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Project:Filter - Using Applied Games to Engage Secondary Schoolchildren with Public Policy

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Abstract

Applied games present a twenty-first century method of consuming information for a specific purpose beyond pure entertainment. Objectives such as awareness and engagement are often used as intended outcomes of applied games in alignment with strategic, organizational, or commercial purposes. Applied games were highlighted as an engagement-based outcome to explore *noPILLS*, a pan-European policy research project which presented policy pointers and suggested methods of interventions for reducing micropollution within the wastewater treatment process. This paper provides an assessment of a video game which was developed for the purpose of public engagement with policy-based research. The video game, *Project:Filter*, was developed as a means of communicating *noPILLS* to secondary school children in Scotland as part of a classroom-based activity. Knowledge development and engagement were identified using Interpretative Phenomenological Analysis to evidence topical awareness, depth of understanding, and suggested methods of intervention. Analysis of observations also provided insights into challenges surrounding logistics, pedagogy, social interactions, learning, and gender as contributing factors to the schoolchildren's experiences of *Project:Filter*. The intention of this paper is two-fold: firstly, to provide an example of developing video games from policy-based research; and secondly, to suggest methods of phenomenological assessment for identifying play-based engagement.

1. Introduction

noPILLS was a research project which brought together academic, governmental, and industrial stakeholders with the intention of assessing causation and consequences of micropollution across European public and private water supplies. The final report highlighted a breadth of impacts that have "contributed towards a better understanding of the complex systems of processes and – probably more importantly – actors that influence the presence of pharmaceutical micropollutants in waste water and, ultimately, receiving waters" (Adamczak, 2015). Among these impacts was the influence of human behaviors and attitudes: the research found publics to have a lack of knowledge and understanding of their behaviors and their consequence on environmental and public health (Adamczak, 2015). Additionally, the research highlighted that, while industry partners and members of the public were, in general, willing to support changes, this did not necessarily equate to having an understanding of the means in which to create change (Adamczak, 2015).

noPILLS explored the development and potential use of digital technologies – in particular, the use of video games – to address public attitudes and understanding of issues related to micropollution. The *noPILLS Jam* (Ramzan & Reid, 2016; Adamczak, 2015) provided evidence of prototypes in which information could be presented to different audiences in a playful and digestible manner. The *noPILLS Jam* provided initial evidence that a game-based approach to addressing issues surrounding micropollution offered a potential avenue to target public behaviors and attitudes (Ramzan & Reid, 2016).

The purpose of this study was to develop and evaluate the effectiveness of a game for the purpose of developing knowledge and understanding of micropollution among schoolchildren. Specifically, the study aimed to highlight the impact of a game-based learning approach in addressing outcomes of awareness and engagement in public policy defined by *noPILLS*. The study also aimed to provide a case study on the use of phenomenology as a method of describing and assessing game-based learning The study addressed the following questions:

1. How might a game be designed and deployed to encourage schoolchildren to engage with public policy?
2. To what extent can phenomenology be used as a way of assessing engagement through play?
3. How far does the game highlight the overlap between engagement and learning?

1.1. Game-based Learning and Phenomenology

Game-based learning describes the use of games with the intention of satisfying a learning goal (Prensky, 2001). The use of a game-based learning approach suggests that knowledge development is a precedent for attitudinal and behavioral change. While it cannot be assured that an individual will necessarily show evidence of acquired knowledge (Buckley & Anderson, 2006) or associate their behaviors to knowledge (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2012), there equally exists research which shows the impact of knowledge development on informing human activity, particularly within the context of digital games (Shaffer, Squire, Halverson, & Gee, 2004; Ritterfeld & Weber, 2006; Gee, 2007; Cain & Piascik, 2015; Boyle, et al., 2016).

Phenomenology, the philosophical study of experience and consciousness (Husserl, 2001), presents an alternative perspective to assessing learning outcomes. Phenomenology has value in the assessment of user experiences for "investigating both experience and meaning, and by providing holistic insights appropriate in user research" (Arvola & Linder, 2017). To this end, phenomenology provides a descriptive method in which to explain not only what is learned, but how and to what length someone has learned and applied, certain information. Additional to this is the usefulness to interpret

individual experiences as well as generating holistic insight of a group. This suggests clear benefits to game-based research, where individual and demographic experiences are useful in the development (Pagulayan, Keeker, Wixon, Romero, & Fuller, 2003; Canossa & Drachen, 2009) and assessment (Charles et al., 2005; IJsselsteijn, de Kort, Poels, Jurgelionis, & Bellotti, 2007) of games.

