Savannah

A Futurelab prototype research report

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This is the final report from the Savannah project trials produced by Futurelab from preliminary analysis of the data for all project partners. Further theorisation and analysis is being conducted through ongoing work by project partners - conference papers are being presented at CAL05, EARLI, ACE among others, in 2005, and several more detailed journal papers are in production. Versions of these papers and presentations will be available on this site where possible.

1. FINAL TRIAL PROCESS

1.1 Sample, data collection and researchers

1.1.1 Trial location

The final trials of Savannah were conducted from 31 March to 2 April, at The-i City Learning Centre, Monks Park School, Bristol. The City Learning Centre is a purpose built facility that is managed independently from the school and which has a remit to encourage teaching and learning with digital technologies. It is a well-equipped modern two-storey building, comprising six teaching rooms and large lobby, and is adjacent to the large Monks Park School playing fields.

Limitations were placed on the use of the playing fields during the trials, which prevented us from using the fields during the school break and lunchtimes, and when children were leaving the school at the end of the day.

1.1.2 Process of selecting children for trials

Neil Dennison at the City Learning Centre recruited children from six schools serving different socio-economic groups, four groups from Year 7, one from Year 6, one from Year 8. The schools were asked to identify mixed gender groups, on the basis of friendship. The schools themselves determined the types of children that attended, which led to a mix between 'gifted and talented' children, mixed ability and children described as under-achieving in school. Permission to participate in the trials was sought and granted from the children's parents/guardians in writing.

The trials comprised 35 children from six different schools, as summarised below:

	Morning session	Afternoon session
Wednesday 31 March	6 children from School 1, Year 7, gifted and talented. School selected.	6 children from School 2, Year 7, gifted and talented. Gender-based friendship groups.
Thursday 1 April	6 children from School 3, Year 8, under-achieving. School selected.	6 children from School 4 Primary School, Year 6, gifted and talented. Gender-based friendship groups.
Friday 2 April	5 children from School 5, Year 7, mixed ability. Gender based friendship groups.	6 children from School 6, Year 7, mixed ability. Gender-based friendship groups.

1.1.3 Trial observers

In the den, Ben Williamson (Futurelab) Kathy Fawcett (Teacher-Consultant) and Neil Dennison (The-I CLC) acted as the children's key points of contact. Observing in the den were: Jo Reid (Mobile Bristol), Jo Morrison (Futurelab), Keri Facer (Futurelab) Danae Stanton or Richard Joiner (University of Bath). Also present in the den were Duncan Rowland (MRL), Richard Hull (Mobile Bristol), Steve Benford (MRL) and one to two others running the game server and GPS system - they were partially screened from the Den by a low divider.

A separate room with live video feed was provided adjacent to the den, in which visiting observers, and the children's teachers could watch proceedings in the den. This room also housed all the equipment for play in the field - the children's backpacks, batteries etc - and the equipment for filming play in the field - the cameras and tripods etc.

1.2 Data collection

Data gathered comprised:

1. Introductory questionnaire
2. 2 x video camera capture in den
3. 1 x observation sheet
4. 1 x observer fieldnotes during den activity
5. 2 x radio mic video capture (one boy, one girl) in field
6. 30 minute debrief interview including repertory grid and enjoyment ranking sheet with children in gender groups
7. Digital photographs of all maps and notes created by children during trials
8. Digital photographs taken during den activity.

1.3 Trial structure

0.00 - 0.30: Pre-experience:
The children arrived at least half an hour before the experience proper began. Accompanied by their teacher they were briefed by KF on the purposes of the trials and the general aims of the experience. They were then asked to complete an introductory questionnaire concerning their use of mobile phones, computer games and their interests in science and wildlife. At this point the children were given their lion pseudonyms - from a choice of six names. With different groups these were assigned either randomly, or by request. With three groups this initial introduction also included a discussion of the children's pre-existing understanding of the savannah and lion behaviour. This pre-experience briefing took place in the lobby of the City Learning Centre, with the children's teacher present.

0.30 - 3.30: The Savannah game
When children came upstairs to the den, they were told that they were now entering the game and were passed over to the care of Ben Williamson (GamesMaster), Neil Dennison (Game Support), Kathy Fawcett (Lion Support). The experience broadly followed the following structure within a three-hour period:

- introduction by BW to 'the savannah'
- introductory video - outlining lion behaviour on the savannah
- introduction by ND & KFw to their roles and resources available in the den
- Level 1 challenge - set by BW
- free research time
- Level 1 play
- reflection on Level 1 play + decision about whether to reattempt Level 1
- Placing the Cubs Challenge
- Level 2 challenge - set by BW

- free research time
- Level 2 play
- reflection on Level 2 play + decision about whether to reattempt Level 2
- Level 3 challenge - set by BW
- free research time
- Level 3 play
- feedback on success at Level 3 - BW
- final results and roar.

The exact timings of each of these phases altered with each group for a variety of reasons: first, the times children were allowed on the field outside differed between mornings and afternoons; second, children were able to decide whether to repeat levels or not; third, technology readiness sometimes required a delay before outside games activities.

On the first day of trials, children were given complete freedom to decide when or if they would go outside for the challenges. They were asked simply to give a two minute warning so that the technology would be ready. By day two we changed this to provide a general outline schedule which offered the children specific 'windows' for outside play opportunities - this afforded them, on average, four opportunities to go outside, and therefore the chance to play only one level twice. This greater specification of timings was triggered by: technical issues, as a rough schedule allowed pre-planned preparation of equipment; and by game play observation, as it enabled children to focus on preparing strategy and planning activities instead of debating the issue of when to go outside which seemed to offer little to the experience.

The impact of structured time on the game was significant and will be discussed in later sections of this report.

3.30 - 4.00: Final interview
For the final interview children were (in all but one case, School 4) divided into two gender groups. They were interviewed in the den about their experiences of Savannah. They were asked to complete a repertory grid exercise discussing the similarities and differences between Savannah and activities in school (either in lessons or outside). Children were also asked to rate on a continuous line, their enjoyment of Savannah in comparison with a typical schoolday or a typical weekend. These interviews were video taped and rep grid comments recorded.

2. EDUCATIONAL AND RESEARCH OBJECTIVES

Savannah was designed to explore the overarching question:

Is it possible to create an integrated mobile gaming and research environment which encourages children to develop self-motivated and collaborative approaches to developing conceptual understanding of animal behaviour?

The specific learning objectives informing the Savannah design were developed iteratively with the technical development of the project. These were finally defined after the first November technical and experience pilot trials.

The aim of the Savannah experience is:

1) To encourage understanding of animal behaviour and longer term survival. By the end of playing Savannah, children should have:

    a) developed an understanding of the key features of the Savannah environment
    b) developed a conceptual understanding of the opportunities and threats faced by lions

in the Savannah environment

c) developed a conceptual understanding of the strategies and choices faced by lions in interaction with the Savannah environment

d) developed a conceptual understanding of the relationship between individual lion behaviour and longer term survival of the species.

2) To encourage strategies for working with problems as a team. By the end of playing Savannah, children should be able to use a range of different strategies for problem solving, including:

a) research
b) discussion
c) hypothesis generation and testing
d) revision of ideas
e) requesting expert advice
f) listening to each other and building on each others' ideas.

In addition to this, there was the overarching objective of exploring the extent to which features of computer games design and mobile computing could contribute to creating an engaging and enjoyable experience for children, and encourage self-motivated learning in the process of playing the game.

3. FINAL TRIAL FINDINGS

3.1 Aims of the analysis

Drawing on the educational and research objectives outlined in the previous section, the analysis of the trials was organised along two axes, on one axis were the outcomes we hoped to see from the project: understanding, collaboration, engagement. On the other were the dominant features of the experience: game structure and challenges, mobile gaming in an outdoor space, den resources. What we hope to explore in this analysis, were the contributions made by these dominant features to the overall objectives of the project.

At the same time, however, it is clear that these different objectives are not discrete. We will therefore, in the analysis, be exploring how engagement, collaboration and understanding are inter-related. Finally, the question of gender, 'ability', and age differences will be explored, although statements on the impact of these variables on the experience can only be made with a degree of caution given the small size of the sample.

Analysis has comprised:

1. Detailed transcription of experiences of Groups 3, 4, 6, then coding of these transcripts along the axes above.
2. Themes/issues emerging from case studies cross-checked against fieldnotes of all six groups, to identify issues common to all groups, or specific to individuals and groups.
3. Transcription of all groups final interviews.
4. Follow-up interviews conducted with five children as triangulation against observations and interviews during the trials.

The following analysis can only begin to tap into some of the implications of the Savannah project for children's learning with these sorts of technologies. Its aim is to provide an overview of key findings to inform future development of the project, and to highlight potential areas for more detailed and focused analysis by project partners. Arguably, each of the following sections and each case study could provide the basis for significantly more detailed analysis and discussion. To do that is outwith the bounds of this report.

3.2 Diverse experiences and diverse outcomes

3.2.1 Changes to the experience during the trials

The first point that needs to be made is that there were very different experiences for each of the six groups. In the first instance, lessons learnt about how to structure the experience from the early groups were incorporated into the experience in subsequent sessions. Key changes that were implemented during the trials included:

1. A shift away from children determining when they wanted to go outside and how long they wanted to research for. This was as a result of two issues: first, there were constraints in terms of technology readiness and in terms of the periods during which children were allowed on the school field. These constraints made a nonsense of suggesting that the children choose their own time periods. Second, the time variable added an additional layer of complexity to the experience without any evidence that it was a valuable way of them spending their time. This resulted in a relatively strict format of 'windows' of outdoors play time. The only choice children then had (by Thursday afternoon and all day Friday) was of whether to replay different levels.

