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Profiling the Educational Value of Computer Games

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Abstract. There are currently a number of suggestions for educators to include computer games in formal teaching and learning contexts. Educational value is based on claims that games promote the development of complex learning. Very little research, however, has explored what features should be present in a computer game to make it valuable or conducive to learning. We present a list of required features for an educational game to be of value, informed by two studies, which integrated theories of Learning Environments and Learning Styles. A user survey showed that some requirements were typical of games in a particular genre, while other features were present across all genres. The paper concludes with a proposed framework of games and features within and across genres to assist in the design and selection of games for a given educational scenario.

Keywords: game design; games educational value; learning styles and games; learning environments and games.

1 Introduction

Interest raised by the use of games to support education has fluctuated several times over the years [3], [25], [15], [29], [26]. Seeing a wave of renewed interest [32], [16] it would be useful to review the current state of affairs in the area, as well as to consider some future avenues for potential research.

The potential of gaming to enhance and support learning has been widely discussed, with gameplay promoting a broad range of values and skills which include problem-solving, decision-making [1], motivation [8], real-time feedback and assistance [9], situated learning [14], communal responsibility [4], collaborative learning, data collection and analysis, hypotheses testing, and development of debate skills. But what features of games enhance learning experiences and ultimately promote learning in students with diverse learning needs and different learning styles?

As research continues into the creation and use of computer games for educational purposes, the differences between games that belong to particular genres become more evident and relevant [31]. Interestingly, these differences which become relevant at the time of selecting a game for an intended learning outcome appear to

have been largely overlooked by the academic community, adding to the uncertainty of determining the value of computer gaming as a whole in formal education.

Based on the assumption that the features (and combinations of features) present in games influence the gaming-learning experience, in this paper we review our work on learning environments, the use of mini-games, and studies of games genres that led to defining a criteria of features needed in a game to offer educational value. We present studies carried out in order to identify significant features offered by different game genres, and, through a user survey, to determine whether game quality improves as more of the identified value-features are included in a game. The tasks to complete our studies are shown in Figure 1 and the structure of this paper follows the sequence of the tasks displayed.

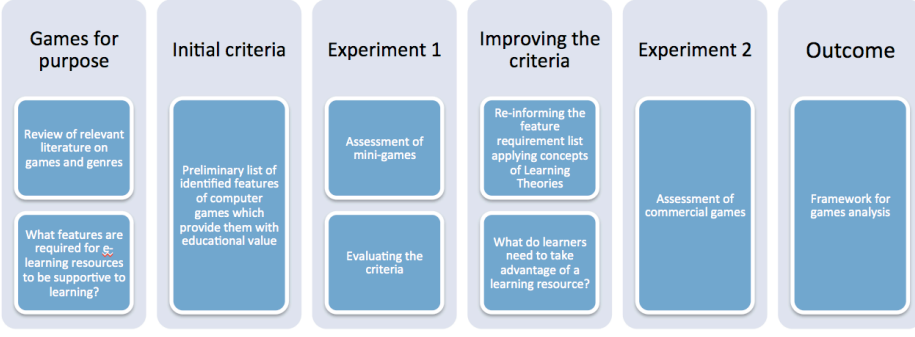

Fig. 1. Sequence of tasks used for the identification and testing of a game-evaluation framework

1.1 Games for purpose: characteristics, game genres and learning

In our paper [12] we began to review current research into the importance of genre when considering computer games in an educational context. This review identified several patterns when genre was factored into educational game research. The first covers researchers identifying that games of different genre are likely to offer different player experiences, but without investigating exactly what those experiences are, and how they might differ [28], [30], [17]. Another involves a genre-based approach to investigation [2], but without any clear education-based rationale for the chosen genres. Finally, there is research where little or no consideration has been explicitly made to game genre. Here, either all games are treated equally or a single game is treated as representative of all games [7]. In exploring existing research, it becomes apparent that no single piece of work has identified that game genre could influence the game play experience in different ways, considered what those ways might be (with a sound, pedagogical rationale), and conducted studies to investigate how genres map onto game play experiences.

1.2 Preliminary requirement criteria for educational games

A game space could be considered to be a self-contained space with its own system of rules and populated by entities that exhibit distinct behaviours. It could therefore be reasonably suggested that a game used in a learning context would in itself be a learning environment. In turn, it could be suggested that a set of requirements for a successful learning environment could also be an appropriate set of requirements for a good educational game.

This section highlights research into learning environments (fully discussed in [11]), and the suggested features that are required of them. The result is a preliminary list of required elements of good computer games (Table 1) which we later use to assess the potential usefulness of a selection of games to education and ultimately learning.