1.2. Project:Filter

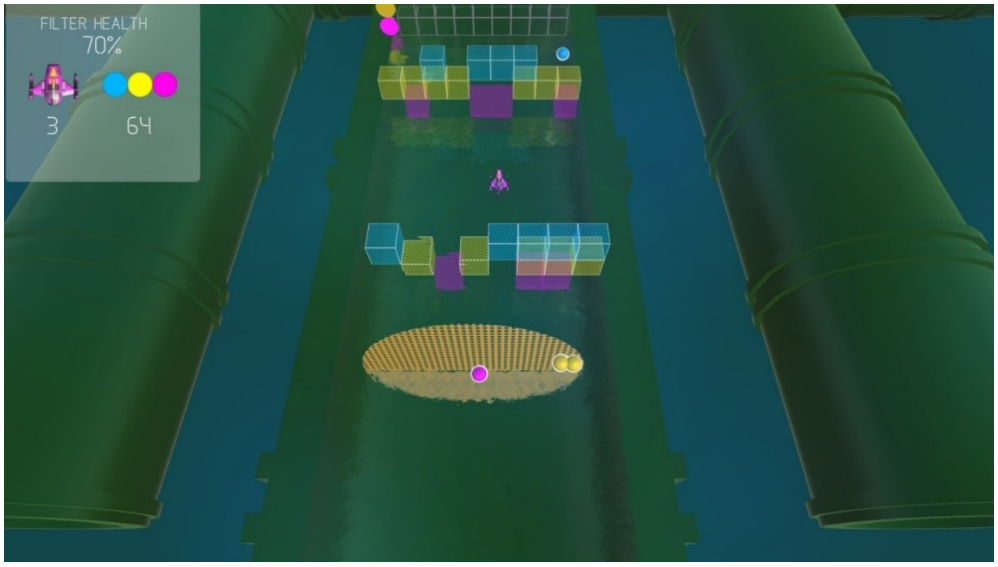

Figure 1: Screenshot of Project:Filter

Project:Filter (Figure 1) was developed in order to present the research of *noPILLS* through a formal education environment – the school classroom – as a route for engaging secondary schoolchildren. This project was conscientiously designed with respect to the Curriculum for Excellence, the national framework for education in Scotland (Education Scotland, 2013). The Curriculum for Excellence afforded a set of criteria in which a game-based learning approach would be required to satisfy. With consideration to the purpose of *noPILLS*, and the intention to address public knowledge and attitudes on micropollution, *Project:Filter* considered the learner's ability to "discuss the environment impact of human activity and suggest ways in which we can live in a more environmentally-responsible way" (Education Scotland, 2017). This assisted in the identification of the subject (Social Studies), the target audience (Stage Two learners in secondary education), and the intended learning outcomes ('discussion' and 'suggestion') which informed the game's design.

1.2.1. The Game Component of *Project:Filter*

Figure 2: Screenshot of Project:Filter

Project:Filter presents the player as an Environmental Inspector with two main tasks. First, the player must explore and interact with an environment which has been impacted by high levels of micropollution. Seven topics from *noPILLS* are depicted within the game: Parasites and Insects, Rural Living, Marine Wildlife, Urban Living, Solid Waste, Agriculture, and Public Health. Once they have identified these areas (Figure 2), the player can enter effluent pipes nearby in order to help with the filtration of micropollutants from the water system. By utilizing the game aesthetics of discovery, narrative, and challenge (Hunicke, LeBlanc, & Zubek, 2004), the game aimed to promote an inquiry-based experience in which to investigation and interaction would lead to knowledge acquisition.

The development of *Project:Filter* followed a six-stage iterative framework (Figure 3) which serves as a creative process and practice-based exploratory research method. The model was influenced by iterative game development practices (Fullerton, 2014), models of criticality and value-based design (Flanagan, 2009; Flanagan & Nissenbaum, 2014), and a component-based game design framework (Hunicke, LeBlanc, & Zubek, 2004). Each stage of the development framework intended to follow a sequential and iterative manner with the aim of addressing the identified goals of awareness and engagement in public policy.