2. Children clearly had difficulty in framing their own 'research questions' to help them prepare for each level. We therefore formulated research questions for them in a wall poster and drew these to their attention. Children on Thursday and Friday (Groups 3-6) were all offered this additional structuring device (although not all groups referred to this).

3. Clarification and delineation of roles of adults in the den - to reduce numbers of people providing the same information, and the occasional instance in which adults provided conflicting information. By the final day, BW was responsible for managing time and KFw/ND for supporting information.

4. Separation of different challenges. There was confusion initially in combining the 'location of cubs' (indoor) challenge, with the preparation for the Level 2 challenge and completion of Level 1 challenge. By the Friday, we identified the location of cubs challenge as a discrete task arising from Level 1 and before beginning the Level 2 preparation.

3.2.2 Different group backgrounds and differences within groups

The second way in which groups differed was in the types of children attending each session - this ranged from children selected as 'gifted and talented', to children selected as underperforming in school (see 1.1.2 above).

While there were differences between groups, what is also clear from the analysis is that there were differences in terms of the benefit derived, level of understanding achieved, enjoyment and engagement within the groups. There were gender differences, and ability differences within groups. There were also clear differences in terms of children's collaboration skills, and different roles adopted by different children - as leaders, followers, collaborators, advisors and so on.

These differences within and between groups, both in terms of what the children brought to the experience and in terms of how we structured the experience, make any of the generalised 'outcomes' from the project described in the following sections, somewhat 'advisory' rather than universal. These outcomes should be seen as trends rather than universal for all the children involved.

3.3 Expectations meet technology

While it is common for naïve users of a new technology to attribute more intelligence to a system than it possesses, there were a number of ongoing misconceptions across all groups about the ways in which the game actually worked that served to shape children's expectations of how the game world operated.

3.3.1 'World' behaviour expectations

Generally the children expected the world of the Savannah to operate as the real world, when combined with GPS instability and possibly a tendency to initiate attacks near the borders between zones and lack of clarity in the games rules, this led to a number of misconceptions about how the game worked:

1. That animals in the evironment could move around.
2. That animals in the environment could be 'scared away' by another player approaching or moving while in an attack formation.
3. That animals had been eaten by someone else (when they had in fact disappeared due to GPS instability or the child moving from one zone to another).
4. That animals/Masai can attack with no provocation.
5. That animals/Masai will return attacks and that this would lead to 'damage'/loss of energy.

These misconceptions could be seen as children actually having a more complex idea of the relationships between animals and their environment than the game was actually able to model. The trick here is not to 'cure' the children of these ideas, but to ensure the game would actually allow this to be modelled.

It's also worth noting that these misconceptions often added to the children's experience of the game, rendering it significantly more complex and engaging than it might otherwise have appeared.

3.3.2 Game play expectations

Three of the groups started the challenge with the expectation (generated perhaps by the video which showed lions attacking waterbuffalo in formation or by pre-existing understandings of animal behaviour) that they would have the opportunity to develop sophisticated hunting strategies. These children often spent the first stage of the research planning the location of different individuals in different attack positions. The actual experience offered was considerably more crude than these initial plans.

Aslan 3:   *So, this is a hippopotamus taking a drink, this is like land, and there are all these funny animals, all this hippopotamus round here.*
[The boys put the book down to represent the marsh, then put the different animals, like hippos on it to explain how things will work. Aslan then shows how different lions will take their positions and creep up on the water-animals.]
(Group 3, Thursday am)

Simba 4:   *I got one thing to say about giraffes... if you can bite anywhere you want to go for the legs... and then we all just pounce on 'em.*
(Group 4, Thursday pm)

Second, having shown in the opening video the interactions between lionesses and cubs, and the risks to cubs, and having asked the children to select a place to locate their cubs, the

children expected there to be more interaction with the cubs than the game offered. Early hunting plans in several groups focused on appropriate places to hunt in order to be able to return to cubs if necessary if they were attacked.

Mufasa 6:   *If we put it there, there's the spring there... they need places to hide as well... if we put them here* [M speaking about the Kopje], *there's the spring here and there's lots of hiding places for the cubs*

Simba 6:   *We've also gotta think about where were gonna hunt and about whether we're gonna be near them*

Elsa 6:   *Yeah, cos where will we be hunting?* [pointing at the short grass]

Mufasa 6:   *There - that's short grass*

Simba 6:   *Yeah, that's probably where we'll be hunting?*

Dandelion 6:   *So, the light green?* [decision to place cubs in light green/short grass area]
                [...]

Elsa 6:   *That would be a good place to go there... here and there... Because then we'd be near them* [the cubs] *but not really there because...* [...]

(Group 6, Friday pm)

The initial den message 'return to den, your cubs have been found', led in all groups to a hurried return to the entrance to the field, with the expectation that they should have to do something about this. Similarly, the children expected the cubs to play a role in the dry season level. (The role that caring for cubs might play in future iterations of the game design is potentially significant, and I'll discuss it later.)

3.3.3 Expectations of game aesthetics and interactions

Although this was not in evidence as a major issue affecting the enjoyment or experience of game play, in interviews after the experience, many of the children (boys in particular) suggested that they had expected a more sophisticated visual environment (this came up in earlier trials as well). Their ideas for future designs of the game would allow children to see the other lions on their screens, would offer different views depending on which way they were looking, would allow distance and close up views. All of this may be related either to cultural expectations of immersive virtual reality environments (many of the children talked about wrap-round goggles for example), but it is also related to their expectations of how lions would be able to interact with and perceive their environment in the real world.

3.4 Engagement and enjoyment of Savannah

Observations of children's engagement with and enjoyment of the experience

The following discussion draws on transcripts of the children's play and fieldnotes taken during trials. It focuses specifically on moments when children voiced clear expressions of emotion during the trials. It also focuses on observations of children's immersion in activities - for example, when were they 'on/off task'?

3.4.1 Enjoyment

Pleasures on the field: Getting into character

Some of the children seemed to actively enter into the process of role-play created by the game in the field. They were visibly 'acting up' out on the field, with melodramatic calls for

help and hammy challenges to other characters. These children (in particular Mufasa, Group 3, Elsa, Group 6, Simba, Group 4) clearly derived a high degree of pleasure from exaggerating and heightening their emotional experiences in the game (perhaps for others' benefit/to gain attention?). Mufasa 3, for example, seemed to cast his lion 'character' as a Clint Eastwood type:

Mufasa 3:   *I've found them, I've found them... come on then punk, come and kill us*
Mufasa 3:   *Come on you stupid elephant, you're going down punk*

Whereas Elsa 6 preferred the damsel in distress as her lion model:

Elsa 6:   *People!* [screams loudly and runs down the field]
Elsa 6:   [in a wailing tone] *Will you please help me, I need some food* [on returning to the den in one piece]
Elsa 6:   *We're alive! We're alive!*

And Simba 4 osillates between bravado and pleas for divine intervention:

Simba 4:   *What's over here? I wanna eat you for God's sake, I want your liver and your heart and your head and your ribs. I wanna bite your head off* [...]
Simba 4:   *Oh I missed it. Lord give me food...!*

These actions could be interpreted as an active attempt to heighten the risks of the environment while staying within the confines of the games rules. Other children explored the 'lion character' by lifting their legs and pretending to pee while 'spraying' (Group 3, Group 4). What's clear is that these children thoroughly enjoyed playing roles in the game and suggest that it's worth considering Savannah alongside other activities such as drama workshops.

Pleasures on the field: Risky business

In many of the groups, there was another form of 'acting up' which consisted of exploring and testing the limits of the 'reality' of the game. For example, many of the children would explore the results of intentionally carrying out risky activities - such as moving into other lions' territories, staying in the fire and so on. The most popular of these activities seems to be exploring what happens when you 'take on' the humans. In Group 4 Mufasa, for example, much to Dandelion's concern, gets Aslan to pee on the village to see what would happen. While the boys in Group 3, and girls in Group 6 both attack the humans:

Mufasa 3:   *Cool, ah, I've found them*
Aslan 3:   *OK, when they take out their thingies to shoot us, we run like fuck*
Aslan 3:   *Now it's the little kid*
Mufasa 3:   *Come on little kid, we'll take you down you punk*

Elsa 6:   *It was the tribe*
Nala 6:   *Oh no, I'm getting hungry*

Nala 6:	*I attacked the humans, come on, I attacked the humans*
Elsa 6:	*Roar, roar*
	[all three girls now giggling and skipping and roaring]
Nala 6:	*Oh no!*
Dandelion 6:	*Shall we attack them?*
Elsa 6:	*Yeah... One, two, three*
All:	*Aaargh, they're attacking us!* [running away]

Other more tentative explorations of these risks, included moving into and out of dangerous areas to see what happened, and then in a similar manner to the role-playing above, exaggerating the consequences:

Dandelion 6:	*Let's see the lions, it's really funny, it's like*
	[both of them screaming and giggling as they see the lions]
Elsa 6:	*You see, you see the lions, it's like whoah!*
Nala 6:	*I haven't seen any*
Elsa 6:	*You go up here like* [the three girls walk towards the lions]

