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Computer game design: Opportunities for successful learning

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Abstract

Developing children as successful learners is a key aim of *A Curriculum for Excellence* in Scotland. This paper presents qualitative results from an eight week exploratory field study in which a class of ten year olds made their own computer games. The analysis focuses on the development of aspects of successful learning as identified in the curriculum: enthusiasm and motivation for learning, determination to reach high standards of achievement, independent and group learning, and linking and applying learning in new situations. As teachers have an important role in facilitating and supporting learners as they use technology, the paper concludes with a discussion of implications for classroom practice.

Keywords: Successful learning; Game based learning; Game design; Classroom practice

1. Introduction

The potential for learning with computer games has been described as "striking" (O'Neil, Wainess, and Baker, 2005). In this paper we offer evidence of successful learning – as set out in *A Curriculum for Excellence* (Scottish Executive., 2004) – resulting from the use of the Neverwinter Nights game authoring tool with nine and ten year old pupils.

The curriculum in Scotland is undergoing substantial revision with a view to implementing it in schools by 2009 (Scottish Executive, 2004). The new curriculum (*A Curriculum for Excellence*) establishes a set of principles for learners from the ages of 3–18, based around developing pupils' capacities as: confident individuals, responsible citizens, effective contributors and successful learners. These categories are related to the redevelopment of the curriculum in England and Wales, with its very similar aims of enabling young people to become: "successful learners, who enjoy learning, make progress and achieve; confident individuals, who are able to lead safe, healthy and fulfilling lives; responsible citizens, who make a positive contribution to society" (QCA., 2006).

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In this paper, we focus on the *successful learner* strand of *A Curriculum for Excellence*. An aspiration of the curriculum designers was to develop "successful learners with enthusiasm and motivation for learning, determination to reach high levels of achievement and openness to new thinking and ideas" (Scottish Executive, 2004). Some component skills of successful learning are considered to be the ability to learn independently or in groups, and to link and apply learning between contexts.

The work described here is part of the Adventure Author project, which is investigating the creative process of game design in an educational setting. We are currently developing theoretically motivated software scaffolding to support learners through the stages of the creative process. The scaffolding will be embedded within an educational plug-in for the Neverwinter Nights 2 commercial game authoring tool, along with various other educational tools to support learners and their teachers in this task. We are in the process of designing this software using the CARSS learner centred design framework (Good & Robertson, 2006). The work reported here focuses on a classroom field study using the Neverwinter Nights software. The purposes of the study were to clarify which aspects of the software should be improved in the next version of our software, but more importantly to investigate the educational impact of using game making software in a classroom setting.

We begin by looking at related studies which consider the importance of powerful learning environments, issues relating to learning how to learn, and implications for the learner of both playing and making games. We then go on to introduce the Neverwinter Nights software and provide the context for our study. We present the findings of a thematic analysis of our data with respect to the successful learner strand of *A Curriculum for Excellence*, and consider the implications of these findings for classroom practice.

2. Related work

The Adventure Author project is informed by current research thinking about environments which promote effective learning and learner autonomy. In the following sections, we relate the features of the *successful learner* strand to previous research findings in order to better understand what underlying skills are required, and how these can be fostered within appropriate learning environments. We also place this game making project in the context of recent research on the potential of game based learning and previous work on the benefits of computer game making for learners.

2.1. Powerful learning environments

Smeets (2005) describes "powerful learning environments" as those which foster optimal learning processes. In such an environment, learners are actively engaged (sometimes independently and sometimes collaboratively) on authentic, rich tasks which have been adapted to their individual needs. These attributes for powerful learning environments are included in Christie and Boyd (2007) overview of the key messages from the research literature which inform *A Curriculum for Excellence*. Active engagement is seen as an important theme when considering appropriate teaching and learning approaches for developing the four capacities. Co-operative, collaborative and independent learning are considerations when planning how learning should be organised and the relevance of classroom learning to pupils' lives outside school is important when creating an environment for learning. Christie and Boyd phrase the key messages in question form, rather than providing any answers as to how the four capacities may be developed; presumably answers will emerge as the curriculum matures.

Although ICT has the potential to provide powerful learning environments, Smeets' work indicates that this potential is often not realised because teachers use ICT to consolidate rather than change classroom practice. Indeed, teachers' beliefs and attitudes, particularly to constructivism, are a major factor in the adoption of ICT in the classroom (Hermans, van Braak, Tondeur, & Valcke, 2007). The features of game making which qualify it as a powerful learning environment are considered in the section entitled "Learning by Making".

2.2. Learning how to learn

Developing pupils as *successful learners* equips them to continue learning beyond the school setting into their adult lives. *A Curriculum for Excellence* suggests that there is a set of abilities which will facilitate this:

core literacy, numeracy and communication skills; the ability to use technology for learning; the ability to think creatively and independently; the ability to learn independently or in a group; the ability to make reasoned evaluations and the more general ability of applying learning to new situations. Black, McCormick, James, and Pedder (2006) discuss the concept of "learning how to learn" (LHTL), characterising it as a "collection of good learning practices …. in both individual and collaborative contexts that seem to have the most potential to promote pupils' autonomy in learning" (p. 130). Learner autonomy is highly important because "it implies that the learner can not only give meaning to the learning, but that she can also create new learning tools" (p. 129).

In their overview of research issues relating to *A Curriculum for Excellence* Christie and Boyd raise the question of meta-cognition: "how can pupils be encouraged to be reflective – to 'learn how to learn'?" (Christie & Boyd, 2007; p. 2). Black et al. (2006) observe that successful learners use knowledge of cognition and self-regulating mechanisms, both aspects of meta-cognition, to monitor their own understanding. They note that while teachers have a role in modelling these skills, the principle of learner autonomy implies that learners need to be given opportunities for strategic thinking and reflection about their own learning.

Other effective learning methods which are included in Black et al. (2006) as examples of LHTL practices relate to the *successful learner* strand. These are cognitive acceleration, in which pupils develop a set of reasoning skills for science and maths (Shayer, 1999) and Talk Lessons (Mercer, 2000) which were designed to raise pupils' awareness of their own problem solving strategies, and their contributions to collaborative discussion. A third example of LHTL practice comes from the Assessment is for Learning (AiFL) approach. Effective learning methods used within AiFL are: encouraging pupils to contribute to discussions, even if they don't know the "correct" answer, facilitating pupils to answer questions from each other, rather than just answering questions posed by the teacher; providing comment-only feedback on written work so that the focus is on improvement rather than competition for marks; and developing pupils' skills in self and peer assessment. Adaptations of some of these AiFL practices were used in game making project described in the "School Based Field Study" section.

2.3. Games and learning

The educational potential of computer games is often celebrated. Researchers have argued that playing computer games gives learners a "mental workout"; that the structure of activities embedded in computer games (as opposed to the game content) develops a number of cognitive skills. Players are faced with a stream of both long and short term decisions, and must plan problem solving strategies which involve monitoring a series of complex tasks and nested sub-tasks (Johnson, 2005). Gee (2003) describes a four part cycle in which players engage – probe, hypothesize, reprobe, and rethink. Throughout this cycle the player reflects on the effect his actions have on the game world to establish the underlying game rules. A similar cycle is described by Garris, Ahlers, and Driskell (2002) for educational games, in which the learner engages in repeated judgement-behaviour-feedback loops. In addition, McFarlane, Sparrowhawk, and Heald (2002) linked game-playing with the potential to develop skills in decision making, design, strategy, cooperation, and problem solving.

At a recent event organised by BECTA on "Enhancing Learning; virtual worlds, simulations and games based learning", the BECTA director of content stated that "The question is no longer *if* games help learning, but *what* kind of learning and *how*". (BECTA, 2007). This is in contrast to BECTA's own landscape review of the impact of ICT on schools which rather more cautiously comments that "…while much has been written about the potential of games as learning tools, the evidence is as yet limited" (Condie & Munro, 2007; p. 51). In a review of peer reviewed qualitative and quantitative research findings relating to learning outcomes of games and simulations in the context of adult training and education, O'Neil, Wainess, and Baker (2005) found that while the evidence of potential was "striking", empirical evidence of educational effectiveness of games was "scant" (p. 468). A framework for evaluating games is proposed. The authors take the position that the instructional context in which games are used is important; games are not effective in isolation but should be used in conjunction with other instructional support. This is consistent with Sanford, Ulicsak, Facer, and Rudd (2006) discussion of their Teaching with Games project, in which they report that successful use of games in the classroom is dependant on the quality of the teaching including the teacher's skill in diagnosing pupils' abilities, identifying clear learning objectives, and deploying games in appropriate ways to meet

these objectives. de Freitas and Oliver (2006) offer a framework for assisting tutors in evaluating the potential of games within their practice, although it does not appear to support tutors in identifying which games would be applicable for given learning objectives. The framework thus relies on tutors possessing a greater depth of knowledge about computer games than is predicted from Sanford et al.'s findings that 72% of teachers do not play games for leisure.