Figure 3: Game development framework for Project:Filter

The development of *Project:Filter* aimed to address the difficulties associate with micropollution, including its environmental impact (Adamczak, 2015, pp. 24-41), regional differences (Adamczak, 2015, pp. 42-69), technological constraints (Adamczak, 2015, pp. 83-86), and issues surrounding public awareness (Adamczak, 2015, pp. 19-22). Goals of public awareness were coupled with gaps in public knowledge as a contributory factor to the problem. As a result, the game's conceptual design focused on the development of knowledge and understanding of issues in order to inform attitudes and behaviors of publics. The game also aimed to highlight concerns of sanitation, consumption, and illness as part of the game's content. These formed the basis of information that would be used to communicate issues to the player through *Project:Filter*.

These objectives were translated into various game components (Table 1) with the intention of providing a play experience that would address the identified area of research. The 'mechanics' act as a means of reflecting awareness-based research objectives through defining the rules and objectives of the game. The 'aesthetics' and 'dynamics' (Hunicke, LeBlanc, & Zubek, 2004) of the game identify play styles and means of communicating curiosity and responsibility to the player. The 'player agency' enforces an antagonistic perspective of micropollution as the obstacle to the player's goal. The 'deployment' and 'resources' of *Project:Filter* supports a free, multimodal approach which aimed to develop literacy and communication skills (McGinnis, 2007; Jewitt, 2008; Arzarello & Robutti, 2010; Lotherington & Jenson, 2011). 'Quality assurance' concerns the maintenance and validation of the game's standards in terms of design, programming, and assessment of user experience (Novak, 2005; Schultz & Bryant, 2016). The 'play ethics' of *Project:Filter* follows a closed ethical design approach in order to allow players to reflect on the scenario they are following in an attempt to create self-responsibility (Sicart, 2009).

Table 1: Design components for Project:Filter.

Game Component	Description	Design of Project:Filter
Mechanics	Purposeful user activities and rules that create the boundaries for play.	**Locate and identify areas of environment affected by micropollution** **Remove micropollution from environment** **Protect carbon filter from micropollution**
Dynamics and Aesthetics	The behaviors and emotions as a result of the visual and aural stimulus of the game.	**Play as discovery** **Play as challenge** **Play as narrative** **Play as expression**
Player Agency	The perspective afforded to players within the game irrespective of whether this is explicitly defined.	**Assume role of 'new recruit' to water management service** **Narrative cues focus on cause-and-effect of micropollution** **Environmental issues presented as antagonist to player objectives**
Deployment	The publishing strategy of the game, including platform and accessibility.	**Optimized for low PC specifications** **Free to download resources**
Resources	The software, hardware, and access requirements for the game.	**Keyboard-and-mouse input** **Physical workbook to support digital game**
Quality Assurance	The validation of standards and procedures to be met by the game.	**Engagement with, and feedback from, interest groups in game development, education, and civic technology.**
Play Ethics	The ethical experience relating to play.	**Closed ethical design** **Encouraged self-responsibility**

1.2.2. The Workbook Component of *Project:Filter*

The workbook for *Project:Filter* was inspired by *The Mystery of Taiga River* (Center for Games and Impact, 2013), which used a workbook and a game to deliver a multimodal, blended learning exercise. It aimed to support learning through various methods of pedagogical delivery (Table 2). A task-based learning format was utilized to emphasize the investigative nature of the exercises. The learner was asked to complete a job application before they could be recruited. Each succeeding task

informed the next activity: the exercise on word association introduced the learner to relevant information to look out for in the game; the information taken from the game informed the development of a poster for raising awareness to the public. The task-based format allowed the progress of each learner to be monitored alongside the achievement of knowledge-based research objectives. A role-play pedagogy provided context to the learner's experience. By setting the context of the learner as an environmental inspector to be recruited, the intention was to apply a level of structure to the learning activity, where each individual would have a shared or similar perspective of the overall lesson. A discovery-based learning approach encouraged learners to explore the game environment and identify areas of interest that would contribute towards their knowledge in environmental health. A constructivist learning approach allowed learners to make sense of their discoveries and how these instances translate into a real-world context.

Table 2: Pedagogies in digital game-based learning (adapted from Prensky, 2001).