Theories on learning environments have been discussed in the "Conversational Framework" model [21] and in the works of [20]. Emphasis on the need to provide a practical environment to exercise any theoretical model which in turn creates contextual meanings and a more "learner-centred, non-linear and self-directed" learning are points of convergence between the models. In sum, a learning resource derived from users' existing knowledge and educational requirements will be as useful as it is customisable. An important suggestion from the previous work is the compatibility of learning resources across environments which will further its functionality by allowing multiple users to re-use the resource without needing further development. Another aspect of learning discussed by [20] utilises Merrill's [22] "first principles of instruction", which suggest learning is promoted when learners are engaged in solving real world problems, existing knowledge is activated as the foundation for new knowledge, and finally new knowledge is demonstrated to the learner, applied by the learner and integrated into the learner's world. [24] highlights even more requirements taking Norman's [23] "seven basic requirements of a learning environment and Keller's [18] ARCS (Define) method. These cover areas such as intensity of interaction, provision of well-defined goals, motivation and immersion. These requirements reinforce many of those already established, in particular those relating to flow and immersion – by immersing him or herself fully, the learner can absorb information from their own experiences, rather than from instruction.

Based on the theories reviewed a list of key requirements for a game as an educational learning resource was compiled. Table 1 shows the resulting list which suggests that the most important features of an educational resource are the ability for learners to explore contextually relevant environments, learner-instructor conversation, the opportunity for learners to integrate new knowledge with existing models, and the option for instructors to offer feedback on student activities.

Table 1. Game requirement preliminary list gathered from literature and previous work

Short form	Criterion	Lau	K&O	P&B
Conversation	Allow conversation between instructor and learner	X	X	X
New knowledge	Demonstrate new knowledge to the learner	X		
World creation	Allow instructors to establish experiential, explorable environments that are contextually relevant	X		
World exploration	Provide opportunity for learners to explore these worlds	X	X	X
Useful feedback	Allow instructors to provide feedback on the learners' actions	X	X	X
Balance difficulty	Provide a customisable balance between boredom and frustration		X	X
Clear goals	Provide the learner with explicit goals			X
Contextual-isation	Allow the learner to integrate new information with their existing knowledge	X	X	
Provoke curiosity	Motivate the learner by provoking curiosity			X
Immersion	Promote a sense of immersion within the environment, free of distractions outside the environment's context			X
Offer rewards	Offer rewards when goals are achieved successfully			X
Unite resources	Unite a number of learning resources in a single environment		X	
Blended support	Support blended and full online learning		X	
Full pedagogy	Allow the full pedagogical meaning of data to be expressed		X	
Standards	Compatibility with different standards		X	

Lau: Laurillard; K&O: Koper & Olivier; P&B: Parras & Bizzocchi

The theories used in our analyses were chosen on the basis of their focus on the characteristics of learning resources which we coupled with our interest in game spaces.

2 Study 1: evaluating the features of mini-games

In order to try the criteria compiled from the analysis of learning spaces, a study of game analysis was organised. First, a decision was made on the type of games to review and evaluating mini-games seemed obvious for three major reasons. 1. The large number of freely available mini-games aimed at having or supporting an educational purpose; 2. ICT facilities in schools increase the likelihood that schools adopt mini-games more easily than commercial games and 3. Mini-games are web-based, thus readily available for evaluation.

The question to answer from study one was: how do mini-games meet the requirements for learning environments to be useful? In order to answer the question, we used the preliminary requirement feature list (Table 1) to assess the suitability of 20 single-player mini-games, selected to give as wide a variety as possible of content and design, available from the British Broadcasting Company (BBC) website categorised as educational resources [11]. The BBC has an international reputation for

the quality of its provision and its resources, and all schools in the UK use BBC resources in their classrooms. At the time of the study in 2010, the BBC published a large number of Web-based mini-games. Shortly after the study completed, a change of policy at the BBC resulted in all these games being removed from public access. The selected mini-games were all played to completion by the first author, some more than once. A sample of 13 of the 20 games evaluated and the results of the evaluation are shown in Table 2. The other 7 games showed evaluation patterns that were the same as one or other of the 13 games shown, and so have been omitted for clarity.