The Teaching with Games project also identified that there is a need to consider the issue of pupils' motivation for playing games in more depth. Their study suggested that pupils are most likely to find games motivating when they are familiar from home, and when they have a degree of autonomy in playing the game. This latter finding is of interest in considering the balance of game-playing (or indeed game making) to instruction in the classroom environment.

The focus of this article goes beyond the educational potential of playing games in the classroom to consider the possibilities of making games. As the process of making games naturally includes playing games in order to test them, some of the same arguments about the development of meta-cognitive and decision making skills apply. Further issues are considered in the next section.

2.4. Learning by making

Game making has the potential to be a powerful learning environment according to attributes identified by Smeets (2005). Making games is a rich task, in that it offers opportunities for children exercise a wide spectrum of skills (such as devising game rules, creating characters and dialogue, visual design, and computer programming) to create a complex artefact. It is also authentic on the grounds that the resulting artefact is of value in popular culture and can be enjoyed by friends at home or at school. Making a game actively engages learners because they construct their own game using a software tool; it is not a passive experience. Pupils can learn autonomously using the software as a sounding board for their ideas – they can embody their creative ideas in a testable way in their game and then try it to evaluate their ideas. Furthermore, as the concept of audience is extremely important when making games, peer collaboration is a necessary component. The purpose of making a game is to create an artefact which somebody else will enjoy, and so inviting others to play test the game is a natural part of the process.

Kafai (1995) conducted a ground breaking study, based on the principles of constructionism and learning by design in which a class of fourth grade children made their own educational fraction games using the Logo programming language. The project was successful in promoting learner autonomy by putting the children in control of their own learning and thinking and challenging them to plan and manage the complex process of creating a game over a six month period. In the course of the project, the children took on many roles, as users, designers, writers of storylines, teachers (of fractions concepts), and programmers.

Logo is a general purpose programming language, and was not designed specifically for creating games. Since this project, other studies have been conducted using specialist game programming toolkits such as Stage Cast Creator (Habgood, Ainsworth, & Benford, 2005), Gamemaker (Perciles, 2007), Alice (Kelleher & Pausch, 2006) and Neverwinter Nights (Howland & Good J., 2006; Robertson & Good, 2005a; Robertson & Good, 2005b; Szafron et al., 2005). These studies indicate that making games is motivating, bolsters esteem, and develops storytelling as well as technical programming skills. The nature of the task of making games is slightly different in purpose-built environments, and the balance of the roles assumed by the learner shifts accordingly. More recent game programming toolkits tend to have a stronger visual aspect than Logo, either in the sense that they enable designers to easily create graphical games or because they have a visual programming language, or both. This shifts the emphasis away from low level programming, enabling learners to focus on the other roles as designers or writers.

Game making can be seen as a type of user-generated content, a concept which has lately attracted attention in educational technology circles (e.g. the symposium on social software at CAL '07). "User-generated content" refers to media content of blogs, wikis, podcasts, and digital videos which is created and published by end users rather than media companies. Used in a learning context, these types of software can empower learners by enabling them to express their creativity and share it with a genuine audience. However, the activity of game design is more complex than publishing in other media because it involves the creation of an interactive artefact. Designing digital content which responds to users' input through a series of rules requires the

specification of conditions, consequences and sequences of behaviour, which is not required in writing text, or producing still or moving images.

2.5. Summary

Successful learning can be viewed as a collection of good habits of learning, some of which are listed in *A Curriculum for Excellence*. Black et al. (2006) suggest a number of approaches to teaching and learning which are likely to contribute to learner autonomy and which are consistent with Smeet's powerful learning environments. We have attempted to use such approaches in developing the game making sessions used in the field study.

Another important issue which emerges from the literature is the valuable role the teacher plays in facilitating learners to develop successful learning skills, by modelling them and giving the pupil opportunities to reflect on their progress. The teacher's attitude to ICT and her skill in using games and other technology in supporting learning objectives is also important. This issue is considered further in the section entitled "Implications for Classroom Practice".

3. The Neverwinter Nights software

There are various commercial and open source game authoring toolsets available, including the Unreal Editor, The Half Life 2 editor, Gamemaker, Mission Maker and Alice. We have chosen to work with Neverwinter Nights (NWN), a commercially available game which was first released in 2002. NWN is a Dungeons and Dragons style 3D role-playing game which comes with a free toolset for creating games using the game engine. This choice was made in 2003 when the research began for two main reasons: it was suitable for use by non-expert designers without requiring computer programming; and the 3D graphics were of high quality at the time.[1] The toolset enables novice users to create landscapes, customise characters, write interactive dialogue and script sequences of actions. A screen shot of the toolset interface is shown in Fig. 1. A top down view of a game area (a desert landscape) can be seen in the centre of the screen. The designer can adapt and decorate the area using library objects from the right hand side of the screen. An area is the geographical setting for the level of a game. Areas can be connected together by creating an area transition; transitions can also be set up to take place under certain conditions, such as when a particular key is used. Creatures can also be selected and added from a large library in the same way. The left hand side of the screen shows the list of creatures and items which are in the currently selected area. An example interactive conversation, taken from a game made by a 10 year old, is shown at the bottom of the screen shot. The conversation takes place between the player (dialogue lines shown in blue) and a character called Pebo (dialogue lines shown in red). The conversation has a tree structure; choices available to the player are indicated by parallel branches. For example, the player can choose to reply "Friend" or "Foe" to Pebo's initial question. The designer can also specify actions which will occur after a character has uttered a line of dialogue, including giving a reward, or starting a fight.

In order to illustrate the domain-specific learning which takes place when the children master using the Neverwinter Nights toolset, three examples of commonly occurring tasks which the children find challenging are documented below.

3.1. Testing

When working on a game, as in software development, it is useful to work in a cycle of design, followed by implementation, followed by testing. This occurs at two levels: when the learner tests his own game to ensure that it is working as he intended, and when a peer tests the learner's game to give an opinion on whether it is enjoyable. Both of these forms of testing can be challenging and require problem solving skills. In the first

[1] The graphics now appear slightly dated, but this issue will be addressed in the new Adventure Author plug-in which is for the new generation Neverwinter Nights 2 game engine.