Pleasures on the field: Narrowly avoiding death

In fact, the three girls in Goup 6 seemed to spend much of the time enhancing their experience by playing up to any perceived threats and dangers:

Dandelion 6:	*There's an elephant! Run!*
	[both girls run screaming across the field]
	[...]
Elsa 6:	*People!* [shouting to others as warning]
	[All three girls run screaming]
Elsa 6:	[screams, then they move out of reach of Masai] *Ah, that's better*
	[...]
Dandelion 6:	*People! Run!*
	[All three girls run across to the middle of the field again]

They seemed to exaggerate intentionally the danger posed by these threats, and to enjoy the sense of having come close (but not too close) to death. Similarly, some of the greatest examples of expressions of joy and exhilaration came after the children had been struggling for some time to find food. We saw children walking around on their own muttering to themselves about their need for food, and their proximity to death and then moments of relief when they finally found food:

Simba 6:	*Hey, my health hasn't got any higher*
Aslan 6:	*I'm on full health AND full hunger*
Simba 6:	*Mine hasn't*
Mufasa 6:	*Let's go and help them*
Simba 6:	*Well, you go and help them, I'm going to continue until I get full health* [heads back to the wildebeest area and wanders around looking for animals while the other two boys walk towards the

girls]

Simba 6:   [talking to himself and now on his own] *Mmmmmmm* [having just
           attacked a wildebeest] *yeah yeah! I've got full health now! - hello
           little wildebeest, you're gonna become mine! I'm gonna eat you...
           Hello, you are tasty... yeah, I win!*
           [Mufasa 3 heads off on his own, he's in the marsh, he's just lost
           his last dinner to Aslan and is very hungry. He's sounding very
           irritated and huffing under his breath 'oh, for god's sake', walking
           around on his own. He then runs up the field and suddenly stops,
           balancing on one leg, his arm in the air, he finds something, says
           'yeah!' Then looks at his screen intently, stays absolutely still until
           he gets feedback, then suddenly says 'yeah! yeah!', dances
           around and shouts 'I want you to quote me happy! I want you to
           quote me happy!' then heads up the field singing.]

At the same time, the challenge provided by overcoming death through a group attack was
seen as exciting and rewarding by several of the groups (although most groups developed an
effective strategy of individual hunting, discussed in the section on collaboration). The most
notable example of this was the joint attack on the hippo by Group 3, who not only overcame
hunger, but the problems of instability of images, and difficulties of coordinating a group
attack. They had also had little success on the previous levels, and had been told before going
out that working as a full team would lead to success in the game.

Mufasa 3:   *Come here, someone come here, what are these?*
Nala 3:   *Hippos*
Mufasa 3:   *Let's attack them... no, I've lost them, I've lost them*
               [Dandelion 3 and Elsa 3 call over: 'We've got hippos!']
               [They all join together and group around. One person says attack,
               another one ways 'wait wait']
Nala 3:   *Everyone do this, everyone do this* [getting them all to spread
               out]
Mufasa 3:   *You got it?*
Aslan 3:   *No, I haven't got it*
               [Dandelion 3 standing outside the group a little keeping hold of
               the hippo on her screen]
Nala 3:   *Wait, I haven't got it*
Mufasa 3:   *Wait, I'm starving*
Nala 3:   *Who's got it?*
Dandelion 3:   *Me, I've got it*
Aslan 3:   *I've attacked already*
Elsa 3:   *[Aslan!]*
Aslan 3:   *Well I've gotta hurry up, I'm hungry*
Mufasa 3:   *Aren't we all?*
Simba 3:   *I've lost 'em, I've lost 'em*
Mufasa 3:   *I've got 'em, I've got 'em, hurry up*
Elsa 3:   *One, two, three... go!*
               [A few moments pass during which they stare at their screens
               then they receive a success message. The whole groups breaks

	into cheers and there is dancing amongst all of them except for Aslan who having attacked before the others, is dead, and walks off.]
Elsa 3:	*I'm gonna have a drink to celebrate!* They all head off to the waterhole together, for all the world like going to the bar for a drink to celebrate success]
Mufasa 3:	[singing] *I'm gonna celebrate* [The team later refer to this event in the den. On getting back into the den Mufasa 3 announces 'We got a hippo!']
BW asks:	*What went right that time hey?*
All:	*We gotta hippo!*

An interview with the children involved in this attack two months after the Savannah trials underlines the importance of this sort of experience. All the children interviewed remembered having attacked the hippo, all cited the hippo as an animal to be found in the savannah, and most of them discussed the importance of attacking as a group.

Pleasures of mobility and challenge

It is worth reiterating the fact that on the first level, the first time out into the 'savannah' the children enjoyed looking at different sights and sounds for the first time, and discovering what was out in the field. In particular, as with the first trials, many of the children enjoyed dancing and singing to the songs of the Masai tribespeople.

It is also worth noting that many of the children, in particular the boys and the younger group (Group 4), enjoyed the opportunity to be outside and to run around in the field while playing. They often took the opportunity to run from one place to another (either through, as described above, exaggerating the dangers, or in response to indicators that they were nearly starving). Through running the children were able, it could be said, to exaggerate the threats of particular features of the game and to heighten their experience .

In debrief interviews, when asked which they would prefer, playing Savannah in the field or inside, all of the children reported that they preferred it as an outside game. The children reported enjoying the opportunity to "stretch your legs and move around" (Aslan 6), "it's better cos like you're doing something physical, you're not sitting down" (Simba 6).

As outlined above, many of the children participated in the Savannah as a form of 'role play'. We saw many of the children using their lion names to refer to each other (with the exception of Groups 3 and 4 who tended to continue to use their own names for the majority of the experience). The Savannah, despite comments later on the desire for more technically sophisticated experiences, seemed to be a 'believable' place for the children, with real threats, dangers and opportunities. We saw children talking about the Savannah 'as though' it were real, talking about features of the space as though they were there: "it's here man, past the ditch" (Aslan 6), "this is the bit where the cubs are, hello cubs!" (Elsa 6).

The total immersion of children in the field during play, the level of concern about their own health, the shouted commands to other children to do things, the running across the field from dangers, the panic as they were warned of failing health, all indicate that Savannah succeeded in creating a believable experience and a level of challenge that engaged the children.

Pleasures of the game structure: Time

What was noticeable with each group was that the provision of 'warnings' of short periods of time left before going outside galvanised the children into action and provided a sense of urgency in their preparations. Groups who had already decided on their plans would revisit

these and revise them, groups who had been off-task and bored, would develop plans. It's not possible to provide quotes for this, as it is all observed behaviour in the den. What's clear is that a sense of time pressing provided both motivation and engagement with the game.

Pleasures of the game structure: Scoring, competition and conclusion

It is not clear that the process of scoring children's successes in the den had a marked effect in generating either positive or negative emotions, if there were responses to these, they were not voiced. To some extent, the scoring system seemed somewhat detached from the visceral experience of having eaten well or died on the field. While the children compared energy and hunger levels repeatedly out on the field, we saw little evidence of this in the den space. We also saw few comments comparing themselves with other schools (when we reported these comparisons) other than what seemed to be a general air of contentment that they had succeeded. There isn't the data to analyse this in more detail, but it seems as though the game was sufficiently intrinsically motivating in itself for the external motivation of group scores and comparison with other schools to be less relevant.

What was very clear from observation of the game, however, was the lack of a fully motivating 'finish' to the experience. The last minute decision to ask the children to 'roar' was embarrassing for the children, and the media provided was far from inspiring. It's likely that this last request to ask children to 'role play' lions in the den was a mistake, as they were used to acting as lions in the field rather than the den, and by moving this into the den we were 'muddying' the different roles between den and field. Had we been able to generate a satisfying conclusion 'in character' on the field, its likely that this would have been more successful, as the children were already playing at 'being lions' outside.

Pleasures of the den: Planning and resources in the den

Given the wide range of different resources in the den, and wide range of different strategies for using these and planning, it is hard to clearly identify which features of this environment most contributed to the children's enjoyment of the experience. For different children, therefore, different features of the den were more or less exciting and interesting.

The toy animals provided an enjoyable opportunity for role play for two groups in particular (Groups 3 and 4). These groups spent time acting out possible hunting scenarios and planning a savannah territory. The talk around these toys was similar to talk around subbuteo play, with positioning and strategies being developed (it is also possible that the children enjoyed sitting on the floor to play with these as it allowed them in the early parts of the trials to be relatively private and unobserved by the researchers in the den).

The videos in the den provided initial engagement, in particular the first intro video led to frequent giggles and comments (particularly during attack sequences, spraying sequences and for one group (6) cub sequences). For some groups, these video resources tended to be used when the children wanted some respite from more active planning. They were often used between Levels 2 and 3, during long breaks from the field. They were also more likely to be requested by the girls than the boys (which ties in to a lot of other research on girls' preferences for narrative vs interactive resources).

The interactive whiteboard was less significant than in the earlier trials. Some groups ignored it after initial interrogation (Group 3) preferring to work on the laptop instead. Others used it occasionally as a reference device, then returned to other resources. The issue of front projection caused significant difficulties when the whole group was using it which perhaps led to a preference for the laptop.

Map creation: most groups (the exception being Group 3 who had to be directed to do this) created maps as part of their planning activities. These were the moments when we saw most children involved, animated and engaged with the activity. The opportunity to write and to create in the den seemed to act as a motivating factor.

The contribution of these resources to the experience will be discussed more fully in the following sections on collaboration and learning.