Pedagogy	Description
Discovery Learning	Players are encouraged to discover methods of play to overcome certain challenges. Designed learning experiences based on discovery can encourage players to experiment with actions or source information in order to succeed in the game.
Task-based Learning	Video games can encourage players to learn skills by completing specific tasks. A scaled progression of difficulty with each subsequent task can be useful in challenging and developing player skills.
Role-playing	Simulative experiences can be created in video games to provide players with a replicable and intentional learning experience. Role-play can be effective for preparing players for particular events or environments.
Constructivist Learning	Constructivism encourages learning through exploration, as opposed to instruction. Video games can facilitate players to construct theories, hypotheses, inventions, or processes in order to make sense of an experience or situation.

2. Method

2.1. Recruitment

Two Scottish secondary schools were recruited through responding to an open call to voluntarily participate in the study: this study refers to the schools as School A and School B, respectively. With respect to national standards, the schools were considered to deliver similar quality standards of education, based on the most recent assessments of the academic performance at the time of the study. Consent from schools was sought through a Plain Language Statement, while individual schoolchildren were asked to complete and return a consent form authorized by a parent or guardian. A total of fifty-two schoolchildren aged between eleven and thirteen took part in the study. The distribution of gender (M = 33, F = 19) was beyond the direct control of the study conditions as a result of the nature of the recruitment strategy.

2.2. Procedure

Three fifty-minute sessions were delivered to each school in accordance with their respective availabilities and timetables. The first session involved a didactic introduction to *Project:Filter* with workbook-based exercises that aimed to familiarize pupils with general terms related to micropollution. The second session revolved around the play of the game in order to record information from the virtual space pertaining to micropollution and its effect on the environment. The final session challenged the schoolchildren to create an awareness campaign poster based on the information they had collected from the game, highlighting the problem, its impact on the environment, and a potential behavioral solution to resolve the issue.

2.3. Data Collection

Two approaches were used to collect data. Firstly, the pupils' workbooks provided evidence of participation and understanding of the subject matter. Knowledge development could be traced from the initial exercises on basic terms, to the capturing of information during play, and in its application within the poster exercise in the final session. Secondly, an observational protocol (Cresswell & Poth, 2018) was followed. Observations were categorized as descriptive (interpreted phenomena within the session based on the perception of the observer) or reflective (reviewing of phenomena to assess contextual reasoning). Observations and their related categories were defined (Table 3) prior to the commencement of the study (Cresswell & Poth, 2018).

Table 3: Descriptive and Reflective Observations

Descriptive	Reflective
• Demographics	• Rationale
• Participant Remarks	• Sketches
• Participant Activities	• Themes and Connectedness
• Participant Queries	• Recurrence
• Social Interactions	
• Participant Behaviors	
• Situated Environment	
• Duration of Tasks	

2.4. Data Analysis

The study evaluated *Project:Filte*r, with respect to learning and awareness, using Interpretative Phenomenological Analysis (IPA), a qualitative analysis method with the purpose of interpreting and describing individual experiences (Smith, Flowers, & Larkin, 2009). IPA was considered as a suitable approach to interpret resulting phenomena from play, which can be characterized as unpredictable (Hunicke, LeBlanc, & Zubek, 2004; Caillois, 1961). The purpose of adopting IPA was to collate phenomena into emergent themes, provide rationality through rationalization, and explain its significance in the context of game-based learning and awareness.

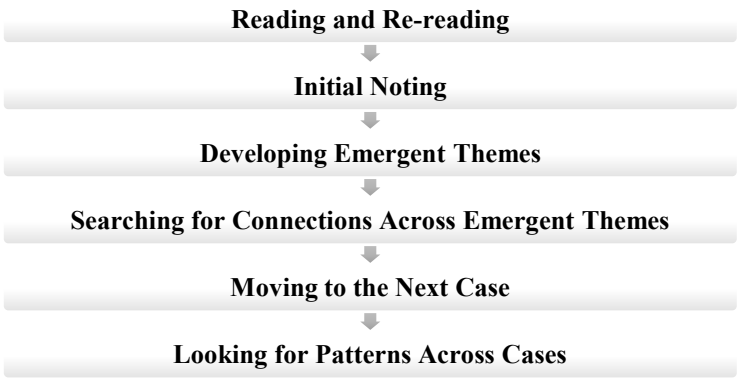

Figure 4: Interpretative Phenomenological Analysis process.