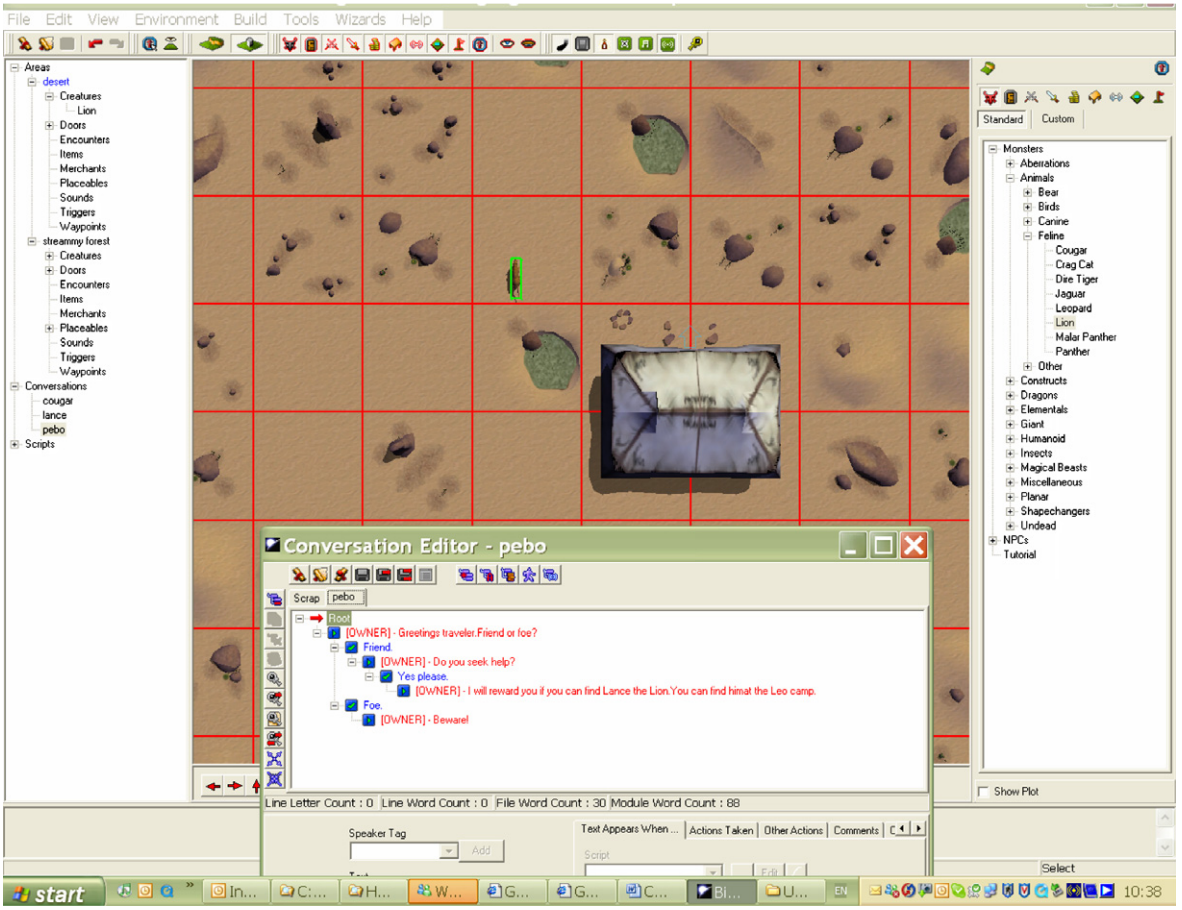

Fig. 1. A screenshot of the toolset.

case, the learner must reason about the behaviour of the game rules to hypothesis why it does not behave in the way he expected. In the second case, the learner must watch his friend's reaction to the game and think of improvements to the game which would address the friend's criticisms.

3.1.1. Worked example 1

Ben has been experimenting in the toolset and has placed a dragon character near a boy character close to the point where the player starts the game. He knows that hostile characters cannot talk to the player, so he has carefully changed the boy to the "commoner" faction so that he will be friendly. When he tests the game he notices yellow sparks in the air immediately when he starts. The player character is finding it hard to move. The boy is nowhere to be found. What has happened? In discussion with an adult, Ben realises that the yellow sparks are magic spells cast by the dragon which have the effect of stunning the player. The dragon has been fighting. The adult asks him why this might be the case, and Ben remembers that the dragon is a hostile character. He has discovered that hostile characters fight commoner characters on sight. He reasons that the boy must have been killed by the superior strength of the dragon. There are some possible solutions to this problem which the adult helps him think through, including moving the dragon and boy further apart so that the boy is outwith the dragon's perception range, or making the dragon a commoner too.

3.1.2. Worked example 2

Jessica is testing Nicola's game. She is upset because she keeps getting killed by spiders. Every time she reloads the game after being killed, she is ambushed by more spiders. She complains because she has no chance

to defend herself. This leads to a discussion about whether the game is too hard, and whether Nicola has too many "baddies". During a class discussion later, they talk about this issue more. Some of the children like games with lots of fighting, while others prefer not to be attacked. Some of the class have decided to reduce the number of monsters in their game, while some have decided to include more on the advice of their testers. Nicola decides to distribute the spiders more evenly across the area so that the player is less likely to be overwhelmed.

3.2. Area transitions

Another common but challenging task in NWN is joining areas together. An exterior area can contain buildings, but in order for the player to go inside a building, the designer must have created a separate interior area and linked the two together using an area transition. This can be accomplished through doors, portals or arbitrary sections of the landscape which are set up to transport the player to another location when he walks over them. The sequence of steps for creating an area transition in this software is finicky and requires some understanding of the programming concept of unique identifiers.

3.2.1. Worked example

Jade (aged 10) wants to set it up so that the player can go inside the house which appears in her forest.

1. *Create an interior area*. Use the area wizard provided by the software to make an interior area representing the inside of a house. Decorate the house with placeable objects as required.
2. *Place a door in the outside of the house*. In the 3D model of the house in the forest area there is a door frame which contains no door. Select a door from the menu and place it within the boundary of the door frame.
3. *Assign the outside door a unique tag*. Type in a unique tag for the door in order to distinguish it from other objects in the game.
4. *Place a door inside the house*. Switch to the interior area. Select a door and place it within a blank door frame inside the house.
5. *Assign the inside door a unique tag*. Type in a unique tag for the interior door.
6. *Set up an area transition*. Use the area transition tab on the properties of the door to specify a target area for the transition, whether the door should work both ways, and the tag of the target door.
7. *Test whether the transition works correctly*. Play the game. Attempt to walk through the doorway of the house in the forest and test that it leads to the interior of the house.

There are a few potential causes of mistakes in this process. Children sometimes mix up the sequence of steps and attempt to make an area transition between area 1 and area 2 before they have made area 2. It requires some manual dexterity and manipulation of the 3D world to place doors within the door frames. Some children have difficult in understanding why the door tags must be unique and leave in the default tags provided by the software. This leads to unexpected behaviour if there is more than one door with the same tag. Learners also often forget how they spelled the tag, so that the identifiers don't match, again resulting in unexpected behaviour. Lastly, there are a number of screens to go through to achieve the area transition and the learners can find this difficult to remember.

3.3. Writing a conversation

Conversations in Neverwinter Nights are interactive: the game designer specifies alternative choices for the player to make during conversations. Each of these choices can lead to further unfolding of the conversation along different paths. A conversation can be arbitrarily deep (many back and forth exchanges between interlocutors) and wide (many choice points associated with each line of conversation). In addition, conversations can have conditions and consequences. The designer can specify that actions should be executed after a line of conversation is uttered, a common example of which is a character attacking the player if the player makes a threat. It is also possible to specify that characters should only utter lines of dialogue if certain conditions are met, for example if the player is carrying a certain object. The game state can also be maintained through

conditions and consequences, by updating and checking variable values when lines of dialogue are executed. This enables the designer to set up quest structures. For example, the player might meet a character who asks him to bring back a stolen object from a dragon. If the player returns with the object, he should be congratulated and rewarded. If he has failed in the quest, the character should prompt him to try again. Child designers who we have worked with often devise a quest structure of this sort in order to tell a story, but accomplishing it within the Neverwinter Nights software is non-trivial and requires an introduction to some basic computer science concepts, including variables, conditionals and in some cases Boolean logic.

3.3.1. Worked example

Blair (aged 10) wants to set up a quest in his game. The player will go into the forest where he will meet an elf on the path. The elf explains that the ogre has stolen his magic dagger and asks the player to retrieve it in exchange for ten gold pieces. The sequence of steps to accomplish this is as follows:

1. *Create the setting and characters*. Make a forest draw a path and place an elf character on the path.
2. *Create a conversation with the elf*. The elf says hello and asks the player for help. If the player selects the "Yes, I will help you" option, then the elf explains that if the player gets him the magical dagger by fighting the ogre, then he will give him ten gold pieces. If the player selects the "No, I won't help you" option, then the elf says "Attack!".
3. *Set up an action*. Using the action wizard provided by the software, set up an attack associated with the elf's dialogue line of "Attack!".
4. *Create an ogre character*. Place an ogre character in the forest. Assign a magic dagger item to his inventory. This step may also involve creating a new dagger and specifying its magical properties, or altering the properties of the ogre to make the fight with the player fairer. If the player defeats the ogre in a fight, he will be able to pick up the dagger and add it to his inventory.
5. *Amend the conversation with a success condition*. Add a further line of dialogue to the conversation in which the elf says "Thank you for getting my dagger. Here is some gold as a reward". On this line of dialogue, use the script wizard provided by the software to check what the player is carrying in his inventory. The designer must ensure that the tag of the magic dagger item is the same as the target tag that the script checks for. If this condition is met, then the dialogue line will be spoken.
6. *Add a reward*. On the line of dialogue on where the elf congratulates a player, add an action using the script wizard. This time instead of triggering an attack, the "give reward" option is selected, and 10 gold pieces specified as the reward.
7. *Test the quest*. Start the game and follow the steps of the quest from start to finish to check that they work as expected. In this case, testing what happens when the player fails to get the dagger will highlight the fact that there should be another dialogue line to prompt the player to try again if he has already been issued with the challenge but has not yet got the dagger. To accomplish this, the designer would need to store the state of the quest using variables. In the example so far, the quest progress is implicitly maintained by the presence or absence of the dagger in the player's inventory.