3.4.2 Boredom and irritation

The most frequent trigger for boredom during the trials was 'waiting around'. The pace and timings of the trials left a lot to be desired on the first two days. The constraints on access to the field, and the need to wait for the PDAs to be charged both provided moments in which children were standing around waiting to play. While the move to pre-determined timeslots for later sessions overcame many of the technical issues, the limits on time outside that led to children being required to spend up to 40 minutes inside 'planning and reflecting' before going outside again, were significantly too long to maintain some children's attention.

Similarly, in the field, there were one or two occasions when the children felt they had finished the task but had not yet been recalled to the den. Occasions like this led to one of the girls saying "this is boring", and one of the boys saying "wouldn't lions just sit down and have a rest now?". The time issue is crucial to the emotional engagement with the game, as it relates to challenges being sufficient to require the time assigned.

On several occasions (with Groups 1-3) miscommunication between the adults in the group meant that children who had already completed one activity (for example, placing cubs) and were ready to report their decision, were brought together to be told to go away and make the decision, leading to unnecessary repetition of discussions.

Another trigger for boredom was the failure to find a role in the den. While there were sufficient resources available for all children to have a role, some were seen as more useful/desirable than others (particularly the laptop with the den interface, the internet laptop and the whiteboard). While in some groups this was managed effectively, with children working together around a laptop, in others, this led to some children feeling marginalised and sitting doing little for periods of time.

A major irritation during play was the need to wait for other players to get the same image on the screen during attacks. Although arguably this led to the development of some interesting collaborative techniques, there is no denying that the children felt massively frustrated by this at various points:

Mufasa 3:   *Come on everybody... I'm getting hungry*
Dandelion 3:   *I can't see it, I can't see it, where is it?*
Nala 3:   *Why's everyone attacking, I can't see it?*

Elsa 6 :   *We're attacking, we're attacking - you go and stand in that corner*
               [pushing Dandelion 6 to one side]
Nala 6:   *What are we attacking?*
Dandelion 6:   *Zebra - come on attack!*
Elsa 6:   *We've already attacked*
Nala 6:   *I can't see it any more*
Dandelion 6:   *Yes it worked!*
Elsa 6:   *Yeah! We killed them!*
Nala 6:   *I didn't see it...*

On other occasions, the difficulty of keeping an image on the screen led to serious frustration

with other players, as one child who had initially found an animal, would call others over to help, then lose it, and as a consequence, lose the food. This happened in Groups 3, 4 and 6.

Elsa 6:   *Oh, look, come over here, I've got one, we can attack this!*
Elsa 6:   *Oh, it's just gone*
Aslan 6:   *I've got a carcass now*
Elsa 6:   *Yeah, it's starving beasts*
Aslan 6:   *Yeah, I just ate it*
Elsa 6:   *Ah, you idiot!*

Mufasa 3:   *Ah, there you are* [finding an antelope]
               [Aslan 3 comes running over to the same area]
Mufasa 3:   *Move out of the way, this is my antelope, fool*
               [Mufasa then moves a little, gets different images]
Mufasa 3:   *I attacked him*
Aslan 3:   *I attacked him too*
Mufasa 3:   *You bumhole, you attacked him! That was MY FOOD!*
Aslan 3:   *No, that was mine*
Mufasa 3:   *Get bent! I'm dying now thanks to you... stop following me now*

These irritations could be read as part of the process of playing the game or as a challenge to collaboration, at the very least, the vehemence of the children's responses suggest a high degree of involvement in the activity.

3.5 Collaboration in Savannah

3.5.1 Different group approaches and group 'cultures'

The collaborative strategies of the groups varied widely in the den. The following summaries highlight the different initial responses of each group to the first challenge set at the start of the day and provide a 'flavour' of the different groups' approaches throughout the experience.

Group 1 (Wednesday morning)
After being given the Level 1 challenge, two girls stand up and talk to the others saying "what shall we do? Shall we do some research and stuff?". The girls then move to the books and the boys go to the internet. There is little group discussion of what they are going to do until they are prompted by KFw. The girls explain what they have found out and the boys respond by affirming they have found the same things through the internet and video resources. Because the PC can only be operated by one person, there is an opportunistic development of a collaborative strategy - this involves one boy reading out the types of animals and habitat that have been found on the internet, then one girl decides to draw this list onto a piece of paper to bring out with them. Animal toys are used to simulate attack behaviour - drawing on images from BBC video, children plan out the locations of animals and also discuss, using the sizes of different animals, the types of animals they are likely to be able to 'take on' as lions. The introduction of time constraints - "you have five minutes" - galvanises activity and discussion. Leads to identification of further information required and separation out into individual work to feed back into the group.

Group 2 (Wednesday afternoon)
After initial briefing, children break out to work individually (no gender patterns). They are regularly asking "what information do we need... do we have what we need?". From the video

and their reading (particularly of the crib sheets), the children take notes individually and use these to share ideas with the rest of the team. They work well individually and adopt a division of labour approach before coming together to write a list on the flipchart to assign responsibilities for getting different items on the list as part of the Level 1 challenge.

Group 3 (Thursday morning)
The boys move straight to the toy animals. The girls look at the game structure and at the PDA, then move over to where the boys are planning how to position animals for attacks. The girls read the crib sheets and talk to each other, the boys plan attacks with the toys and identify areas they need to get for territory. One girl asks KFw what the skulls are while the boys then look at the crib sheets. There is some discussion of what grouping they need on the field that is based on relative sizes of animals. There is not a shared strategy for scenting, one boy (Aslan 3) has a clear plan, but it's not clear that this is shared with the others. There is no production of a shared representation through a list or a map. When asked if they have a strategy, the answer given is "nope" (although later observation on the field suggests that individuals have developed their own implicit strategies that are not shared with the others).

Group 4 (Thursday afternoon)
Five of the children go directly to the toys to plan strategy. Then they separate out and four children (three girls, one boy) create an imaginary Savannah map on the floor with a list of different habitats they are likely to need. They discuss how they will distribute their sprays and decide which areas they will need - eg rock, grass, water. One girl more separate from the others, reading on her own and then watching a video. There are comments to each other about what research they should be doing and what they should be finding out - movement to books and cribsheets and laptop. There isn't a coherent plan, but different children offering different plans at different times. All have read the crib sheet. Map-making group reconvene around a notebook to make a list for going outside.

Group 5 (Friday am)
This group all go to use the internet as their primary resource in the first instance. They are them prompted to think about using other resources and KFw prompts them to think about what might be in the Savannah. Two boys and a girl then move to the floor to look at the books, with KFw talking to them. [Missing data due to technical fault.]

Group 6 (Friday pm)
Initially, five children go to the computer, one boy picks up a crib sheet and is reading it. The children on the computer are looking up information about lion habitats. There is some discussion of whether a leader is needed on the team. They create a list of areas they will need in their territory on the flipchart and each child writes their own names next to these. They then discuss how to use their sprays and have a conversation about which areas are essential and which less important. They then all read the crib sheets.

What was clear from the outset was that different groups brought with them different levels of expertise in collaboration - some groups were able to listen to each other and share ideas, other groups were characterised by conflict and isolation of particular individuals, other groups divided labour and adopted 'cooperative' rather than 'collaborative' approaches. In one group (Group 4) we had to intervene and set rules for discussion - whoever held the toy lion would be able to speak at any time.

3.5.2 Strategies for decision making

The most common approach to decision making was the constant proposing of one option, followed by either a counter-proposal or an addition to the original. The children often did not articulate why one approach may be better than another, but simply 'piled up' strategies in conversation until one was agreed upon:

Dandelion 4:   *Hey hey I found food*
Simba 4:   *What food?*

Dandelion 4:	*Giraffes*
Simba 4:	*Huh, we want giraffes, we want giraffes. We get giraffes*
Dandelion 4:	*Hang on let's see what's down there. All this yellow bit there's probably food down there. And that's buffaloes*
	[...]
Mufusa 4:	*Me,* [Aslan] *and* [Dandelion] *will go there*
Dandelion 4:	*We'll have buffaloes. We're having the buffaloes*
Mufasa 4:	*Yeah what about there?*
	[...]
Mufasa 4:	*Hey I've got it*
Dandelion 4:	*There's gazelles*
Mufasa 4:	*Listen a minute*
Nala 4:	*We know*
	[Lots of talking all at once]
Mufasa 4:	*No listen right. Me,* [Aslan] *and* [Dandelion] *will hunt not gazelles, but the* [inaudible]. *You three will hunt the buffaloes... Can you listen to me?*
Nala 4:	*All just shut up a minute and listen to* [Mufasa]
Mufasa 4:	*Me,* [Aslan] *and [Dandelion] will hunt for... we will go in, in that space* [pointing on IWB]. *And you three will go here, right and once we've all done that we'll all group together and go for the giraffes*

When there was a clear difference of opinion, some groups simply moved away from the topic under discussion, while others decided to vote on a strategy. Both of these options remove the need for reasoning and discussion of the merits of different actions.

In three of the groups (3, 4, 6) one child, often slightly detached from the rest carrying out their own research, tended to have some degree of authority amongst the group. Their input could also close down, or finalise a decision. There were also a number of different roles adopted by different children in the groups - some were actively encouraging other children to participate, others liked taking control, others were simply happy to be told what to do.