Table 2. Results of the evaluation of a representative 13 freely-available mini-games

	Aliens	Archaeology	Battle Atlantic	Beckham	Early Church	Guy Fawkes	Journey Deep	Ice Breaker	Life on the Edge	Dive to the Abyss	Open Ocean	Webs of Life	Destination Death
Conversation													
New knowledge	×	×	×	×	×	×	×	×	×	×	×	×	×
World creation	×						×						
World exploration	×						×		×	×		×	×
Useful feedback													×
Balance difficulty		×	×	×				×	×			×	×
Clear goals	×	×	×	×	×	×		×	×	×	×	×	×
Contextualisation	×	×	×				×	×	×	×		×	×
Provoke curiosity			×			×	×	×	×	×			×
Immersion									×	×			×
Offer rewards		×									×		
Unite resources													×
Blended support													
Full pedagogy	×	×	×					×	×	×	×	×	×
Standards													

As can be observed in Table 2, results of the study were not too encouraging in terms of how well mini-games attributes meet the requirements associated with good learning environments. From this sample of 20 mini games, 1 met 10 out of the 15 criteria, 1 met 8, 1 met 7 and 6 met 6 of the criteria. With a few exceptions (e.g. Aliens, Archaeology, Battle Atlantic, Dive to the Abyss, Webs of Life), the games seemed to be either too short or too shallow to offer any real sense of immersion.

Many of them relied too heavily on question prompts, creating a layer of separation between the player and any immersive experience of in-game content. None of the mini-games provided any opportunity for conversation or feedback. While we concede that perhaps the games were too short to offer much conversation, assistance with feedback would certainly be possible.

In spite of the results, we identified a strong point in the mini-games. Due to the games' simplicity, it should be relatively easy to capture all of the player's significant moves. This could help instructors assess how well the players interact with the game, allowing them to alter it to better suit their teaching goals. Furthermore, even if it is true that none of the games really managed to "unite a number of learning resources in a single environment", possibly due to being too short, could there perhaps be benefits from uniting a number of different mini-games, incorporating different gameplay mechanics which focus on a single learning topic, into a single compendium? That way, the overarching compendium becomes the game, uniting a number of mini-game resources to better express the pedagogy of a single area.

In addition, by putting multiple mini-games into a series, learners could be helped in their assimilation of new knowledge into their existing mental models. Currently, mini-games are so short that there is often little incentive for learners to contextualise any new knowledge they acquire. But if that knowledge were required in a later "episode" in the series, players would have to reconsider the old knowledge within the newly presented context, reinforcing the integrity of their mental models.

Results of the evaluation showed the potential of mini-games, and some of these met important educational requirements proposed in our criteria. However, in their current state, most games fall short of the mark in their lack of information, their formulaic gameplay, or their failure to provide a context for their content. By implementing the changes proposed, these mini-games could become the lightweight, flexible gaming solution that educators need.

2.1 Learning theories vs. games features

With the purpose of re-informing the criteria for game analysis that had been collated thus far, established educational principles were analysed focusing on one premise: how do the tenets of the theory link to the purpose and nature of games? By understanding gameplay affordances in relation to these principles, any future assessment of games was strongly grounded in educational theory, leading to more useful observations and analyses [13].

2.2 Constructivism

Constructivist learning supports the idea that people forms new knowledge by interacting with their environment [5]. Everything the learner perceives is tested against their prior knowledge: if the perceived content is consistent within the learner's mental model of the world, it becomes new knowledge and is assimilated with what the learner already knows. At a basic level, this is exactly what playing a game is. The player begins in a new "world" with a limited understanding of how

anything within it works. Through “active experimentation” [19] and by interacting with their new environment, the player begins to understand more about the world, all within the context of what they already know. In some games players are allowed to turn off or ignore game objectives to explore seemingly endless combinations of weapons, equipment and environmental interactions in order to understand more. In games with tightly-constraining rule sets, such as puzzle games, the player's experimentation may only extend as far as the different placement of coloured blocks, or differing strategies in using certain “special” blocks. At both ends of the spectrum, the principle remains the same: the player explores and experiments within the bounds of the environment's rules, gradually adding new knowledge to their existing model wherever it is viable. The more they explore and interact, the more deeply the results are understood, and the richer the player's knowledge becomes.

2.3 Behaviourism

Behaviourist theory suggests that if a behaviour is reinforced by positive consequences (a process known as “conditioning” [33], [27]), the subject is more likely to repeat that behaviour in the future. In this way, “learning” is the increase in probability of a behaviour based on past reinforcements, such that antecedents include the consequences of the learner's previous actions. This type of reinforcement is often present in computer games. For example, if a player does well enough in a First-Person Shooter to defeat an enemy, they may be rewarded with a more powerful weapon. This weapon not only acts as a reward for success, but also as a tool for replicating the actions which granted the success in the first place. The player can use the weapon to more easily defeat the next enemy, resulting in another dropped weapon or piece of equipment as a reward. In this way, as the player continues to be rewarded for their success, the rewards encourage them to replicate the actions to repeat the success.