The process of IPA is a six-step method of analysis (Figure 4). This involves the isolated and thorough reading and understanding of data. Initial noting covers phenomena within the data that is of significance to the context of the research: these notes are categorized as descriptive (key words or phrases used by the participant), linguistic (the language used in relation to the activity), and conceptual (based on the interrogation of the researcher). Emergent themes can be derived from notes, and connections can be established across these themes (Table 4). This process is repeated for each individual case before patterns are sought across cases.

Table 4: Description of Connectedness Types (adapted from Smith, Flowers, & Larkin, 2009)

Connectedness Type	Description
Abstraction	Themes which can be grouped by likeness under a superordinate theme.
Subsumption	A theme which becomes superordinate and encompasses other emergent themes.
Polarization	Related themes which can be compared by differentials in the responses.
Contextualization	Local influences on the data, such as culture, narrative, and temporal events.
Numeration	The frequency of the theme within the responses.
Function	Themes which emerge as a result of the 'self'.

3. Results

From the participants available for the study, a total of forty-two completed posters were submitted. Posters were considered as 'complete' based on a criterion sampling process (Miles & Huberman, 1994) in which the poster featured adequate textual or visual information to assess the efficacy of *Project:Filter*. The analysis of contributions from, and observation of, the schoolchildren resulted in eleven emergent themes (Table 5).

Table 5: Emerging Themes from Interpretative Phenomenological Analysis

Theme	Identified Connectedness Types from Analysis
Topic Coverage	Abstraction, Subsumption, Contextualization, Numeration
Literacy	Abstraction, Function
Perceived Stage of Learning	Abstraction, Subsumption, Polarization
Incomplete and Inconclusive Contributions	Contextualization, Numeration
Recording of Play Activity	Polarization, Numeration
Logistics	Contextualization
Pedagogy	Contextualization
Social Interaction	Contextualisation, Function
Play-based Feedback	Abstraction, Subsumption
Task-based Learning	Contextualization
Gender	Subsumption, Function

3.1. Topic Coverage

Topic coverage related to the coverage of subject matter through visual and textual information. The choice of topics (Table 6) suggested various outcomes from *Project:Filter*. Firstly, the numeration of topics suggested a likelihood of engaging with subject matter which featured dynamic environment components (in which animation was visibly present) in comparison to static environments (where no animated elements were present). This suggested that the animated features of the level could have been significant in creating resonance with the schoolchildren, particularly as the exercise provided the freedom to choose any discovered environment.

Table 6: Topics covered in posters created from Project:Filter

Topic	No. of Instances
Parasites and Insects	6
Rural Living	2
Marine Wildlife	9
Urban Living	6
Solid Waste	7
Agriculture	1
Public Health	1

Student posters evidenced correlation to the content of *Project:Filter*. An example of this concerns the impact of micropollution on marine wildlife, where a schoolchild made reference to the impact of micropollution on the behaviors of fish (Figure 5). This was associated with the level on Marine Wildlife, in which the game makes reference to 'the concentration of micropollution' and 'fish act[ing] aggressively.' Additionally, the poster featured language that was not directly taken from the in-game text, suggesting that the schoolchild was able to interpret and translate the issue using their own words as a signal of understanding.

Figure 5: Poster identifying the impact of micropollution on marine wildlife

Visual associations were also evident across some posters. One such poster visualized the Solid Waste level from *Project:Filter*, in which the land mass was shown to have deteriorated as a result of micropollution. The poster was interpreted as a reimagining of the environment in *Project:Filter* with the depiction of an orange landscape and bare trees (Figure 6). This poster was also perceived as evidence of understanding the message of *Project:Filter*, while communicating through visuals rather than text.

Figure 6: Poster identifying the impact of solid waste on environmental health.

3.2. Literacy

Literacy was perceived as a multimodal method of communicating knowledge and understanding, through textual and visual interpretations. From a descriptive perspective, it was most common for participants to convey text-based information in their own words and phrases, rather than duplicate information from in-game text. This suggested that the schoolchildren cognitively interpreted and translated information to develop their own understanding of the issues presented through *Project:Filter*. Through self-developed descriptions of issues, participants evidenced knowledge transference that involved interpretation, understanding, and application of their experience with the game.