Finally, the question of gender played a significant role in decision-making as almost all groups decided to split labour into boy/girl activities (the exception being Group 4, who split into two groups seemingly dependent upon the age and height of the children). Although the game neither specified the need to hunt in two groups, nor any benefits to hunting in gender groups, and all the children were acting as lions of the same gender, the children seemed to bring to the game cultural expectations of division of labour into sub-groups organised around gender. This was contested at various points as the demands of the game to hunt in a larger group (or to act as individuals) meant that the children could not accept this gender split as unproblematic (particularly by the time the children had reached Level 3).

3.5.3 External representations

The most effective strategy for developing a shared plan of action, and for debating that plan of action, was the creation of shared external representations which enabled all children to both visualise their planned actions and reflect upon these. All of the groups (with the exception of Group 3 who only created a map for the final level, and this only at the instigation of Kathy, and only for the purposes of copying from the den interface the locations of the prey animals) created some form of external shared representation.

For Level 1, the limiting of scent markers was successful in encouraging children to consider the different choices open to them and the need to develop effective division of labour in the

field (again, with the exception of Group 3). Two strategies were observed here. Groups 1, 2, 4 and 6 created lists of areas and assigned different children to hunt for different areas. Group 5 simply divided up the area and gave each child the responsibility for scenting different parts of the terrain. This suggests two strategies, the first is directed at the content, the second (more appropriate for the game design but perhaps not ideal in terms of what we were wanting the children to think about) focuses on the territory as space that all needs to be claimed. This 'list system' helped the children decide how to assign roles and share responsibility for a joint goal.
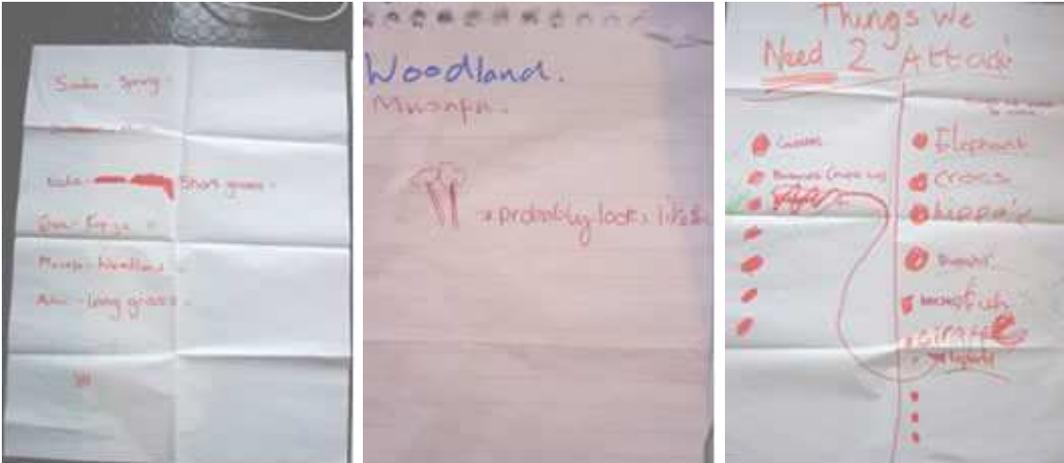

Group 6: Level 1 list; Mufasa's personal list for Level 1; Level 2 list of animals to attack and avoid

For Levels 2 and 3, the different groups adopted different strategies in their map creation. Some were spatial (involving the creation of maps of different safe and dangerous areas) others were focused on particular 'targets' (involving the creation of lists of different potential prey animals).

Personal representations from group representations:

At Level 1, Group 6 had created personal lists and images to take out into the field to remind themselves of what they were looking for. At Level 2, children in Groups 2 and 6 created their own hand drawn maps (copies of the group map/list) to take out into the field with them. Groups 3 and 4 only adopted this strategy of developing hand held maps by Level 3 (Group 3 after receiving prompting from KFw). Group 6, by the third level had developed a number of different hand held resources, including maps and lists of animals to attack and avoid.
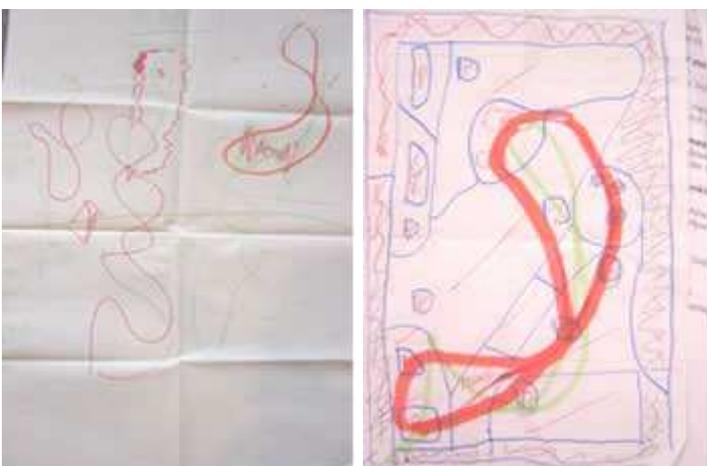
Group 6: Level 3 group plan; Aslan's personal plan (with boys & girls routes marked on, and areas of danger and food)
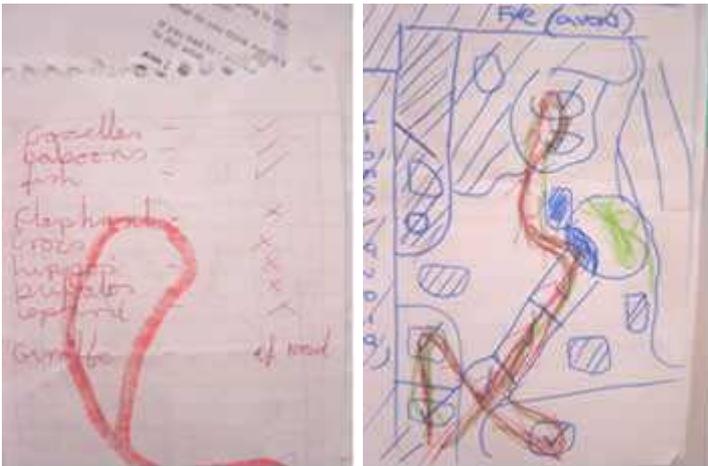
Group 6: Aslan's list of dos and don'ts; girls route plan

Shared representations in the field

While some of the earlier groups suggested that they had tried to mark the location of particular animals/habitats on the field using their feet to scuff a mark in the ground, Group 6 took this external representation of the Savannah field significantly further. Instead of simply relying on maps, the children decided to create a stable representation of the virtual world through physical objects. The genesis of this idea is interesting. In Level 2 play outside we see Simba standing and scuffing the ground where he finds an antelope. In Level 3 preparation two boys are discussing the different variables they have to manage to succeed in the challenge. Having realised that water is important to them, and that, unlike the animals (they believe) the water is likely to stay in the same place, they think about marking the location of the water, this is then expanded to discussions of marking the location of the rough areas of 'good hunting'.

Simba 6:   *I know, let's get loads of bits of paper and then when we find the bits where there is good hunting we can put them down*
Simba 6:   *Each of us will have a piece of paper*
Aslan 6:   *With a map on?*
Simba 6:   *No, they'll have something on them, water or good hunting or something, and then we can put them down when we find something special and then we'll remember where it is*
Aslan 6:   [now joins in and takes the idea as his own] *So we all put it down where the water is, so we can all find the water and claim it for our own*

They then discuss with Kathy whether they could use the toy animals to mark outside, she suggests these might be too small to be visible. About ten minutes later they start a conversation with ND about what markers they will need. The conversation highlights their priorities:

Simba 6:   *Have you got the markers for us?*
ND: [explains what they've got] *How many do you think you'll need?*
Aslan 6:   *One for water*
Simba 6:   *One for water*
Aslan 6:   *We'll need about three*
Simba 6:   *One for water and two for food*

Aslan 6:	*But there's lots of food*
Simba 6:	*We need quite a lot of ones for food*
ND:	*You know you only get about ten minutes out there*
Simba 6:	*Well certainly one for the waterhole*

Interestingly, the boys never really get the girls' attention to explain their plan for taking objects into the field - they mention it to them, but the girls pay little attention, even though they take up the idea later in the game.

In the field, the children all carry out objects that they will use to mark the field to show themselves and other players where particularly desirable areas of the savannah are. These external representations allow the children to supplement the other collaborative techniques in the field (such as shouting to each other) and also enable independent collaboration (ie not time dependent, one child can leave a marker for another to pick up later). For example, Simba 6 takes it upon himself to find the water and mark this for the rest of the players.

> [The boys are all in different places in the field with Simba 6 on a mission to mark out the water. He's talking to himself: 'Where's the water... Where am I? Oh, I know where I am' and then he places the blue plastic box on the floor. 'I think I'll have a little drink' he says, then runs back to join the other players. At which point A heads off to the blue plastic box (water) and is drinking. Simba 6 to Mufasa 6 - 'the water's over there'.]