2.4 Bloom's Taxonomy of Cognitive Skills

Bloom divides the cognitive skills associated with learning into six categories: remembering, understanding, applying, analysing, evaluating and creating [10], [6]. Each of these categories encompasses a number of different skills, many of which could be catered for by modern computer gaming mechanisms.

Remembering - Very few games rely on simply recalling information without applying it in some way. However, when twinned with the concepts of finding and retrieving, they form a large part of the gameplay experience offered by classic adventure games

Understanding - Modern video games require the player to process large amounts of information if they are to succeed in achieving the game's goals.

Applying - At a very basic level, any well-designed game will require players to recall information they have learned, and apply it appropriately later on.

Analysing - This type of activity will usually come once a player has begun to master the basic gameplay. Once satisfied with their understanding, a player may start

to investigate the workings of the game more closely in an attempt to further their understanding of it.

Evaluating - A well designed game should always provide players with genuinely meaningful choices. If the course of action a player takes has no impact on what follows, then there is no need for the choice to be offered.

Creating - Whatever the type of game, the player will need a strategy if they are to succeed. These strategies will need to change as the game-state changes, forcing the player to generate new ways of understanding things once their old strategies become useless.

2.5 Scaffolding

Scaffolding is a technique put forward by Bruner [34]. It involves creating a learning activity with a number of different sub-tasks to be considered. At first, the majority of these sub-tasks are completed automatically, with the learner concerned with only a few. As they gain proficiency in the sub-tasks, they are granted control over more of them, until they are ultimately able to understand and control them all. In this way, the learner is slowly eased into a learning activity, only progressing onto more difficult tasks once they are proficient enough in the initial ones.

This type of system rarely happens within computer gaming. In a scaffolded environment, all tasks are made apparent from the start, with most being controlled automatically. Conversely, a typical game will not introduce a gaming concept at all until the player is ready to use it. In this way, the player is never expected to control a mechanism for which they are not ready, but at the same time, they lose out on the ongoing context found in a scaffolded environment.

However, there are some gaming types which lend themselves to a scaffolded system. Many vehicle simulation games offer a number of “driving aids”, such as automatic gears, braking assistance, or a suggestion of which gear to use for a given corner. A novice player can leave these aids turned on, concentrating on approximate speed control and steering while they acclimatise themselves to the game. As they grow more confident, they can turn the aids off, granting more control over the system at the cost of added complexity.

Tactical squad-based combat games may also afford a level of scaffolding to the player. As well as controlling their own in-game avatar, the player (taking the role of squad leader) may be given a number of simple commands to give to their team mates, e.g. “cover me”, “assault that position”, or “protect the hostage”. At a low difficulty level, these orders may be “given” automatically by the computer, allowing the player to focus purely on their own role within the squad. Once the player moves onto a higher difficulty, they can give the orders themselves, making them responsible for their own actions as well as those of their whole team. Again, this allows the player to get used to a complex game system without initially having to understand all of its intricacies, while at the same time exposing those intricacies once the player is ready.

Table 3. Learning approaches against the list of requirement criteria used in Study 1

	Constructivist	Behaviourist	Scaffolding
Conversation[1]	☐		
New knowledge	☐		☐
World creation			
World exploration	☐		☐
Useful feedback	☐	☐	☐
Balance difficulty		☐	
Clear goals			☐
Contextualisation	☐		
Provoke curiosity			
Immersion			
Offer rewards		☐	
Unite resources			
Blended support			
Full pedagogy			
Standards			

2.6 The evaluation criteria improved

After integrating the results of Study 1 and a second literature review it became obvious that the list needed changes to enhance its practical use. The result was a more robust list of criteria, shown in Table 4, that was then tested in a Pilot task.

3 A pilot to explore the role played by game genres

In order to identify some of the differences between gaming genres, a set of genres had to be chosen, followed by a number of games from each one. Although the genres selected were not exhaustive, they did represent a large proportion of games available today, and are different enough from one another to warrant distinction. The genres selected were:

- "First-Person Shooter" (a popular, combat-heavy genre where the player views the game from the perspective of the main character),

[1] For practical purposes, the labels used to name the evaluation criteria were simplified from Table 1.

- "RPG Adventure" (a hybrid genre focusing on character development and problem solving),
- "Puzzle" (where the player has to solve increasingly more intricate puzzles, usually relying on a single, core mechanism)
- "Strategy" (where resource management, planning and strategic deployment are the main player requirements).