Conceptual interpretations of visual communication suggested evidence of the schoolchildren's understanding of issues surrounding micropollution. Figure 7 shows an example of a player's communication of industrial waste management through the visual structure of a comic strip. The structure of the comic strip was effective in conveying a hypothetical scenario through narrative, in which civic activism informed the decision-making of industry stakeholders. By highlighting public forums as a method of facilitating change, the poster emphasized the pupil's understanding and positive reflection of civic engagement for addressing societal concerns surrounding micropollution.

Figure 7: Poster with prominence of visual communication.

3.3. Perceived Stage of Learning

The study categorized learning stages with reference to Bloom's Taxonomy (Anderson, Krathwohl, & Bloom, 2001) and, in particular, the Cognitive Process Domain as an assessment of *Project:Filter's* facility to engage players in learning. This categorization was applied to *Project:Filter* to evidence the ways in which learning stages were identified through the schoolchildren's contributions.

From the analysis (Table 7), there was a large volume of participants who engaged with tasks at the low-learning stages of learning ('Remember', 'Understand' and 'Apply') than the domain of high-level thinking ('Analyze', 'Evaluate' and 'Create'). This was indicative of the expected learning outcomes from Stage Two students within the Social Sciences subject as outlined in the Curriculum for Excellence, where the language used to describe benchmarks for learning (Education Scotland, 2017) correlate with the language of low-level learning (Dalton & Smith, 1986). Thus, *Project:Filter* can be assessed to have provided an appropriate environment for meeting the required level of learning set within the national curriculum for education.

Table 7: Evidence of Cognitive Process Domain in action through Project:Filter.

Cognitive Process Domain	Evidence in *Project:Filter*	No. of Instances
Remember	Referred to in-game content	7
Understand	Evidence of interpretation and explanation of in-game content	14
Apply	Applied understanding of in-game content to a real-world issue related to micropollution	8
Analyze	Evidence of critical thinking, such as connecting the impact of an environmental issue to other situations.	3
Evaluate	Evidence of comparing different approaches and solutions to the issue.	1
Create	Evidence of creating an intervention and/or system which could be used to address the issue.	0

3.4. Incomplete and Inconclusive Contributions

Incomplete and inconclusive posters were highlighted as those which had a lack of information on a subject matter to evidence knowledge and understanding. While it was not the intention of this research to highlight a lack of engagement, it was an emergent theme from the analysis of posters based on numeration. One reason for the volume of inconclusive posters was the unforeseen absence of some pupils: this was identified as a perceived weakness of the lesson structure as opposed to the failure of the participant to complete the task.

Figure 8: Poster on litter pollution with inconclusive connectedness to *Project:Filter*.

Another characteristic of inconclusive poster contributions was the presentation of information which could not be connected to the content of *Project:Filter*. Figure 8 showcases an example of an inconclusive poster in this nature: the poster presents textual and visual information of litter pollution. However, *Project:Filter* did not project the issue of litter pollution as part of its content. This may be an indication of the task's lack of clarity in ensuring the participant communicated content that they had collected from the game.

3.5. Recording of Play Activity

Schoolchildren were expected to record their gained knowledge within their Pupil Workbook as part of the play exercise. Recorded information was expected to form the basis of information to be used for the poster exercise. In total, thirty-four schoolchildren were identified as having logged their observations into their Pupil Workbook. The note-taking exercise was perceived to provide two benefits to the player. Firstly, the exercise gives the player a facility to log thoughts and understanding, as opposed to placing an expectation on memory and recall. Secondly, the objectivity of the participant's transcription provides an evidential basis for identifying engagement with the subject matter through play.

There were seven instances in which schoolchildren created posters without evidence of connectedness to the exercise within the Pupil Workbook. These posters were also categorized as inconclusive posters that covered topics that were not included in the game. These instances emphasized the importance of the task-based exercises in directing the attention of the player in order to engage with the desired topics.

3.6. Logistics

The delivery of *Project:Filter* was spread over three fifty-minute lessons to complement each school's timetabling system. The Pupil Workbook played an important role in maintaining continuity over the three lessons: this was particularly evident with the continuity between the play-based exercise and the poster creation exercise, which was delivered in two separate sessions. Participants were perceived to be more likely to complete the poster-based exercise if they had made notes of observation while playing *Project:Filter*. Thus, the structure of the exercises was considered to be logical and supportive of facilitating awareness of *noPILLS*.