As it was Simba's idea, it's not surprising that we see him maintaining this strategy throughout the play. For example, he tries to use other people's markers that have been left, and then moves them when he finds they are incorrect:

Simba 6: *I'm getting dangerously hungry, I can't find anything to eat, has anyone found anything to eat yet? Wait - what's that sign?*
[running over to where a box has been left on the field. He goes over and stands next to it and obviously tries to attack something. Seems like he fails because he says 'oh great' sarcastically and picks up the box and moves it away. He then picks it up and runs with it, saying 'I'm almost dead' 'Go away' (exasperated) then finds somewhere and places the box and says 'yes!', then attacks something and say 'yes?'... breathing hard... 'phew... that's ok, now I can just keep walking around here and see if I can find any gazelle... Urgh, humph...' Sings under his breath, walking around in circles around the same area... 'OK, there doesn't seem to be anything there any more...' He then

looks up and sees a pole one of the other children has placed in the ground, 'what's that?' he runs over to it 'ah, it must be a river' he says and walks on; he keeps singing under his breath. Then, to another child, 'I was on the brink of starvation just then!' as he walks over to another box laid on the ground. 'Mmmm', he says, 'OK, so that's a box... What's this?' Mufasa 6 comes over to where Simba is standing next to a white plastic object on the ground. Mufasa 6 says 'I think it's a bit of rubbish...']

The other children, however, all also take responsibility for marking. Aslan 6, for example, placed poles next to the lake and the catfish, which effectively guaranteed the pride's survival for the whole of Level 3. The girls too see a responsibility in placing boxes where they have attacked food. In fact, they placed the cardboard box that Simba finds in the extract above.

This strategy seems to be particularly effective form of collaboration. It has two downsides: the first is that animals may disappear after having been eaten (which the children don't take into account), the second is the nature of the objects chosen (which can blow around in the wind or be mistaken for rubbish - see example above).

What the strategy enables, however, is a focus on the process of hunting and survival rather than searching for particular areas/food. It also enables the children to pool their shared understanding effectively, by allowing lessons learnt by one player to be permanently 'logged' for others to benefit from.

3.5.4 Communication on the field

Communication on the field is characterised by shouting, chatting and organising (and abuse):

In the field children shout to each other across distances. These shouts are usually calls for other children to join them in an attack, to let other children know that they have found food or water, or warnings of an impending dangers. All the groups seemed to automatically adopt this behaviour, providing help and support to each other at a distance.

Children also join up in smaller groups, in these groups of two or three the children often chat together to compare how well they are doing (how many sprays left, what hunger levels etc). They recount experiences ("I was nearly dying" etc). They discuss what other children are doing and whether to join them or not.

Communication on the field is also characterised by organising behaviours - when working in groups for attack purposes, for example, children often give instructions to each other, directing where other children should stand, using repeated phrases such as "one, two, three, attack" to organise attacks.

Communication in the field, at the earliest stages, often involves children providing help and

advice to each other. Children show each other how to use the PDAs, they explain different features of the screen, and they help to explain issues of confusion.

At various points, communication in the field is also characterised by abuse. When children see themselves as being in competition with each other there were moments of heated exchange, in one instance resulting in one boy calling another girl a 'bitch'. These moments of abuse weren't discussed later by the children, and in some cases were seen as 'just playing the game', but the ill-feeling they generated was referred to in the debrief interviews. (I'll come shortly to the tensions between collaboration and competition in the game design.)

3.5.5 Collaboration in the field: from planning to play

Level 1: from planning to play

At Level 1 we saw most groups stick closely to their plans created in the den. The children who were assigned particular objects to scent, searched these out in the field, the children assigned particular areas of the field to scent, stayed within these areas. On the field, however, they soon found that they had enough sprays to be slightly more profligate than they had planned and proceeded to adopt opportunistic spraying techniques by spraying any area that was unscented (once they had found their target areas). At the same time, while out on the field, the initial excitement of entering the Savannah sometimes led children away from a focus on their task to exploring features of the Savannah that they found exciting or surprising. The following summarises the strategies of three groups (3, 4 and 6).

In Level 1 play on the field it was clear that the boys in Group 3 (Thursday morning) had developed a plan that was not apparent from their den conversations, and that this wasn't shared with the girls. The girls went round spraying indiscriminately, with little discussion of what they were spraying or collaborative techniques, simply comparing the number of sprays they have left.

Dandelion 3:   *Shall I spray?*
Elsa 3:   *If you want, I sprayed that one over there*
Dandelion 3:   *Shall I?*
Elsa 3:   *You got one left! I got three*

One of the boys, on the other hand, seems to have developed a plan for walking round the boundaries of the space and scenting the edges of the territory, which the other boys adopt during play, only when they have done this do they enter the middle of the field. The boys also had an idea of which areas they needed, what might be in them and a sense of being frugal with their sprays. They took it in turns to spray particular areas one by one:

Mufasa 3:   *Someone have a pee, someone have a pee, there's water! There's water!*
Aslan 3:   *I pressed, I pressed*
Mufasa 3:   *OK let's go*
            [...]
Simba 3:   *What've you got?*
Mufasa 3:   *Uh, pee on it*
Simba 3:   *It's long grass, it's where there'll be hyenas and shit*
Mufasa 3:   *You pee on it*
Aslan 3:   *You pee on it*
Simba 3:   *You don't pee on this*
Mufasa 3:   *How many pees have you got? Three... how many pees have you*

	got? Three - right, you pee on it
	[...]
Mufasa 3:	*Water, yeah, water, we need this*
Simba 3:	*Yeah, spray, water, we need water*
Mufasa 3:	*Yeah, spray* [Aslan] *spray, you've got three*
Simba 3:	*Go in the middle, go in the middle*
Mufasa 3:	*No, let's go round the outside first*

The difference in attitude and understanding of the purpose and collaborative nature of the task between the girls and boys is evidenced in this exchange at the end:

Mufasa 3:	*What did you get?*
Elsa 3:	*What do you mean - what did I get?*

Group 6 (Friday afternoon) showed very different strategies for collaboration on this level. Before going out they had clearly defined areas to target for spraying and on going outside they hunted for these.

Aslan 6:	*I've found my area*
Mufasa 6:	*Mine's over there*
	[...]
Aslan 6:	*We've got quite good areas*
Mufasa 6:	*Let's go and stand there... this is the best place... I've done this bit*
Aslan 6:	*Oh, this is all marshy - I've just sprayed it... oh, there's a spring which we haven't sprayed*

This group had some trouble with the technical aspects, accidentally using up sprays, that detracted from their plans. Despite this there was evidence of them splitting up to focus on different areas, and then coming together to discuss what they had done and how effective this was. We also saw examples of them deciding how to respond to areas they hadn't planned for in the den:

Elsa 6:	*Shall we spray in the human place? Shall we spray in the human territory*
Aslan 6:	*No* [definitely] *cos they're hunters*
Mufasa 6:	*Actually we could*
Aslan 6:	*We could but they'd hunt us*
Mufasa 6:	*I don't think they'd hunt us*
Aslan 6:	*We could probably kill one but then they'd kill us*

Group 4 shows a different strategy again. They start off having a list of areas that they want to spray, although without assigning children to particular places. Much of their initial time out on the field is spent figuring out how the spray system works and tentatively coming to understand the choices they have open to them about spraying, with Dandelion having quickly figured out how the game works, and the others coming to her for help:

Elsa 4:	*I can't see anything. I can see water - shall I spray it?*

Dandelion 4:	*I sprayed it, don't worry*
Elsa 4:	*I see this desert thing. Let's spray. It won't work*
Dandelion 4:	*You've already sprayed*
Elsa 4:	*I've found the ground, shall I spray it? I've found this place, shall we go here?*
Dandelion 4:	*Don't waste too many sprays*

This group, however, rather than sticking to a predetermined plan throughout the level, come together in the middle of the field to discuss how they are doing, and then split up again to go about claiming the rest of the field individually (with the exception of Mufasa who is running forwards and backwards across the field screaming for much of the level). When given one minute's warning they all split, running, to look for unsprayed areas.

The importance of understanding the PDA interface for this collaborative task was brought home when Group 4, who had not been told that a red paw mark would indicate that an area was already sprayed, had little success at this level. As a result of not understanding this symbol they sprayed the same areas multiple times. This emphasises the importance of the design of the interface in encouraging particular collaborative strategies.

Only one group decided to repeat Level 1 (Group 4), so it is only with this group that we can examine the extent to which they developed different approaches to the problem on a second attempt. On the second time out they have a clearer understanding of the task in hand, but also, notably, they have come to some understanding of how they need to work together as a group, and there is evidence of them providing advice to each other, comparing areas of coverage and avoiding areas of danger. The following is taken from the case study notes:

[case study notes begin]

Group 4, Level 1 replay

As and Mu stay together again; Nala and Simba team up; Initially, Dandelion and Elsa go off alone. They soon coalesce into two groups of 3 and cluster around the top half of the field. They get good coverage of the field quickly, but spray the river - perhaps understandably since they have identified that water is important. There is, however, less straying into the Masai village or into other lions' territory.

The group are much more systematic this time, recalling where areas are and searching for them methodically and by asking others if they have seen them.

Mufasa 4:	*This way!* [...] *Hey you guys*
Aslan 4:	*Lionk*
Nala 4:	*Run away then go to the rock down there*
Mufasa 4:	*Where is it?*
Nala 4:	*Down there*
	[...]
Mufasa 4:	*One of us has sprayed down here already.* [Aslan], *whatever you do don't spray down there*
	[...]
Mufasa 4:	[Dandelion], *I can't find the rock*
Dandelion 4:	[inaudible]
Mufasa 4:	*It's not that one though*
Dandelion 4:	*It's the second one. I sprayed there coz you never went there*

Elsa and Nala also work together, with Nala essentially operating as Elsa's tutor.