Table 4. Improved list of criteria for a game after integrating Learning Theories review and results of Study 1

Support communication between players
Allow players to modify the game using editing tools or programming APIs
Reward the game with in-game resources
Reward the player in a socially visible way
Teach new skills throughout the game
Require that the player use their skills throughout the game
Use difficulty balance to maintain the player's state of Flow
Allow the player to complete the game in a non-linear fashion
Provoke curiosity in the player
Foster an immersive environment
Accept different possible solutions for a given problem
Provide qualitative feedback on the player's actions
Provide quantitative feedback on the player's actions
Set out clearer goals for the player to achieve
Provide intuitive interaction mechanisms

The games were all played to completion by the first author, some more than once. Salient results of the pilot indicated differences in the attributes of games categorised under different genres. In the first instance, the FPS games performed strongly in affording conversation, displaying new knowledge, encouraging exploration, immersing the player and offering rewards for success. However, they are poor at uniting resources and balancing difficulty, and are generally too fast-paced to work in blended learning scenarios. The RPG/Adventure games lacked the FPS games' support for conversation, world creation and contextualization of information, but were much better at provoking curiosity and uniting different learning resources. This genre of game, therefore, may be better suited to a multimedia-heavy learning area, where learners need to explore a range of different learning resources in a self-motivated manner. In contrast, the FPS genre may be better at providing a setting where the environment itself is the learning resource to explore, with its opportunities for conversation allowing multiple users to be present in it at once. The puzzle genre was observed to lack many of the affordances offered by the previous two game types, but excelled in its clear provision of goals, its opportunity to contextualize information well, and its deep immersive properties. This type of game was deemed to be better suited to explaining a single, important concept. It would allow the user to immerse him- or her-self in a working example of the concept, in order to thoroughly explore its intricacies without external distractions. Finally, the strategy genre excelled at providing new knowledge, uniting different resources and expressing

information extremely clearly. It also often works well in blended learning situations, making it a strong candidate to enhance current, information-heavy teaching styles. The game could easily be played alongside a traditional, instructor-led session, with its efficiency at displaying rich, dense information being a strong replacement for the textbook. The detailed feedback offered to the user regarding their performance would also assist the instructor in assessing how well the learner had done.

Information from the pilot task allowed us to improve further the evaluation criteria and as a result some items from the original list of criteria were removed. It was identified that "Allow the full pedagogical meaning of data to be expressed" could be potentially confusing when interpreted as part of a self-contained online questionnaire, so it was removed. "Support blended learning" was determined to be a factor of other criteria, rather than a criterion in its own right, and was also removed ahead of the final study. During the pilot task, "Provide a customisable balance between boredom and frustration" was represented by two distinct questions. For any given user response, both questions elicited the same response, and so the questions were merged into a single question for the final survey. Similarly, the separate criteria of "Allow instructors to establish explorable environments that are contextually relevant" and "Compatibility with different standards" were both understood by participants to focus on support for user-generated content. Both survey questions received identical responses, so these criteria were also merged. Finally, additional criteria were selected from a game design perspective which complemented the existing criteria selected from learning environment design. These criteria were selected by analysing "The 400 List" – a collaborative list of criteria for good game design and development, maintained by a group of professional game designers[2]. As a result, the criteria "Offer choice and variety", "Be intuitive and immersive" and "Be able to invoke a feeling of fun in the player" were added to our overall list.

4 Study 2: Features of games from different genres

A questionnaire was designed using Likert-type items, allowing the participants to show how strongly they felt that each of the criteria were met by a certain game in a way that could be quantitatively analysed with relative ease (see Appendix A for the detail of the survey). The study asked 165 participants to rate named games with which they were familiar, resulting in 967 sets of ratings. On average, each participant rated a median of 5 games. The games were classified into four genres: "Action" (a somewhat more general label than "First Person Shooter" used in the pilot task), "Role-playing adventure (RPG)", "Puzzle", and "Strategy". In order to limit the effect of additional external factors on the results, "expert" users were chosen from groups of computer gaming enthusiasts. These users had already have played a wide selection of the games mentioned in the survey, removing the need for the usual "familiarisation" session required for typical software evaluations.

To evaluate the differences between game genres, multivariate analysis of variance revealed the criteria which differentiated one genre from another. While a

[2]http://www.finitearts.com/Pages/400page.html

total of 108 games received ratings, some games were more popular than others, and received more ratings. To be included in the analysis, a game needed to receive ratings from at least two users; 49 games qualified (8 puzzle, 9 role playing, 14 action, 18 strategy). To manage the relative popularity of some games (such as Tetris and Call of Duty), game ratings were averaged over users, resulting in a data set of ratings on 15 criteria for 49 games categorised into 4 genres.

