatically. Patient cards, text, and images represent the game world rather than an explorable environment. Consequences appear through answer revelation, scoring, Challenge, and Second Opinion rather than changes to a simulated world. These qualities may affect experience and implementation but do not prove better learning or engagement.

4.3 Establishing a Comparative Baseline

The card condition establishes the first interpretation of the instructional core: four outcomes, three bacteria, repeated case decisions, and corrective feedback. Later prototypes will address the same source and outcomes through medium-specific affordances, potentially changing mechanics, interfaces, spatial structures, or genres. The study therefore compares interpretations rather than replicas.

5. Design Findings and Limitations

The design process generated three findings. First, content became playable when factual relationships were reconstructed as uncertain cases and committed choices rather than reproduced as information on cards. Second, the discarded speed-based prototype showed that pacing had to follow the interpretive demands of the learning outcomes. Third, cards could externalise commitment, disagreement, and corrective feedback without digital automation, while transferring rule and score management to the players. These are findings from developing the artefact, not evidence of learner attainment or classroom effectiveness.

Right Opinion is intentionally compact, creating trade-offs. Version 1.17 represents three bacterial categories from the source and supplementary NHS guidance, not the full domain of foodborne illness. Restricting the game to three bacteria keeps play manageable, but it may allow players to identify the expected diagnosis from a single familiar food cue rather than interpreting the patient's food history and symptoms together. Repeated play may produce memorisation. A larger patient pool and equivalent test questions using unseen examples could reduce these effects, while the modular structure permits revision without changing the central interaction.

Points provide both feedback and competitive currency. Although the model caps categories and separates primary accuracy from competitive score, it has not been tested with learners. The Section 6 pilot will examine strategic behaviour, identify unusual or ambiguous gameplay and scoring situations, and determine whether Key Stage 3 learners can set up, play, and score without my intervention.

Finally, no learner data have been collected. My play-throughs can improve the design but cannot demonstrate learning or classroom suitability. Before formal rollout, the artwork and components require review for consistency, accessibility, representation, and usability.

6. Planned Classroom Evaluation and Comparative Role

I plan to evaluate *Right Opinion* in a Key Stage 3 science lesson. Learners will replay the 10–20-minute game in pairs for 60 minutes. Matched knowledge tests will be administered before play, at approximately 30 minutes, and after the hour. The midpoint will indicate first-half acquisition and whether it changes with further play. The teacher will explain the closed model, ensure that the rules are followed, and debrief misconceptions after the final measures. These tests, not competitive scores, will provide the primary evidence of immediate acquisition (All, Nunez Castellar, and Van Looy, 2013).

Right Opinion is the first of five conditions: card, board, 2D digital, 3D digital, and virtual reality. Source content, outcomes, and assessment constructs will remain as consistent as practical while each prototype uses its medium. Because the formats are composite delivery conditions, medium cannot be separated completely from representation, interface, mechanics, genre, spatiality, automation, and immersion; differences must therefore be interpreted at the level of the complete delivery condition, not attributed automatically to one fidelity feature.

Before formal rollout, a small pilot will involve Key Stage 3 learners excluded from the main study. It will examine the clarity and age appropriateness of the cards, rules, and instruments; the feasibility of three knowledge tests, repeated play, and the player-experience measure within the hour; and possible floor or ceiling effects in the knowledge test. Pilot data will not enter the main analysis. Refinements will be documented before the finalised game, instruments, and procedure are used in the card condition.

A separate measure will distinguish player experience from acquisition (Iacovides et al., 2011). Participants will be recruited from a limited number of Key Stage 3 classes, so the findings may not be representative of the wider Key Stage 3 population. Where possible, testing will precede formal teaching, while the pre-test establishes existing knowledge. Delayed retention will not be measured because a later test is beyond current capacity and could be influenced by subsequent teaching, independent learning, or advance-notice revision. Findings will therefore concern the one-hour session and player experience.

7. Conclusion

Right Opinion transforms a bounded source into a card-based cycle of interpretation, selection, Challenge, and feedback. Its documented design positions the card condition at the lowest level of delivery fidelity in the wider study. Cards make choices tangible, hide answers, and make peer commitment public without digital technology.

Three design insights emerge: the card medium provides mechanisms for active reasoning and social feedback; a medium matters through what it enables and restricts rather than through technological richness alone; and cross-format comparison requires a documented instructional core and transparent medium-specific differences. These insights arise from the design process; whether the game improves learning or differs from other formats remains to be established through learner testing.

Ethics Declaration: My play-throughs formed part of the design process, but no participant research or human-participant data collection has taken place and no such data are presented. Ethical clearance was therefore not required at this stage. The planned pilot and main evaluation with pupils will require institutional approval, consent and assent, data protection, and appropriate safeguarding.

AI Declaration: I conceived and designed *Right Opinion* solely, including its learning design, mechanics, rules, and interpretation of the source. The fidelity analysis, argument, conclusions, and final text are also mine. Generative AI supported language drafting and editing; it did not determine the game or intellectual contribution. OpenAI's DALL-E model through ChatGPT produced prototype illustrations in July 2024 under my direction. No participant data were generated or analysed using AI.