Elsa 4:	*Where? Here?*
Nala 4:	*Here. Spray*
Elsa 4:	*Those trees*
Nala 4:	*Yeah you've done it now, go*
Elsa 4:	*What should I look for now?*
Nala 4:	*Just go round and look for things*
Elsa 4:	*OK*

Throughout, Dandelion and Elsa consult Simba and compare where they've sprayed. Whether Elsa has forgotten or not taken on board the fact that a red pawprint displays in sprayed areas is unclear - but she almost constantly asks others if they have sprayed areas that she is in. When she has used all her sprays she marches straight off the field and decides to stay on the sidelines until the others have finished.

Mu seems to have taken on board warnings from the previous attempt, and shouts to the others not to approach the borders of the territory, "or we might be killed". Dandelion also recruits As and Mu to join her to spray the bottom half of the territory as she has run out of sprays herself. She particularly encourages As to help her spray specific areas that she cannot. Nala also recruits Mu to do some spraying, saying "I'll show you where it is".

Most of the group also frequently begin asking each other if they have sprays left, and Nala and Simba specifically encourage others with sprays left to help them. Dandelion, who has finished spraying, has dropped off her bag but returns to the field and helps As to identify some areas for spraying - both guiding him with her arm and looking at his PDA with him. When Mu runs out of sprays he too drops off his bag and returns briefly to the field to help the others.

At end of level they have sprayed 17 of the 20 areas available.

[case study notes end]

Levels 2 and 3: from planning to play

I'm combining Levels 2 and 3 in terms of exploring children's shift from planning to play as the challenges at these levels were to all extents and purposes the same: avoid death, gain energy from hunting, reduce hunger (and thirst). In terms of planning, the primary discussions in preparation for both levels concern hunting strategies, specifically, the number of lions that will be required to 'take on' any other animals, and the likely location of prey animals. Most groups decide to split into two groups of three (for various reasons, some better articulated than others) with some groups allocating specific areas for each group to hunt in. On the first attempt in the field, however, we usually see this distinction and plan crumbling. Group 4, for example, as soon as they enter the playfield, become distracted by the first food that they can find and by immediate dangers of lions and the river and when they find food start to attack individually. Group 6, on entering the field for the first time can't find any animals and their plan is immediately under threat as they are tempted to head off individually to look for food.

Simba 6:	*OK, so we're attacking the top ones aren't we? OK, so who's attacking the top ones and who's attacking the bottom ones?* [to the girls as they go past]
Girls:	*We are*
Simba 6:	*OK, so who's doing which ones?*

Aslan 6:	*We're going round the middle*
Simba 6:	*Are we doing the top one or the bottom one*
Aslan 6:	*We're going round the middle*
Simba 6:	*Right, it's here then isn't it?* [pointing right]
Aslan 6:	*No it's here man, past the ditch*
Simba 6:	*Well I can't see any animals*
Aslan 6:	*This is where it's meant to be*
Simba 6:	*Well let's split up until we find something*
Mufasa 6:	*Why are we splitting up?*
Simba 6:	*We're trying to find something... anyway, that's in our plan... who says there are loads of animals out here anyway...*
Simba 6:	*Right, we've got to the place we're supposed to be now*

What seems to happen is that the challenge is more difficult than the children expected: they have trouble finding food, they haven't thought clearly about what animals they can attack. The pre-planning they carried out is overturned in favour of opportunistic attacks as they come across food, their plan to stick to groups is often overturned by the need to split up to find food. Both of these strategies are fairly sensible as a means of coping with the environment for the first time. Their shared ideas about how to proceed are frustrated by the environment and require revision. Different groups cope with this differently. Some descend into anarchy, with children heading off in different directions in an 'each man for himself' strategy, while others attempt to stick to plans while having little success. The more usual approach is a mix between individual action and calls across the field for other children to join an attack.

We can see in the children's second attempts at Level 2 and move to Level 3 the development of collaborative techniques that match appropriately the children's understanding of the rules of the game. On returning to the den after first attempts outside, we see frequent discussions of how effectively they worked together. The children discuss what they did well and badly, and the most effective strategies for working in the field again on the next level. The discussions of collaborative techniques tended to focus on their effectiveness of working together in attacks:

Mufasa 6:	*Look look - she attacked the Messiah* [sic]
Mufasa 6:	*Me and Mufasa attacked the elephant and then died*
Aslan 6:	*We'd have got it if we'd been three*
Simba 6:	*It wasn't my fault*
Aslan 6:	*It was totally your fault, if we'd have been three we'd have killed it*
Simba 6:	*If all three of us had been attacking it...*

Nala 4:	*What we didn't think is like, if it was an elephant we need something, like, it needs more of us to attack it*

There are also discussions of what animals to attack and which to avoid (in particular by the time they reach Level 3) and which locations to hunt in. All groups (except Group 3) create relatively detailed plans of which areas to hunt in and how the different groups will operate in the field (usually with an understanding that they will all come together to attack larger animals). These groups create large maps to highlight hunting areas, and lists to highlight desirable animals, these larger maps are then translated into smaller maps for reference on the field.

What emerges, however, is often less a preplanned collaborative approach to the challenge than a loose coalition of children that forms and reforms depending on the animals that the children encounter. There is rarely a strategy to target specific larger animals as a whole team although decisions taken in advance to attack particular animals and avoid others are usually adhered to on the field by all members of the group. The children tend to create parameters for their interactions with each other within which they expect to achieve success, for example, 'avoid elephants', 'call others if large animal' and so on. Two very different strategies are exemplified by Groups 3 and 6.

Group 3's collaborative planning in the den was minimal. By their second attempt at Level 2 they had reached the idea that working in a large group might mean that they could attack the larger animals but they had not created any shared plan to which all players could agree. Immediately they entered the field the suggestion that had been made, but clearly not agreed, to stay together as a large group, was ignored by most of the players, except one who valiantly attempted to reinforce it:

Elsa 3:   *Aren't we supposed to be going in a six?* [Simba]? *You lot? Come*
                 on [Simba]? *We're supposed to be going in a six though... if we*
                 don't go in a six we won't get bonus points though... [Nala, Aslan,
                 Mufasa]! [calling the others]
                 [Nala, Aslan and Mufasa have set off on their own; E's attempts
                 to get the whole group to work in a six failing miserably as
                 Dandelion and Simba also head off in a different direction]
Elsa 3:   [Nala]?*... you two stand still a minute?...* [walks over to Nala]
                 we're supposed to be going in a six, my earphones keep falling
                 off... I'm going to get hungry in a minute... Right, let's get
                 them... [Nala], *go up to them* [to Dandelion and Simba]
                 [Elsa 3 basically then gives up and is in the field on her own. The
                 others all now down the end of the field. She is standing on her
                 own, looking at her screen and attacking something. She then
                 keeps walking round in circles to try to find it. Then walks off
                 down the field again to join the others...]
                 [...]
Elsa 3:   [Nala], *stop going off, we're supposed to go in a six*
Nala 3:   *Yeah, but I keep going off to find something - and that lot're*
                 going off
Elsa 3:   *Yeah, but I'm trying to put everyone together...*
Nala 3:   *I gotta find some food and quickly*
Elsa 3:   *My earphones keep falling off - hold that for me again*
Nala 3:   *I gotta find some food cos otherwise I'm gonna die... I don't*
                 wanna die do I?
                 [N walks off on her own]

In the den debrief after this session ND and KFw encourage the children to listen to each other. They suggest that listening to Nala and Elsa would be a good idea (who were calling the others for a hippo attack and to work as a group). Despite these suggestions there is little discussion in the den of how they will work differently next time, other than the desire to hunt for different animals. By the third level, however, they have been encouraged to create a map. This map, which Elsa carries, seems to shift the balance of power as she has a resource that encourages the others to listen to her. KFw and ND's comments in the den also seemed to have reinforced to the children the idea that they should work together as a full group. As a

result of these two factors, the group start off walking around together and consulting the map as a group, anyone straying off on his own is brought quickly back to the others.

> [Mufasa 3 heads off up the field on his own
> Aslan 3 joins him 'we gotta stay together']

Mufasa 3:   *Yeah, well, I'm hungry*

Aslan 3:   *But the deers are that way*

Mufasa 3:   *They are?*

Aslan 3:   *Yeah*

Mufasa 3:   *Oh, for crying out loud, where are the deer then?*

> [Both boys then walk over to Elsa and look at the map and she
> makes suggestions of where they should all go]

This decision to stay in a group leads to the successful attack on the hippo mentioned earlier. This does not lead, however, to the decision to subsequently continue to hunt as a pride as they split up to look for other animals (notably in closer proximity to each other than they were before however).