Table 5. Multivariate Analysis of Variance results

Effect		Value	F	Hypothesis df	Error df	Sig.
Genre	Pillai's Trace	1.836	3.468	45	99	<.001
	Wilks' Lambda	.046	3.772	45	92.87	<.001
	Hotelling's Trace	6.219	4.100	45	89	<.001
	Roy's Largest Root	3.962	8.716	15	33	<.001

Criterion	SS	df	MS	F	Sig.
Allow communication between players	36.04	3	12.01	17.20	<.001
Support player-/community-developed modifications	13.01	3	4.33	4.48	.008
Offer game-play-based rewards	14.90	3	4.97	9.57	<.001
Offer social rewards	8.80	3	2.93	4.63	.007
Teach new skills throughout the game	8.48	3	2.83	5.66	.002
Provide opportunity to use newly taught skills	4.50	3	1.50	3.15	.034
Become frustratingly hard, or tediously easy at some point	1.11	3	.37	1.03	.387
Provide a non-linear path through the game	22.22	3	7.41	7.01	.001
Provoke curiosity in the player	12.81	3	4.27	6.83	.001
Foster a sense of immersion within the game world	12.65	3	4.22	7.64	<.001
Accept different solutions for a given problem	8.77	3	2.92	7.61	<.001
Offer qualitative feedback on a player's progress	2.76	3	.92	6.81	.001
Offer quantitative feedback on a player's progress	1.02	3	.34	.96	.420
Make the player's goals clear	2.61	3	.87	2.76	.053
Provide an intuitive user interface	.95	3	.32	1.87	.147

As shown in Table 5, ratings of games in each of the four genres of Action, Role-play adventure, Puzzle, and Strategy were significantly different. The per-criterion ratings go one step further, highlighting which types of game are especially good (or bad) at supporting different game-play features. Educational game developers could use the resulting list of significant criteria as a guide, when deciding what type of game to design to achieve a particular educational aim. Where the contribution of certain criteria to game "goodness" could help prevent an educational game from being boring, the more specific relationships between game genre and criteria should help to prevent a game being irrelevant to the concept it is trying to convey, or to the learning styles used to convey it. By combining the general contributions with the specific, per-genre criteria, educational games have the potential to be both fun and relevant to students' learning style, while just as importantly still being educational.

The statistically significant differences in the ratings of game genres from Table 5 are illustrated in Figure 2, based upon a post-hoc analysis of homogenous subsets using the Tukey B test of significance. Where the marker for one game genre is distinctly separated from another in Figure 2, the Tukey B statistic showed a

significant difference between the ratings of the two game genres on the relevant criterion. Where the markers overlap, no significant difference was shown. To aid visualisation and clarity, mean ratings were quantized to reflect a difference of at least one standard error if significant, and a zero difference if not, and any resulting overlapping markers and lines were slightly displaced by a small amount of jitter. The criteria are listed in descending order of overall mean rating.

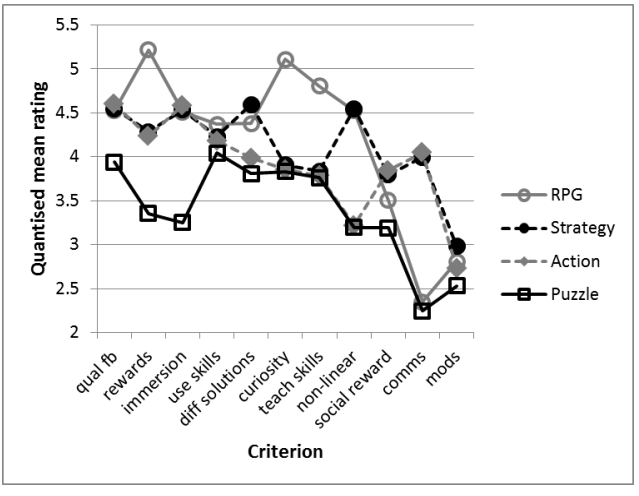

Fig. 2. Quantized criteria rating differences per game genre*
(*) The full descriptions for the criteria labels are as presented in Table 5

Figure 2 shows that puzzle games were rated significantly lower, and other game genres showed no significant differences, on the extent to which such games offered qualitative feedback on a player's progress or fostered a sense of immersion within the game world. Role-playing games were rated significantly higher, and other games showed no significant differences, on the extent to which such games provoked curiosity or taught new skills throughout the games. Puzzle games were rated significantly lower, and role-playing games significantly higher, on the extent to which such games offered game-play-based rewards, provided opportunity to use newly taught skills as the game progressed, or accepted different solutions for a given problem. Strategy and action games were rated significantly higher, and puzzle and role-playing games significantly lower, on the extent to which such games offered social rewards or allowed communication between players. Strategy and role-playing games were rated significantly higher, and puzzle and action games significantly lower, on the extent to which such games provided a non-linear path through the game, while strategy games were rated significantly higher, and puzzle games significantly lower, on the extent to which such games supported player-/community-developed modifications.