The children in the study reported below seldom managed to achieve a full quest structure in the time they had available, but did accomplish individual steps such as causing rewards or attacks, and creating conversations with multiple choice points. The full complex sequence of steps outlined above is time consuming and challenging for 10 year olds, partly because the representations used in the user interface are sometimes difficult to interpret.

4. A school based field study

We have adopted a design-based research approach during the Adventure Author project (Sandoval & Bell, 2004) as we are investigating an innovative use of technology in a classroom setting. In order to better understand the pedagogical implications of game making, we needed to gather initial data to develop a theoretical framework which could be further refined in future studies. We needed a flexible approach which would enable us to revise plans for the field study based on the reflections of the researchers and teachers who were taking

part. The analysis in this paper focuses on skills related to successful learning; analysis relating to methods of supporting children throughout the creative process of game design is ongoing.

4.1. Participants

The study took place in a state funded primary school in Dundee, Scotland. A class of thirty primary 6 (9–10 year old) pupils took part with their class teacher and a specialist ICT teacher who is based at the school. Six of the pupils were selected by teachers and researchers as case study participants on the basis of their ability level, interest in games and examples of their written work. Three of the case studies were boys, three were girls and there were two pupils in each category of high, medium and low ability among them.

Three researchers took part in the study. The first author is an educational technologist with a computer science background and the second author is an experienced educationalist and a former teacher. The third researcher is the software developer on the Adventure Author project.

All pupils and their parents gave informed consent to participate in the study and could opt out of having their games and questionnaire data, photos and audio data used for research. In addition, pupils and parents could opt for the pupil to be given a pseudonym in publications. The three researchers had the appropriate Disclosure Scotland background checks before working in the school.

4.2. Procedure

A two hour introductory session took place in the summer term, the academic session before the project started. After the summer holidays there were eight 2 hour sessions spread throughout the autumn term during the class's timetabled ICT slot in the computer suite. As the computer suite could accommodate only half the class at a time, the sessions operated as follows: 20 min introduction to the whole class; 40 min hands-on time with the software for half the class; 40 min hands-on software for the rest of the class; 20 min plenary discussion with the whole class.

In the introductory discussion, the researchers would demonstrate specific software skills (e.g. conversation editing) to the class using a projector. Model games created by the researchers or by members of the class were used as a basis for discussion. The children were either given a goal for the session (such as try to finish creating an interactive conversation) or they were told that they had time for exploratory play to try out what was possible in the toolset. During the hands-on time, the children worked independently while the adults assisted with individual queries. The researchers tended to answer technical questions about the software, and both teachers and researchers answered questions relating to the storyline or literacy in general. In the second last session, the children acted as peer reviewers by testing a friend's game and giving constructive criticism. In the plenary session at the end, the researcher facilitated discussions about what the children had learned, what they were puzzled about and what they would work on next time. This was also a time for sharing knowledge between learners and praising children for providing peer-support. On the last session, parents were invited to visit to see what the children were working on, along with various educationalists from the local authority. In this session, the children were asked to teach the adults how to make and play games.

4.3. Findings

Thematic analysis was used to identify the sorts of learning which took place during the study with respect to *A Curriculum for Excellence* (Hayes, 2000). Transcripts of interviews with case study children, teachers, visiting educationalists and parents were analysed in conjunction with children's questionnaires and worksheets and researchers' observation notes. In the presentation of results that follows, we have included researchers' observations and immediate reflections on the children's behaviour to help to describe the learning which took place as it appeared to the participants in this design-based research at the time. The intention of the analysis was to characterise the breadth of children's learning under subcategories of the *successful learner* strand of the curriculum, rather than to attempt to quantify the incidences of particular sorts of learning. The analysis indicated that children displayed: motivation and enthusiasm for learning; determination to reach a high standard of achievement; and skills in: independent learning; learning in a group; and linking and applying learning in

new situations. A discussion of creative thinking skills developed through game making can be found in Robertson and Nicholson (2007).

4.3.1. Enthusiasm and motivation for learning

The children's enthusiasm and motivation were noticeable from the introductory workshop, and were sustained throughout the project and beyond – the school is continuing the work as an after school activity and has shared their experiences with other visiting school staff. Alex Rider's[2] comment, "It was the best thing I've done," is typical of the children's responses. All abilities of children were engaged and enthused by the work, including children who had not previously shown a willingness to engage in classroom tasks, children who often struggled with more conventional tasks and children who were already high achievers in many respects.

The children identified a great many elements of the package that they enjoyed: creating areas, adding scenery, creating and going inside buildings, adding doors and creating area transitions, adding decorative objects and items which could be collected by the player, putting in monsters, creating characters from those monsters, writing conversations, adding simple actions as a result of conversations, scripting more complex action sequences, having fights and getting to play the game – their own as well as their friends'.

Some of the motivation and enthusiasm seemed to be linked to the element of challenge: "It was a challenge, but very enjoyable" (James Bond[3]).

"I've found the comments that James Bond made interesting ... Because he's probably the most able child in the class ... and he found it good that he was challenged. It wasn't something he could just pick up as usual and do it. He had to work it out" (Mrs. Galloway, class teacher).

Jack also acknowledged the unusual nature of the project, being asked to author a game, not just to play something ready-made: "It was an opportunity – not everyone gets to do this." It is difficult to know how much of the enthusiasm and motivation for learning to attribute to this novelty value, but the wider evidence gained of impact on learning and thinking would suggest that computer game authoring has much to offer beyond the appeal of being something new and different from the usual classroom fare.

4.3.2. Determination to reach a high standard of achievement

Determination to reach a high standard of achievement is an important aspect of becoming a successful, independent and self-determining learner. But for this to come about in its most successful and fulfilling form, the learner must feel engaged, be willing to make an investment in the task, recognise the value of their own role in the process and see results and progress as they make their way towards their goal. Perseverance and determination were particularly evident with regard to setting up area transitions – this requires a complex series of tasks and thought processes with the current software, and it proved very challenging for P6 pupils, but the children regularly made reference to doors, areas and transition when reflecting on their achievements, and were determined to master the complex series of steps involved. Louise stated, "I'm pleased that I can link areas," and Zoe was typical in her mention of doors and areas in her list of achievements: "The things I have achieved are an ice kingdom and a forest, lots of creatures and a door."

When Ben was interviewed, he focussed immediately on matters to do with transition, even though he had simply been asked by the interviewer to talk about his game: "There are three doors and I'm trying on making another area." The interview went on:

> [Ben] Ehm, he's gonna fight this thing that is lots more powerful than him, and he's got to find this sword to fight him with so.
> [Interviewer] mmhm..
> [Ben] before he could get, cos he's guarding a door.
> [Interviewer] I see.
> [Ben] And once you defeat him, you don't, the door's locked, so, you've got to go and find the key, by going into the dungeon. And then you come back, and you unlock that door, then ehm, that leads you to this,

[2] Pseudonym chosen by the child.
[3] Pseudonym chosen by the child.

ehm, leads you into this, the top of the tower, cos it is a tower, and it's got loads of money and gems and a swords and stuff... and I needed much more help making doors.

Doors and keys and new areas are of great importance to the quest structure of Ben's game, providing quite a high degree of complexity. They also necessitate a high degree of support, which is recognised by Ben, but this was not something which deterred him or made him modify his game design.