References

- All, A., Nunez Castellar, E.P., and Van Looy, J. (2013) 'A systematic literature review of methodology used to measure effectiveness in digital game-based learning', in Escudeiro, P. and de Carvalho, C.V. (eds.), *Proceedings of the 7th European Conference on Games Based Learning, Academic Conferences and Publishing International*, Reading, pp 607-616.
- Arnab, S., Lim, T., Carvalho, M.B., Bellotti, F., de Freitas, S., Louchart, S., Suttie, N., Berta, R., and De Gloria, A. (2015) 'Mapping learning and game mechanics for serious games analysis', *British Journal of Educational Technology*, Vol 46, No. 2, pp 391-411. doi:10.1111/bjet.12113.
- Arztmann, M., Hornstra, L., Jeuring, J., and Kester, L. (2023) 'Effects of games in STEM education: A meta-analysis on the moderating role of student background characteristics', *Studies in Science Education*, Vol 59, No. 1, pp 109-145. doi:10.1080/03057267.2022.2057732.
- Biggs, J. (1996) 'Enhancing teaching through constructive alignment', *Higher Education*, Vol 32, pp 347-364. doi:10.1007/BF00138871.
- Bloom, B.S., Engelhart, M.D., Furst, E.J., Hill, W.H., and Krathwohl, D.R. (1956) *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain*, David McKay Company, New York.
- Candy, L. (2006) *Practice Based Research: A Guide*, CCS Report 2006-V1.0, Creativity & Cognition Studios, University of Technology Sydney, Sydney.
- Chi, M.T.H. and Wylie, R. (2014) 'The ICAP framework: Linking cognitive engagement to active learning outcomes', *Educational Psychologist*, Vol 49, No. 4, pp 219-243. doi:10.1080/00461520.2014.965823.
- Clark, R.E. (1983) 'Reconsidering research on learning from media', *Review of Educational Research*, Vol 53, No. 4, pp 445-459. doi:10.3102/00346543053004445.
- Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., and Boyle, J.M. (2012) 'A systematic literature review of empirical evidence on computer games and serious games', *Computers & Education*, Vol 59, No. 2, pp 661-686. doi:10.1016/j.compedu.2012.03.004.

- Department for Education (2013) National curriculum in England: design and technology programmes of study, [online], <https://www.gov.uk/government/publications/national-curriculum-in-england-design-and-technology-programmes-of-study> (accessed 24 July 2026).
- Department for Education (2015) National curriculum in England: science programmes of study, [online], <https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study> (accessed 27 July 2026).
- Fullerton, T. (2014) *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*, 3rd ed., A K Peters/CRC Press, Boca Raton. doi:10.1201/b16671.
- Garris, R., Ahlers, R., and Driskell, J.E. (2002) 'Games, motivation, and learning: A research and practice model', *Simulation & Gaming*, Vol 33, No. 4, pp 441-467. doi:10.1177/1046878102238607.
- Iacovides, I., Aczel, J., Scanlon, E., Taylor, J., and Woods, W. (2011) 'Motivation, engagement and learning through digital games', *International Journal of Virtual and Personal Learning Environments*, Vol 2, No. 2, pp 1-16. doi:10.4018/jvple.2011040101.
- Ke, F. (2008) 'Computer games application within alternative classroom goal structures: Cognitive, metacognitive, and affective evaluation', *Educational Technology Research and Development*, Vol 56, Nos. 5-6, pp 539-556. doi:10.1007/s11423-008-9086-5.
- Kozma, R.B. (1994) 'Will media influence learning? Reframing the debate', *Educational Technology Research and Development*, Vol 42, No. 2, pp 7-19. doi:10.1007/BF02299087.
- Makransky, G., Terkildsen, T.S., and Mayer, R.E. (2019) 'Adding immersive virtual reality to a science lab simulation causes more presence but less learning', *Learning and Instruction*, Vol 60, pp 225-236. doi:10.1016/j.learninstruc.2017.12.007.
- Ndemic Creations (2012) *Plague Inc.* [digital game], Ndemic Creations.
- NHS (2023) Listeriosis, [online], <https://www.nhs.uk/conditions/listeriosis/> (accessed 28 July 2026).
- NHS (2024) Food poisoning, [online], <https://www.nhs.uk/conditions/food-poisoning/> (accessed 28 July 2026).
- Noda, S., Shiotsuki, K., and Nakao, M. (2019) 'The effectiveness of intervention with board games: A systematic review', *BioPsychoSocial Medicine*, Vol 13, Article 22. doi:10.1186/s13030-019-0164-1.
- North Tees and Hartlepool NHS Foundation Trust (2026) *E. coli* O157 infection, [online], <https://www.nth.nhs.uk/resources/e-coli-0157-infection/> (accessed 28 July 2026).
- Parong, J. and Mayer, R.E. (2018) 'Learning science in immersive virtual reality', *Journal of Educational Psychology*, Vol 110, No. 6, pp 785-797. doi:10.1037/edu0000241.
- Plass, J.L., Homer, B.D., and Kinzer, C.K. (2015) 'Foundations of game-based learning', *Educational Psychologist*, Vol 50, No. 4, pp 258-283. doi:10.1080/00461520.2015.1122533.
- Royal Berkshire NHS Foundation Trust (2024) *Salmonella*, patient information leaflet, [online], https://www.royalberkshire.nhs.uk/media/rwabbgcq/salmonella_nov24.pdf (accessed 28 July 2026).
- Ward, B. (2000) *Epidemic*, Dorling Kindersley, London.
- Whitton, N. (2014) *Digital Games and Learning: Research and Theory*, Routledge, New York. doi:10.4324/9780203095935.
- Wouters, P., van Nimwegen, C., van Oostendorp, H., and van der Spek, E.D. (2013) 'A meta-analysis of the cognitive and motivational effects of serious games', *Journal of Educational Psychology*, Vol 105, No. 2, pp 249-265. doi:10.1037/a0031311.