The differences in the ratings of game genres are illustrated in Table 6 as relative effect sizes, positive or negative relative to the overall mean, derived from the quantized mean ratings of Figure 2, arranged in descending order of overall effect.

Table 6. Relative quantized effect sizes of genre upon criterion ratings

Criterion	Action	Puzzle	RPG	Strategy
Allow communication between players	+++	---	---	+++
Foster a sense of immersion within the game world	++	----	++	++
Offer qualitative feedback on a player's progress	++	----	++	++
Offer gameplay-based rewards		----	++++	
Provide a non-linear path through the game	--	--	++	++
Teach new skills throughout the game	-	-	+++	-
Provoke curiosity in the player	-	-	+++	-
Accept different solutions for a given problem	-	--	+	++
Offer social rewards	+	--		+
Support player-/community-developed modifications		-		+
Provide opportunity to use skills as the game progresses		-	+	
Become frustratingly hard, or tediously easy at some point				
Offer quantitative feedback on a player's progress				
Make the player's goals clear				
Provide an intuitive user interface				

++++, ----: very large effect size, >1.2
+++, ---: large effect size > 0.8
++, --: medium effect size > 0.4
+, -: small effect size > 0.2
blank: negligible effect size < 0.2

The greatest effects of game genre, expressed as effect sizes, were shown in the mean ratings of the extent to which games in each genre allow communication between players, where action and strategy games showed large positive effects, and puzzle and role playing games showed large negative effects. In the extent to which games in each genre fostered immersion and offered qualitative feedback, action, roleplaying, and strategy games showed medium positive effects, while puzzle games showed very large negative effects. The remaining entries of Table 6 may be read in similar ways.

Strategy games are rated relatively positively for allowing communication between players, fostering a sense of immersion, offering qualitative feedback on progress, providing a non-linear paths, accepting different solutions for a given problem, offering social rewards, and supporting player-/community-developed modifications. Such games showed small relatively negative ratings for teaching new skills throughout the game, and provoking curiosity in the player.

Role playing games are rated relatively positively for offering gameplay-based rewards, teaching new skills, provoking curiosity, fostering a sense of immersion, offering qualitative feedback, providing non-linear paths, accepting different solutions for a given problem, and providing opportunities to use newly taught skills. Such games are rated relatively negatively for allowing communication between players.

Action games are rated relatively positively for allowing communication between players, fostering a sense of immersion, offering qualitative feedback on progress, and offer social rewards, while being rated negatively for providing non-linear paths, teaching new skills, provoking curiosity, or accept different solutions for a given problem.

Puzzle games are not rated relatively positively for any of the criteria, while being rated negatively for allowing communication between players, fostering a sense of immersion, offering qualitative feedback, offering gameplay-based rewards, providing non-linear paths, teaching new skills, provoking curiosity, accepting different solutions, offering social rewards, supporting player-/community-developed modifications, and providing opportunity to use newly taught skills.

5 Discussion and Conclusions

These findings have the potential to improve educational game development and uptake, by allowing games to be understood more objectively in terms of their content and educational merit. In order to build on these findings, two main areas of future work have been identified: expand the study to incorporate more varieties of game; and actually use the results to design, or select an appropriate game for use in teaching.

Before the studies detailed in this paper were carried out, current research into different gaming genres was found to be lacking. At best, the genres were arbitrarily selected and poorly analysed; at worst, sweeping statements were made about "computer games" as a whole, without any consideration given to the nuances of different game types. However, while this lack of consideration is a problem when dealing with the wide range of modern games, it was not necessarily always the case. In the early stages of popular computer game development, almost all games would have been either text- based "adventure" games, or simple, reflex-based "action" games. As such, broad, catch-all assertions about "computer gaming" would have been more acceptable, because the computer gaming space was much more homogenous.

In the same way, while the findings presented in this paper are sound at present, this will not necessarily be the case in twenty years' time – or in ten years', or even five. We know now that a statement made about "games" twenty years ago is not necessarily applicable to a particular set of modern action games, role-play games and strategy games. Similarly, a statement made today about "action games" may, in the future, not be equally true of both an action game controlled with a motion-detecting camera, and one played in a live-action "Alternate Reality Game" (ARG) style, or one played online with thousands of other players in a persistent world.