Ben was not alone in needing support and encouragement in order to reach his goal. As one researcher commented, "I helped Nikki to join her areas together. She already had doors but needed to tag them and join them. I don't think I have noticed any of the kids who have made area transitions without help." George had forgotten how to make a new area, but it took only a small amount of prompting to get him going. He created a city interior and made it into a jail. The researcher remarked: "George's jail was small and not really well-thought out. He created it quite haphazardly, but didn't seem too worried about the design. I think the main thing for him was to succeed with the transition."

Over a period of sessions, Cool Game Kid was determined to succeed in creating a successful transition, even though he found it a puzzling and difficult process. On 28 September, Cool Game Kid had placed two buildings in his desert area, but had not altered the door tags nor created an interior area. On 19 October, Cool Game Kid had added an interior area (Spooky castle) and explained that he wanted to create interiors for a tent and a castle in his desert. A researcher worked with him to change the tags for each door to names of his choice. It is not easy to tell from the area name (Spooky castle) and the door tags (tententrance, templegate, stoneexit) which of his buildings he is planning to enter (see Fig. 2).

When Cool Game Kid tested his game on 26 October, the tent door took him to the spooky castle interior, but that was not what he wanted and he seemed very puzzled and concerned. The researcher noted

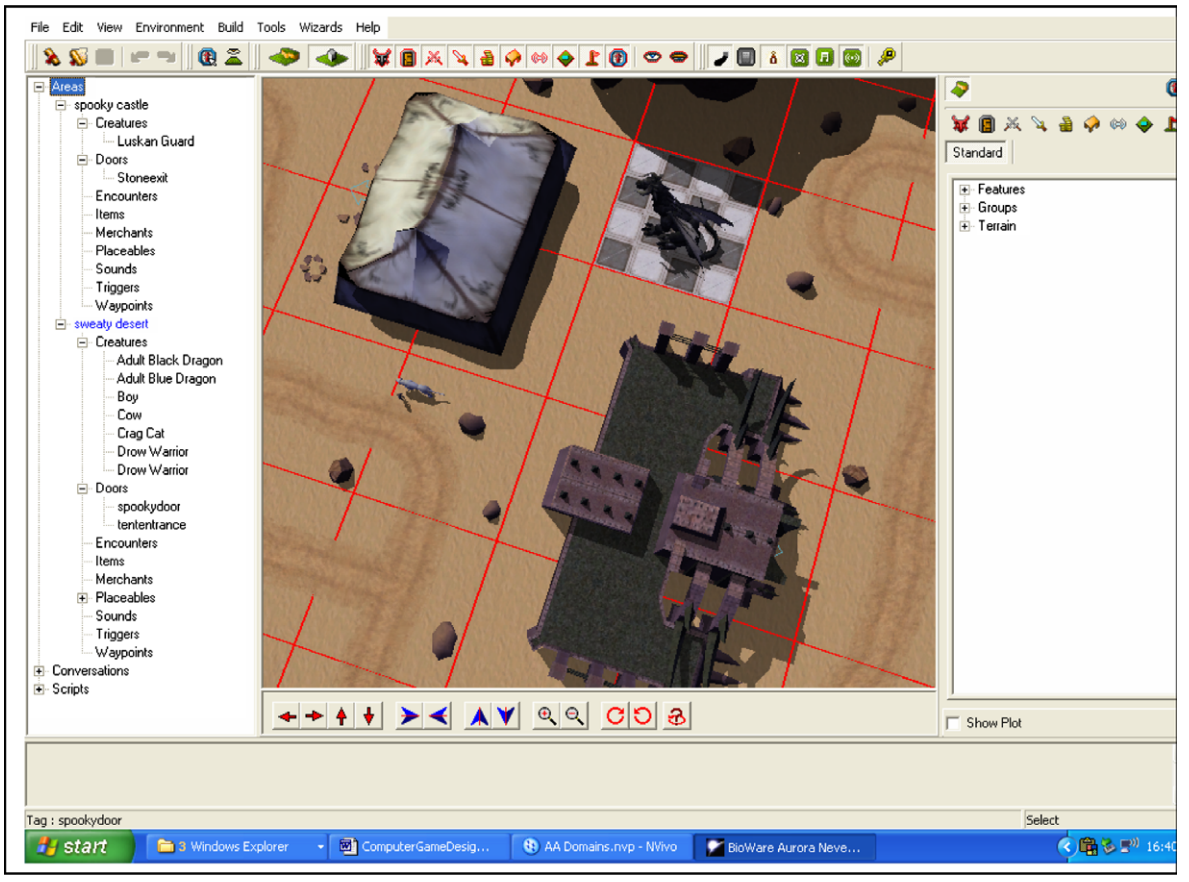

Fig. 2. Cool Game Kid's area.

immediately after the session "He wanted the temple door to take him into the spooky castle interior, and seemed very cast down, uncertain that he could now achieve this. So we looked at the process – he took me through the area transition set up and linked the temple door to the spooky castle. Didn't believe it would work, so we tested – he was delighted! We undid the other door link... He now wants to make a door from the spooky castle that brings you out into the tent. He will need to make a tent interior, and will perhaps need a chance to talk through next time the ways the doors work." With support, and over more than one session, Cool Game Kid achieved his initial goal, despite his obvious disappointment at the failure of his first attempt.

The complexity of the software and the fact that he had not limited himself to one building and one door by way of area design meant that support was inevitably going to be needed, but he was prepared to ask and was buoyed up by his first success to go straight on to announce his intention for a more complex transition, entering one building but coming out into another. It is interesting to note that he clarified the naming of his doors during the process of amending the transition (templegate becomes spookyentrance). He also added a Luskan Guard to the Spooky castle, who talks to the player. Cool Game Kid's dialogue is limited and utilitarian in terms of content and outcomes. It does little to add to the player's experience, but this is perhaps unsurprising in view of the effort required to succeed with the transition.

By the final session, after playtesting with his peers and his sister, Cool Game Kid identified a central idea for his game – he added a gem to the Spooky castle with the intention of creating a quest. It would seem that he had focussed all his efforts till now on learning how to use the toolset, but unfortunately there was no further time available to develop his game idea.

The children did not just look to the adults in their search to solve problems and achieve their aims. "CJ, Kerri and Lucy had been trading support for each other – the girls remembered a creature from a few weeks ago in Chris's game that would be good as the Blue Lizard King, and CJ wanted help with transition so the girls showed him where to find what he needed". (Researcher's notes, 26 October). CJ succeeded in creating a transition in his own game on 26 October and went on to place lots of gems in the monster grassland area in the next session – renaming it "safe grassland" at the same time. He reported at the end of the session on 26 October (along with Zoe, Jack and Ross) that he had both linked and tested the transition between two areas.

The majority of children associated the transition process with a great sense of achievement; when asked to comment on their "best things" within the project, Jack identified "Making multiple areas with transitions all in one game," and CJ was similarly enthused by the possibilities transitions allowed when asked about what he had liked best: "Area transitions – you could make it go anywhere." Indeed, when teachers from Australia were visiting the project two months later, CJ was able to explain, enthusiastically and in great detail, the steps for setting up a transition, using the large teaching screen to illustrate the process, thus demonstrating not only the fruits of his determination, but the clear retention of complex learning after a break of several weeks.

The orchestration of game ideas, new computing and thinking skills and the demands of the NWN toolset meant that the children were faced with much larger global challenges en route to becoming successful game designers. They had to find ways to develop their own ideas within the limitations of the toolset and their own capabilities, they had to learn to understand the player's perspective and they had to work with the constraints of time and hardware which put certain additional pressures on the project. Despite all of this, they persevered and each child managed to produce, to varying degrees of sophistication, a working game by the end of the project and many had further ideas they would have gone on to incorporate had there been more time.

The degree of challenge, rewarded by visible, tangible success in terms of outcomes with the game or the toolset, or comments from peers, seems to have been an important generator of the enthusiasm, motivation and determination to succeed. All abilities of children showed evidence of this powerful interplay, not just the most able, and that determination to reach a high standard of achievement, to rise to the challenge of a very demanding software package was a driving force. This was noted by a visiting educationalist from the government agency Learning and Teaching Scotland: "The sight of these children, of mixed abilities and dispositions, focused, engrossed, challenged, collaborating, teaching adults was superb ... incredible."