Variance in available resources, such as IT equipment, meant that a small portion of the schoolchildren were asked to play *Project:Filter* in pairs. This was identified as the most-appropriate logistical solution. The exclusion of participants would have been contradictory to 'Support for All' policy that is embedded into the Curriculum for Excellence, which grants all schoolchildren in Scotland equal opportunity to learn (Education Scotland, n.d.). It was strongly encouraged to these pupils that they continue to work individually and make their own observations. Through observation and inspection of each participants' Pupil Workbook, the schoolchildren in pairings were adjudged to have worked independently from their peer. This suggested that *Project:Filter* may be delivered in school environments with limited resources while promoting autonomous learning.

3.7. Pedagogy

The demand on resourcing, in particular the requirement for computer-based technologies with appropriate specifications to execute *Project:Filter*, could be an issue for schools that may identify as being technologically or economically underprepared for the use of game-based learning in classrooms (Torrente, Moreno-Ger, Martinez-Ortiz, & Fernandez-Manjon, 2009; Saleh, Prakash, & Manton, 2014). While School A offered a wealth of available classrooms and resources for the research, School B were limited in the rooms that they could offer and the facilities that they had. While this study offered additional resources, such as laptops, to support the learning activity, this approach cannot be perceived as a sustainable method of delivering game-based learning in classrooms. This raises the question of policies on the readiness of schools in Scotland to adopt digital learning-based pedagogies, and whether some schools may be disadvantaged from the increasing use of digital technologies in classroom learning.

3.8. Social Interactions

It was not the intention of this research to record social interactions between participants using audio-visual equipment for two reasons. Firstly, the classroom environment was not conducive to capturing audio-visual recordings of any nature: given the composition of the room and its facilities, any positioning of cameras and recording equipment would have provided recordings which emphasized the actions and behaviors of certain participants that would have been closer to the equipment and, thus, presenting technology-based bias to the data capture. Additionally, the available computers were not considered to have the appropriate specifications to facilitate screen-capture software in order to track player activities within *Project:Filter*.

Secondly, the introduction of audio-visual equipment within the classroom environment may have caused unnatural behaviors among the schoolchildren (Adair, 1984) and, thus, compromising the nature of the data collected. As a result, observations were made by the research and captured using notes, sketches, and reflections (Cresswell & Poth, 2018).

3.9. Play-based Feedback

Table 8: Response from participants on game components of Project:Filter.

Question	Design Reflection	Rating (0-5)
I found the practice area (Tutorial) at the beginning helpful.	Mechanics Player Agency	3.91
I found the environment to be interesting.	Aesthetics Dynamics	3.71
I found the drone that I was controlling fun.	Mechanics Dynamics Player Agency Resources	3.63
I found the filters to be useful and helpful.	Mechanics	3.45
I found the text to be easy to read and understand.	Player Agency Deployment	4.03
I found the controls to be easy to learn and use.	Mechanics Resources	3.67
I found the levels to be not too easy or too difficult for me.	Mechanics Dynamics Player Agency	3.31

As part of the Pupil Workbook, pupils were asked to reflect on their experience of the game as a way of assessing the design of the play-based learning exercise. The collation of the responses (Table 8) suggested that players' experiences of *Project:Filter* was perceived to be positive. Each element of the game was considered to receive an above-average rating, with particular emphasis placed on the response to the presentation and legibility of the text within the game. Responses to the Tutorial emphasized a positive reaction, which was highlighted by the unnecessity to intervene with the schoolchildren in order to explain how to play the game. These questions reflected corresponding design decisions made during the development of the game, which assisted in validating decisions made for the purpose of learning and awareness.

3.10. Task-based Learning

While it was expected that pupils would complete tasks in their entirety due to the nature of delivered education within the school environment, each task within the Pupil Workbook had a varied rate of completion (Table 9). The play-based exercise (Identifying Areas of Interest) and the poster-based exercise (Sharing Your Ideas) were shown to have the most completions across the schoolchildren.

Table 9: Total number of completed tasks.

Task	No. of Completions
(A) Job Application	31 (60%)
(B) Learning the Ropes	27 (52%)
(C) Identifying Areas of Interest	33 (63%)
(D) Reviewing *Project:Filter*	27 (52%)
(E) Sharing Your Ideas	40 (77%)
(F) Thinking Ahead	30 (58%)

Two explanations could suggest the reason for this phenomena. Firstly, the schoolchildren may have been receptive to the strategy of learning through discovery and curiosity, which was indicative to the design of *Project:Filter*'s mechanics. Secondly, there was a perceived element of peer learning (O'Donnell & King, 1999) during the play-based and poster-based exercises which was not evident in the other activities. This emerged organically as a result of the nature of each activity: pupils showed off their discoveries within the game to their peers, as well as discussing their posters at their grouped desks during the activity.