The true benefits of the results presented in this paper will be seen in their application in genuine learning activities. By offering a clearer picture of the relevant and significant criteria for educational games, the opportunity for an instructor to integrate a truly useful educational game into their learning activity becomes more feasible. To determine just how usable these results are in practise, several further investigations could take place: the results could be used to build something new, or

to select something appropriate from the existing set of available games. When designing any computer game (or, indeed, any piece of software, or any type of game), various requirements will be set before the system is built. In general, these could include functional outcomes, expected user experiences, and specific pieces of content. In a learning environment, certain requirements may be stated about learning outcomes, or particular learning styles that are to be supported. In a video game, there may be broad requirements about the genre or theme of the game, or specific requirements about how often rewards are given, how the player will interact with certain objects, or whether there will be a multiplayer component.

The results of both the genre-specific and broader gameplay studies could be applied to this design-and-build process. If a gameplay genre is decided first, the results can be used to suggest features that will most likely support that style of play. If a particular learning style is the primary design requirement, a set of features that support that style can be chosen, and a suitable genre of game can be decided to offer these features most appropriately. Investigations that use the genre taxonomy as part of the design-and-build process could help to determine not only whether the results of this investigation are useful from a game designer's perspective, but how best to apply them to the design process of an educational game.

As well as assessing how the results help to build an educational game, it would be useful to know how they help to use one. In the same way the results are useless without being applied to the design process, the game itself is useless without being applied to the learning process. Once a game has been designed and developed using the results, studies will be required in order to assess that game's usefulness as an educational tool, as well as its value as a game. In turn, the usefulness of the results will be assessed across the whole software lifecycle – from initial requirements gathering, through the design and build process, right through to the final user experience.

In addition, the results can be used to assess existing games, much like they were in the preliminary mini-games investigation. Only a small selection of mini-games was available at the time, and more will certainly have been developed since the investigation took place. By using the results to pick an existing mini-game to support their teaching, an instructor could help to evaluate two things: how useful the results are in evaluating existing products; and how valid the assertion is that mini-games are more easily incorporated into a busy lesson than more comprehensive commercial titles.

Whether selecting existing titles, or developing new ones from scratch, the findings of this study aim to help instructors find the most suitable game for their educational needs. A suitable experiment as part of some actual instruction will help to determine – from an instructor's perspective – how useful the results really are. So far, when considering video games in an educational context, any assertions have been either too vague, or too specific. Results or suggestions either relate to one specific game (which offers little in the way of re-use), or to computer gaming as a whole. The results presented here show that to consider video gaming as one homogenous set would overlook important nuances found between games, and could generate false positive results when asserting games' benefits, or false negatives when branding them as useless.

To maintain the relevance of this work, on-going research will be required in order to catalogue the emergence of new genres as well as evolutions in those that currently exist. Through assimilating new data and augmenting the existing results with new findings, the information in the taxonomy can continue to be a useful representation of the features offered by the spectrum of games at any given time.

By using the results found in this study, understanding different games in terms of their specific educational strengths and weaknesses, and by evaluating, developing and using video games for education based on these qualities, the community can move closer to finding that Holy Grail of educational gaming: an experience that is both educational, but equally importantly, fun.

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Appendix A

Participants identified those games they were familiar with from a list of common and popular games provided. For each game identified, they were asked whether they "completely disagree", "strongly disagree", "slightly disagree", "slightly agree", "strongly agree" or "completely agree" with each of the following statements.

1. While playing this game, I can communicate easily with other players.
2. I am able to create modifications (levels, weapons, units etc.) to this game, that can be used by other players.
3. This game rewards my success in a way that helps me in-game.
4. This game rewards my success in a way that can easily be seen by other players.
5. This game continues to introduce new skills throughout the course of play.
6. The game provides opportunities to use the skills I've learned in new and interesting situations.
7. I found the game (or parts of the game) to be either too hard to progress, or too easy to maintain my interest.
8. In playing this game, I am not restricted to a single linear path.
9. The game includes objects, areas or characters that provoke curiosity.
10. When playing the games, I feel immersed in the game it represents.
11. When presented with a problem in the game, I can use a number of different methods to solve it.
12. The game reliably informs me when I perform an in-game action.
13. The game accurately tells me how *well* I perform an in-game action.
14. The goals of the game are always made clear.
15. The interface to the game is intuitive.
16. The game is fun.