4.3.3. Learning together and alone

Learning in a group provides many opportunities to develop ideas, consolidate concepts and learn about social interaction. The sessions were structured so that a variety of group learning situations were offered: whole class discussions took place at the beginning and ending of each workshop; informal opportunities

arose for paired and small group interactions as the children worked on their games; structured peer-testing sessions also took place; and occasionally a needs-related group would be brought together for focussed input.

With encouragement from the facilitators, the children frequently collaborated to learn how the software worked. The teachers were struck by this behaviour, as it did not seem to be a normal part of their classroom experience (see the "Implications for Classroom Practice" section for a further discussion of this point):

Mrs. Galloway: There's also been a lot of cooperation work.

Mrs. Laird: [They ask each other] "How did you do that"? And then they'll go and help with it. But there's been a lot of collaboration.

Mrs. Galloway: And you know beforehand it would just be their pals that they would show how to do something. But it hasn't been at all . . . it's just if they've overheard that then they go and they help one another out.

There were many examples of children explicitly offering to help each other, from simple help with spelling to support in understanding a whole range of software functions: children often overheard a request for teacher-help and stepped in to support their peers. Nadia was particularly notable in the role of teacher, assisting other pupils in a variety of tasks including creating conversations, simple action sequences and giving the player rewards. These interventions are all the more remarkable because Nadia's machine regularly crashed, greatly reducing her contact time with her own game. She was also considered by her teachers as one of the least able children in the class.

The children regularly offered to tell the wider group what they had discovered, or how they had helped someone, particularly after they were encouraged to develop this sharing behaviour. Examples of discoveries shared included how to use the eraser and how to alter the challenge rating of creatures, both notable because they had been informally shared with peers as they were discovered during the session, and then shared more widely and formally with the whole group during the plenary.

The children also collaborated over the development of ideas, as in a whole class session where a group of boys excitedly elaborated on each other's suggestions for possible character and story developments, or the two girls who chose to work as a pair throughout and took on the alternating roles of the speaking characters whenever they created dialogue.

Testing someone else's game provided an important opportunity to learn with peer-support. The children had to identify three strengths of the game they were testing and indicate one aspect which could be improved. Nikki, commenting on Nadia's game, said that she liked the fact that there was "a dragon to help you" and "a path to lead you"; George felt Cameron's game had some interesting places; Andrew liked the difficulty and the surprises in James Bond's game; Kerri enjoyed "Finding the book, speaking to other people and doing the quest" when she played Lindsey's game; Lindsey liked the fact that Kerri and Lucy had someone waiting to talk to the player when they reached the next level. The game designers then had to reflect on what they had seen and heard and decide how to develop their game. This gave them important insights into the design process, as Predator observed: "You might like it loads, but you can't be 100% sure everyone else will like it," and the different roles that one has to adopt when working with others: "It's hard to stand back and not help when someone is testing your game" (Rebecca).

The children were asked to evaluate their own work, that of their peers, and the software itself during the project. Whole class demonstrations of aspects of pupils' games, such as the use of dialogue, were used to model and encourage evaluative comments. In one of these sessions the children made a range of observations about the dialogue in Kerri and Lucy's game (see Fig. 3) which were typical of the reflective nature of such contributions:

"JJ said that it was exciting, because there was a girl running away with a monster coming up behind her; Predator noted that the monster could easily catch up with the sister which added to the urgency; Mysterio[4] said there was good vocabulary; and Greg Banham noticed that the gem was given in dialogue, and he thought that was more straightforward than hunting for it in the area" (Researcher's notes).

[4] Pseudonym chosen by the child.

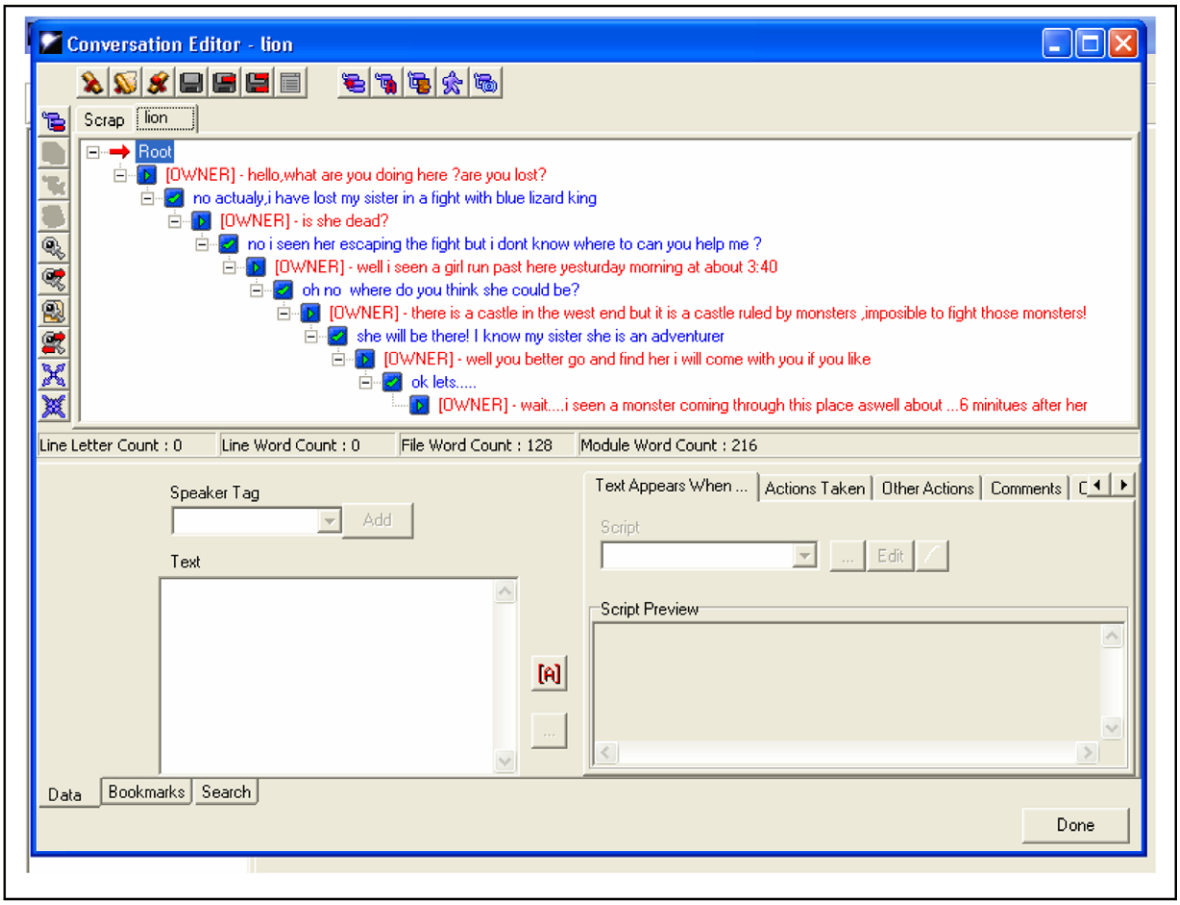

Fig. 3. A screen shot of the dialogue in Kerri and Lucy's game.

The sessions were designed in such a way as to support the children towards independent learning during the course of the project. Whole class teaching and demonstration of new skills and features were used in conjunction with opportunities to explore the software on an individual basis.

Despite the demands of the software, there were many examples of the children taking the initiative and finding their own ways forward within the program; for example, one child used a feature of the conversation interface independently – she had seen it used on the class screen, though it had not been overtly demonstrated; another asked for help, but by the time an adult reached her she had solved the problem for herself. Children had also bought their own copies and taught themselves new skills at home, e.g. how to disarm creatures. This latter example would also seem to be linked to the principle of enthusiasm and motivation considered earlier.

Children were given regular opportunities to reflect on their own progress, particularly towards the end of the project, and their comments show an understanding of the features of effective game design which had been explored in the workshops. For example, Lindsey noted: "I have not yet got at least 1 task in each level, except for in level 1... I am pleased I have got quite a lot of characters speaking to each other," demonstrating her awareness of the needs of the player and her recognition of the importance that had been placed on effective use of conversation during the project.