3.11. Gender

Table 10: Percentage of task completions by gender.

Task	% of Male Completions	% of Female Completions
(A) Job Application	58	63
(B) Learning the Ropes	55	47
(C) Identifying Areas of Interest	58	74
(D) Reviewing *Project:Filter*	52	53
(E) Sharing Your Ideas	76	79
(F) Thinking Ahead	52	68

One observation made during the delivery of *Project:Filter* was the perceived difference in approaching the task-based activities between male and female schoolchildren. On reflection of the rate of completions made by each gender (Table 10), female schoolchildren were, on average, more likely to complete the exercises within the Pupil Workbook compared to male schoolchildren. This was an unexpected outcome of the study and contrasts with a meta-analysis conducted by Cai, Fan, and Du (2017), which suggests a higher self-confidence and more positive attitude to technology use among male learners.

Studies suggest a variance in gender attitudes towards technology-based learning, with some studies reporting a significant variance in attitudes (Gefen & Straub, 2000; Cai, Fan, & Du, 2017) – which could lead to some schoolchildren disengaging with the learning activity – while others dismiss any attitudinal influence over technology-based learning strategies (Vanderheyden & De Baets, 2015;

Al-Azawei, Parslow, & Lundqvist, 2017). Further research and investigation into phenomena surrounding contemporary attitudes on technology-based learning should be considered of great importance given the increasing use of technology within secondary school environments (Montrieux, Vanderlinde, Schellens, & De Marez, 2015; McCulloch, Hollebrands, Lee, Harrison, & Mutlu, 2018).

4. Discussion

4.1. *Project:Filter* as an Engagement Tool

The study was conducted as a cross-sectional project which highlighted significant phenomena at the time of *Project:Filter*'s delivery. This approach did not take into account the longitudinal effect of engaging with *Project:Filter* and the possible impact this may have on attitudes and knowledge over a period of time. Further research and alternative methodological approaches should be considered to pursue this understanding.

4.2. Phenomenology as Play-Based Assessment of Engagement

IPA was considered to be an effective and valuable method of deconstructing and assessing forms of engagement from the perspective of the individual. The themes which emerged from IPA were extrapolated from each individual experience to provide a holistic assessment of *Project:Filter* and its efficacy for engagement. This case provides an example of how IPA may be applied to deliver a user-centered method of assessing play-based phenomena, particularly in the identification of engagement as an outcome of the play.

Limitations of using IPA include its pluralistic application while the method of research continues to evolve (Biggerstaff, 2014). Engagement with IPA as a method, and phenomenology as a research practice, would be beneficial to game-based research as it would help in developing the practice and pluralistic characteristics of phenomenological research methods in assessing play-based outcomes.

4.3. Engagement and Learning

This study sought to assess the efficacy of *Project:Filter* as a game which developed knowledge and understanding of micropollution as presented in *noPILLS* (Adamczak, 2015). The game-based learning approach what was adopted provided a case study of how a game could be applied within an educational context in order to measure awareness among schoolchildren.

Issues surrounding the logistics of applying *Project:Filter* as a game-based curricular approach to engagement would also have to be considered. The availability of resources and IT equipment was a factor that existed outwith the scope of the study, yet this could provide a significant restriction on how effective digital technologies, including game-based learning tools, can be to schools across Scotland. It remains a key policy of the Scottish Government, as part of their enhancement of learning through digital technologies (The Scottish Government, 2016, to support the use of digital technologies in curriculum-based learning.

5. Conclusions

The study has highlighted the impact of a game-based learning approach in addressing outcomes of awareness and engagement in public policy defined by *noPILLS*. The design and development of *Project:Filter* provides a case study in the creation of a digital game with the purpose of encouraging students to engage with public policy related to micropollution and environmental health. The study also suggests the use of a phenomenological method of analysis as a means of identifying and assessing engagement as a result of play. The application of *Project:Filter* within an educational environment to

engage schoolchildren in issues pertaining to micropollution could suggest that learning environments may provide a suitable space to encourage participation with public policy.

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