Knowing you have made a mistake is an important step towards independent learning, and the children were frequently able to identify where they had gone wrong: "Also we looked at the reward he had added to his conversation – he realised he had added it in the wrong place and was able to amend the text to remove it" (Researcher's notes, of Alex Rider). Some of the children, as well as being able to identify their errors, were able to recognise the importance of becoming independent in resolving them: "Alex Rider was writing dia-

logue and he wanted me to correct the structure... He knew if was wrong but he didn't know how to take turns instead of adding choices. He articulated it quite well, and insisted I show him what he was doing wrong rather than doing it for him'' (Researcher's notes). Some of the children were even able to celebrate the identification of errors, recognising this as a valuable opportunity to amend and improve: ''My favourite bit was when I played my game and see what went wrong'' (Rene[5]).

Developing confidence and being prepared to take risks are key aspects of learning independently, and although there is much that could daunt the learner in such a complex program, often all that was required was a small prompt from an adult, a small reassurance, that would then result in the child going on to solve their own problem: ''Carlie was about to create new area but said she had forgotten how. I suggested she just try, and sure enough she did know'' (Researcher's notes).

All these opportunities to collaborate over the learning process and to take on different roles within the sessions helped the children to develop the confidence to support one another, and provided vital experience of taking on the mantle of expert. The scaffolding technique of the learner collaborating with a more capable peer does not require teacher intervention. Once the researchers encouraged the children the share their knowledge, they readily moved in and out of this role as the need arose, becoming the teacher rather than the taught when they could see they had expertise to offer. On occasion it also included them offering to help the adults: ''James Bond offered to show me how to use the inventory and other in-game things, based on his new knowledge of the game from playing it at home'' (Researcher's notes). The head teacher recognised the power of the workshop sessions to help with this: ''It ticks a lot of boxes for me ... even the very poorest children have taken off and have been able to help other pupils.''

4.3.4. Linking and applying learning in new situations

Transferring learning from one context to another is an important aspect of independent learning which we were beginning to see. For example, CJ was able to generalise how to make portals after being shown one example by a researcher. Children were also transferring behaviours employed in the workshop sessions back into the classroom without explicit prompting: ''When we were doing creative writing this week John started off his story one way and then when we came to sharing it the next time he said ''Actually. I've changed my idea. So now it's like this...'' So he's editing it and redrafting'' (Mrs. Galloway, class teacher). A visiting education adviser recognised the great importance of the editing and improving tasks which are fundamental to the game authoring process, and their relationship to both writing and formative assessment in class: ''They are learning something about real authoring, the opportunity to compare, to adopt and adapt, a re-cycling of ideas... Often children have no energy to peer assess, but in this context the can and it feeds back into the classroom.'' The class teacher also took the opportunity to develop language tasks that complemented the branching tree conversations that the children were creating in Neverwinter Nights. Art work was inspired by characters from the children's games, and the IT teacher used the game as the basis for a task to create a CD cover, including a ''blurb'' to summarise and promote each game.

Some of the children were able to make explicit connections between the skills they were using in Neverwinter Nights and other areas of the curriculum, for example Predator: ''it's a better way of learning like, better sort of language work, cos its more fun and it helps you with computing as well... it helps you with your conversation... you think about it a lot more to make your game better''. Another child, Nadia, felt that what she had learned about game-editing had transferred to her story writing: ''Well, I wrote a story and now I'm transforming it and making it better.''

Conversely, the children were also able to apply skills related to reading and writing in the development of their games. Mysterio had created a game based on the theme of fire, ice and water, and the skill of inference was deployed as the children discussed an exemplar conversation from his game (see Fig. 4) on the large screen and considered how it might impact on the development of the game as a whole:

Nikki said she liked the reward (an ice gem). Predator thought it might link to later on in the game when the player might need more gems. Rebecca added that the other gems might be fire and water, and

[5] Pseudonym chosen by the child.

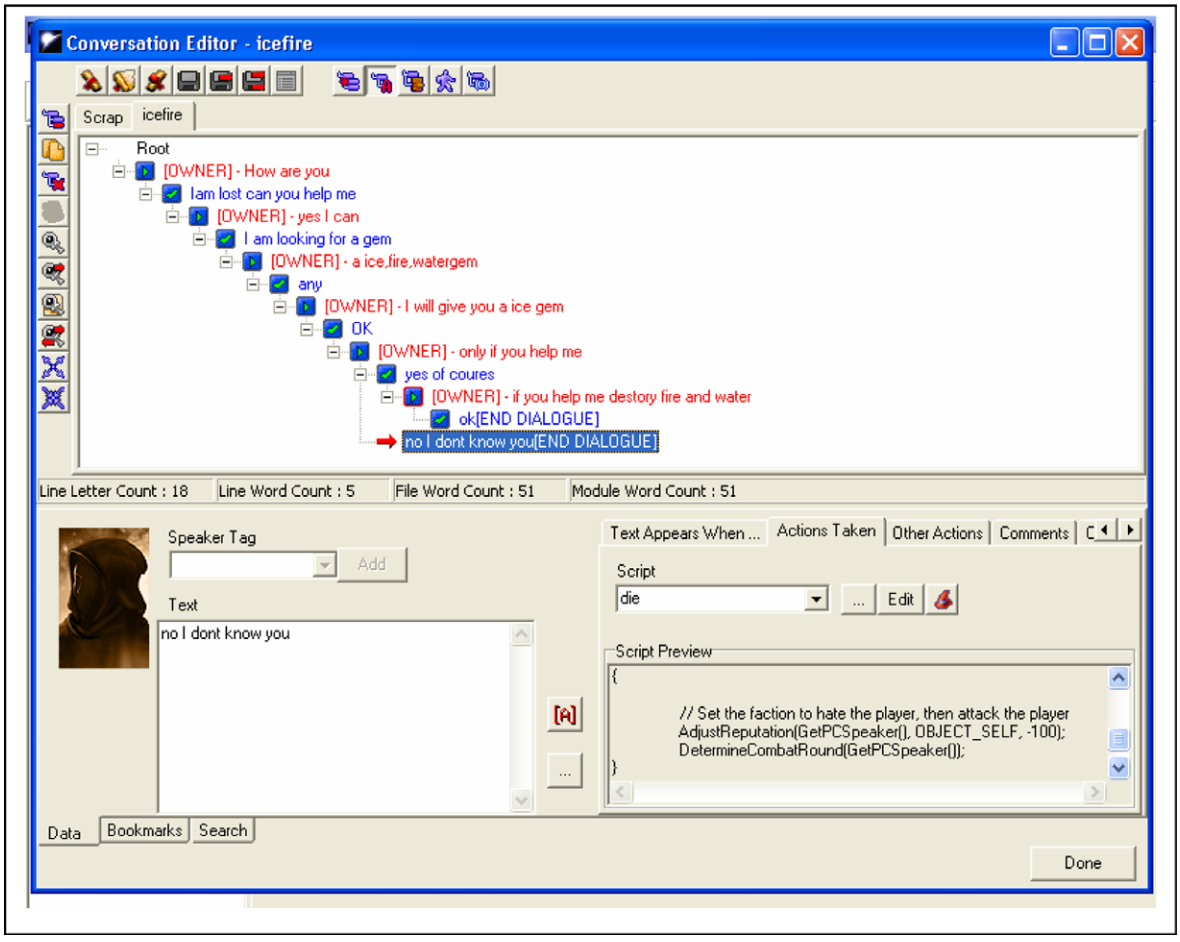

Fig. 4. A screen shot of Mysterio's conversation.

Mysterio confirmed that his game did include ice, fire, water gems. A girl then suggested that maybe the next area would be the fire kingdom and Mysterio agreed that this was the case. The children had simply been asked to identify what they liked about this example of conversation; they transferred their understanding of story and applied their inferential reading skills to the computer game context without teacher intervention.

A successful writer supports their reader in order to help them engage effectively with the text. It became apparent that the children had taken on an equivalent responsibility as they designed their games, with several of them showing a good understanding of the need to incorporate design features that would support the player. They considered the feelings they wanted to evoke in the player, through use of setting, storyline, character and event; they thought about the balance of the game so that it was not too hard and not too easy; they employed devices such as sign posts, paths, welcome characters, maps and customised books to help the player find their way; and they gave thought to the overall experience of the player as they passed through an area. Rebecca put a path into her game to help the player find their way. She also commented, "Flutter will help the player in the first level, and then the deer on the second level." Cameron was able to advise the researcher to add more landmarks to her exemplar game to help the player find his way around, and Jack added that there should be more things for the player to do.

The children's ability to propose improvements to the software also indicates the application of critical thinking to a new, indeed hypothetical, context, and demonstrates their awareness of their own needs as learners as they engaged with the software and struggled with its shortcomings.

5. Implications for classroom practice

Given the evidence gathered during our exploratory work, it would appear that game making projects offer rich opportunities for the development of successful learning skills. However, these initial classroom sessions also highlighted some issues which are likely to become important if such an approach were to be adopted more widely.

The technology for game making should not be considered in isolation. We believe that the successes we have seen so far have emerged from the features of the powerful learning environment identified by Smeets. For this reason, supporting teachers to adopt this style of project requires more than training in how to use the software. It requires consideration of the educational principles behind this style of learning and strategies for teaching effectively within this framework.

5.1. Striking a balance between exploratory learning and instruction

It became clear after a handful of sessions that time for independent exploration of the toolset was vital for the success of the project, and a decision was made to give the children more time to ''play'' in order to consolidate skills introduced and to discover the creative potential of the software. This is particularly important in the early stages of the creative process, to enable many different possible ideas to be considered. From the teacher's perspective, there are important decisions to be made about the management and facilitation of different aspects of independent learning within the game authoring experience. A balance has to be found between time for the children to explore and work independently with the software on their own terms, and time for direct, interactive teaching to ensure that essential skills and features are introduced. It is our view that playful exploration is particularly satisfying for the children and that removing this aspect of the project would reduce the motivational impact. One of the motivating factors is likely to be the fact that they can pursue their own lines of enquiry, and so develop a sense of ownership and self-determination – powerful levers for learning.

However, learning through play requires time and courage on the part of the teachers: there is no guarantee that the children will learn the target skills in an open-ended session. This can make it hard to justify within an already pressed curriculum unless other strategies are used to address this, as discussed below.

5.2. Facilitating the exchange of knowledge between learners

As each child could potentially learn something different in an exploratory session, there is a need to share the new knowledge with the other learners. Here the role of the teacher is no longer as information provider but as facilitator. In the study described above, we directly facilitated the children in disseminating their new knowledge by regularly asking them to contribute to plenary discussions about interesting features of the software which they had discovered during the session. As the classroom environment did not initially appear to embrace collaboration to the same extent as other successful learning environments we had worked with, we tried to encourage it in various ways including promoting sharing in group discussion, requesting children to teach other learners and by more formal peer play testing of games. By contrast, the default expectation of the learners and teachers at the start of the project was that the children should work quietly on an individual basis unless instructed to do otherwise. Initially if children did get up from their seats to watch other learners, the classroom teacher would sometimes tell them that they should focus on their own work as they did not have much time. Through encouraging the children to learn from each other, the load on the adult helpers was reduced: the pupils were able to get advice and help from their peers without adult intervention.

5.3. Facilitating cross-curricular learning and transferable skills

One of the implications for teachers is to be aware of the cross-curricular potential of Neverwinter Nights, and to consider how it might be embedded in a wider curriculum experience. Neverwinter Nights offers many creative starting points for complementary classroom activities such as drama, art, design and creative writing, which could be enhanced by their connection to the game design experience, and which in turn would give a

wider context for the Neverwinter Nights experience. The teachers in this study were beginning to take advantage of these opportunities; this could be further developed and planned for to create a more coherent curricular framework for game authoring, in line with *A Curriculum for Excellence* proposals which advocate a greater emphasis on interdisciplinary approaches.

Capturing evidence of the transfer of skills has long been an issue in schools. Interviews with the children, records of their contributions to discussions and teacher-observations back in class all suggest that skill transfer was occurring during the project, both implicitly and explicitly on the part of the learners. This would be a valuable area to explore further with teachers and pupils, in terms of domain-related skills and skills relating to learning about learning.

5.4. Evaluating successful learning

If the architects of *A Curriculum for Excellence* are sincere in valuing successful learning, then much thought needs to be given to strategies for teaching and evaluating such skills. How will teachers whose training may have focused mainly on assessing domain skills switch focus to evaluating and recording evidence of successful learning? This is not a straightforward issue; see Black et al. (2006) for a report on a failed attempt to develop an instrument for assessing LHTL. However, the Assessment is For Learning initiative in Scotland (Hutchison & Hayward, 2005) has focused on developing and sharing good practice in various forms of assessment, and work has begun on relating this initiative to the new curriculum (AiFL, 2007). Much of the evidence we gathered was through our observations of classroom behaviour, particularly during group discussions. Skilled facilitators can lead discussions while evaluating the contributions of individuals, but it can be difficult to fairly assess the skills of every group member and it is certainly hard to record evidence of an individual's participation. It may be beneficial therefore for teachers to ask a colleague to facilitate a discussion while stepping back from the discussion in the role of an observer, and to write notes on the interactions. Similarly, as supporting the pupils while using a challenging new software package is very intensive initially, it may useful for teachers to have the support of a colleague to free up their attention for assessment purposes. Working with only half the class at a time (for example during a library slot or time scheduled with a specialist teacher) would also enable the teacher for focus in more depth.

Children can be taught to reflect on their own progress, to diagnose their strengths and weaknesses and to participate in planning new learning goals. In our project, the children's own reflections on their progress (written at the end of the project) proved useful for shedding light on individual cases. As discussed above, peer assessment was also useful for the pupils in this field study to enable them to see their games from the perspective of a player, and we encouraged peer tuition and supportive group critiques of games.

Examination of the children's games from week to week was also helpful in evaluating their progress, if somewhat time consuming. Counts of different game features, such as number of areas, characters and dialogue lines are basic indicators of skill mastery. We intend to introduce a tool for teachers into the software which will automatically chart changes in the children's game from week to week in an accessible way.

When assessment is used as a tool for learning, learners need to be part of the process of planning their learning. They need to be aware what is expected of them in terms that they understand. There therefore needs to be a shared vocabulary between teacher and learners, not just for game design concepts, but for successful learning skills.

In future work, we intend to develop exemplars of the successful learning readily developed by game making and make these available for teachers and their pupils. To complement these materials, we aim to produce check lists of success criteria and summative questionnaires to assist pupils in reflecting on the progress they have made with their games.

6. Conclusions

The Adventure Author project has shown that game making provides a range of opportunities for successful learning occur: the children in this study were motivated and enthusiastic; they showed determination to achieve and were able to learn collaboratively and alone; and they also showed evidence of being able to link and apply their learning to new situations. Game authoring using Neverwinter Nights offers a ''powerful

learning environment" (Smeets, 2005) in which children can engage in authentic rich tasks offering a good degree of learner autonomy (Black et al., 2006), but if the full range of learning opportunities is to become embedded in classroom practice, they need to be mediated by a teacher or facilitator.

This has implications for teacher development. Traditionally, the class teacher has operated in the role of provider, delivering subject-based curriculum content to pupils who generally have a low degree of autonomy, despite being increasingly aware of the learning intentions in the lesson and having some opportunities for choice.

For the work set out in this paper to reach its full potential, the teacher-provider will need to become the teacher-facilitator, prepared to alter the traditional balance of the classroom, encouraging open-ended, exploratory enquiry and allowing the pupils a degree of autonomy which may be new to both. They will need to judge carefully the moment at which to intervene with focussed instruction so that the creative flow is not lost, and embrace the opportunity for the pupils to teach each other.

Game authoring does not fit readily into one curricular category, and does not have a neat, linear content that lends itself to being delivered in an instructional way. Our study has indicated that game authoring provides many opportunities for cross-curricular learning to take place and that much of that learning is not linked to individual subject domains. This has consequences for evaluating the learning that occurs: it will be necessary to clarify the learning and thinking skills which this way of working clearly enhances, so that teachers and pupils can readily identify their learning intentions and outcomes and use these as a focus for reflection and assessment, for example during plenary sessions.

Despite the implications for teacher development, it is clear from our work to date that working with the Neverwinter Nights computer game authoring tool provides rich opportunities for children to become the *successful learners* to which *A Curriculum for Excellence* aspires.

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