In contrast, Group 6 develop a completely different strategy. Their first strategy at Level 2 was to adopt the 'divide and conquer' strategy of Level 1, by splitting out across the field to cover different areas. This strategy failed spectacularly as only three of the children survived the first attempt. On return to the den they were encouraged by KFw to think about how they expended their energy, she suggested that they listen to each other (particularly Aslan) and encouraged them to think hard about avoiding attacks on animals that were too large. This led to complex discussions that linked their earlier location based strategy with a focus on individual animals. They still stick to the idea of going round in two groups of three:

Aslan 6:   *OK, so we redo the level*

Dandelion 6: *Yeah, but what are our tactics...*

Aslan 6:   *We all go together*

> [They are then clicking on things on the whiteboard. Dandelion 6
> suggesting that they go in two groups - and assigns what people
> should attack]

Aslan 6:   *We should all go together, up there*

Dandelion 6: *What do we all attack the small ones?*

Nala 6:   *But there's more food downstairs, down there*

Simba 6:   *We could all attack the weak ones, all attack the weak ones*

Mufasa 6:   *If we all attack the weak ones then we'll have enough*

They also reflect on their previous strategies and emphasise the importance of sticking with the plan they had prepared, generating 'loose rules' for action:

Mufasa 6:   [now pointing at the bottom of the map] *'Cos last time, right, you
            said you were going to do there... but you didn't* [he's right, that
            was the area of the map they'd decided to attack in - Nala's map
            that they didn't reference, it seems]

Elsa 6:   *Make sure that you stay in the places that you planned*

Aslan 6:   *But we didn't know where you were going to go last time*

Nala 6:   *It doesn't matter if it's top or bottom, let's just separate it out,
            each stick in a particular area*

Simba 6:	*Let's just look for anything that's smaller and close to the camera*
Elsa 6:	*And we've got to stay on the right side*
Simba 6:	*And if we see anything that it looks like we can't attack, let's just run away from it*

In the field this group stick to their plan, staying in two groups of three and attacking small animals. Halfway through in a bizarre moment of chivalry, the boys decide to go and join the girls to help them as they think that they'll be struggling.

Back in the den between Level 2 and Level 3 there are a number of overlapping conversations that focus on the use of physical objects to mark space, the question of what lions can actually eat, how to combine hunting and drinking, what strategies to use on the field. There are moments of tension between the boys and the girls in the den discussions:

Elsa 6:	*You guys, we need to put all our ideas together cos otherwise we won't make it*
Elsa 6:	*OK, so what's your ideas*
Mufasa 6:	*Not much*
Elsa 6:	*You must have something*
Simba 6:	*Don't attack the bad stuff*

This improves slightly when Aslan offers some information - saying that he's found a river:

Elsa 6:	[Aslan], *don't make too many plans, cos we've got ideas too*
Aslan 6:	*Yeah*
Elsa 6:	*We'll just watch this*
Aslan 6:	*I've found a river*
Elsa 6:	*Where*
Aslan 6:	*It's just near the entrance*
Elsa 6:	*Let's see?*

There is some discussion about whether to work as a large group, or to split up and operate as individuals. Simba 6, who seems to have the most authority in the group, decides that they should all work separately "so we can get lots of different things". The group then decide to use the markers on the field. This group's adoption of physical markers is a way of sharing group expertise while allowing individuals to operate on their own. On the field we see this working as planned, although the girls seem to prefer to work with others. Their strategy is diametrically opposed to that of Group 3, being a loose coalition that allows the children to work together when necessary, but act primarily as individuals.

3.5.6 Individual vs group tensions

These different strategies for working individually or in a group can be seen to arise from tensions embedded within the game itself which saw children having to negotiate the competing demands of keeping themselves alive as individuals and working to support the needs of the whole group.

There were various features of the experiences that led to this tension. First, some children found themselves penalised for collaboration. Having called someone over to help attack an animal, some children found their food being eaten by their team-mate, usually as a result of losing the image themselves (see examples in previous section under 'irritations'). We heard frequent references to children taking food from each other and on several occasions we saw

children deciding subsequently not to tell others when they had found food.

Second, the benefits of group attacks weren't sufficiently clear. Children were learning that attacking some large animals not only didn't benefit them, but killed them (elephant), while attacking others was of benefit (hippo). It was difficult for them to distinguish between these and therefore the tendency was to operate individually with 'achievable' animals (which may be an appropriate lion strategy). At the same time, the points system did not clearly identify to the children the relative benefits/costs of attacking different animals.

A third tension was generated by time pressures. Individual children felt under personal pressure to ensure that they didn't die, and as a result rushed into attacks without waiting for others to join them. We often saw a significant tension between children wanting to attack and other children struggling to get the picture on the screen to allow a joint attack. These situations often saw one child go ahead without the others even while knowing that this was a risky decision to take.

Given these difficulties, and the lack of clear benefits from developing a whole group strategy for attacks, it was unsurprising that most of the children developed a loose coalition strategy for survival. It should be said that this in itself is an admirable collaborative technique. However, if we were wanting to encourage children to plan whole group activities and operationalise these together, the current structure for the game mitigates against this.

3.6 Learning and understanding in Savannah

3.6.1 Evidence of children's acquisition of knowledge through playing Savannah

This section will highlight only those features of the Savannah experience in which we can see clearly documented shifts in understanding or acquisition of content knowledge.

Understanding other animals and hunting strategies

In some instances, we can see examples of the children acquiring vocabulary through the feedback on their attack strategies. Children, seeing an animal that they don't know the name of, for example, would on receiving an error message start using the appropriate name for that animal.

Mufasa 3:   *I've found a monkey, die monkey... I'm attacking a monkey*
Mufasa 3:   [after reading from screen] *Oh yeah! I attacked a baboon and it was successful...*
Aslan 3:   *This is getting really annoying*
Mufasa 3:   *I gotta baboon!*

Although this did work in reverse for one group, the girls in Group 3, who started off calling antelopes antelopes, by the end of the experience grouped all antelope, dik dik and others together under the heading 'deer things'. The children, however, had come to expect this feedback after attacks:

Mufasa 6:   *Mine was successful*
Simba 6:   *All of you were scaring it away... it didn't even tell me what it was*

With each group we saw examples of children coming to understand particular features of the game environment through making mistakes, suffering for these and avoiding the cause of the mistake in subsequent actions. These were usually related to the types of animals children

decided to attack, and the strategies adopted for attacks. Most of the groups, on completion of the game, had an understanding that larger animals and humans posed a threat to a group of lions. There are numerous examples of this type of learning, usually triggered by failed attacks.

	[Aslan 6, Mufasa 6 and Simba 6 all attack an elephant on their first attempt at Level 2]
Aslan 6:	*You have failed in your attack on the elephant* [reading] [They all attack again]
Aslan 6:	*Your attack failed, you are dead* [reading]
Simba 6:	*OK, my attack on the elephant failed... we need to find something else*
Mufasa 6:	*My attack on the elephant failed, I am dead... go to the entrance* [reading from screen]
Simba 6:	[moves off on his own and talks to himself for a while] *Come on little animals... not elephants. I don't like elephants, elephants kill me.* [Aslan] *and* [Mufasa] *died because they attacked an elephant... phew... hate elephants* [The girls shout over to him asking if they can work with him. They all see an elephant and scream and run away]

Elsa 3:	*Wait, what's this? Bees?*
Dandelion 3:	*Bees, attack, you can, quick*
Elsa 3:	*I'm still attacking... oh, flies, failed*
Simba 3:	*Flies?*
Elsa 3:	*Don't attack them, it'll just fail* [...]
Dandelion 3:	*Shall I attack these?*
Elsa 3:	*No, it doesn't work*

Mufasa 3:	*I've got an elephant, I've got an elephant, four people* [holding up four fingers] *four people*
Elsa 3:	*Attack it, attack it, cos we'll need help*
Mufasa 3:	*Come on everybody* [...]
Mufasa 3:	*Oh no, your attack on the elephant failed!*
Dandelion 3:	*It's cos we should have all attacked at the same time*
Mufasa 3:	*OK, all together* [...]
Mufasa 3:	*Your attack failed... OK, let's leave the elephant alone*
Aslan 3:	*I've got the elephant*
Mufasa 3:	*NO, LEAVE THE ELEPHANT ALONE!* [At the second attempt at Level 2, there is this exchange]
Mufasa 3:	*Ah, elephant!*
Aslan 3:	*Don't attack the elephant!*

Mufasa 3:   *I know, do you think I haven't established that?*

This sort of learning was reinforced in the den. After each attempt at Levels 2 and 3 KFw would reinforce to the children that they have choices about what animals they attack, that there were limits to animals that could be 'taken on' by lions, and that attacking different animals led to different levels of expenditure of energy. By the final level most groups were making lists of which animals to avoid and which to focus their energies on:

Dandelion 6:   *OK, so you guys all attack the weaker ones... and we don't attack*
               stupid elephants
Nala 6:   *Or people*
Dandelion 6:   *Or hyenas*
Simba 6:   *No people, elephants or hyenas*

The children, however, came to different conclusions about why their attacks failed for different animals. Some suggested, for example with the elephant, that they simply needed more people (as only two or three of them had attacked together). Others generated little or no discussion about why their attacks had failed and simply learnt to avoid animals that had caused them harm in the past. In some groups, one or two children had understood the need to conserve energy, while others hadn't:

Elsa 4:   *It failed*
Nala 4:   *Failed*
Simba 4:   *I told you, let's go*
Elsa 4:   *My energy*
Simba 4:   *Mine as well, did your energy go down?*
Nala 4:   *Doing the elephant made it go down*
Elsa 4:   [inaudible] *stupid... it's your fault*
Simba 4:   *Whoa, a leopard*
Nala 4:   *What?*
Simba 4:   *I had a leopard*
Elsa 4:   *It doesn't work*
               [...]
Nala 4:   *Buffalo*
Simba 4:   *Buffalo! Attack!... I've attacked. Attack, mate, attack*
Elsa 4:   *It won't work. It's a waste of energy*
Simba 4:   *How do you know, we're all attacking it now*
Elsa 4:   *So? We done it to everything - failed... Oh, my energy - we're*
               dead! [Elsa and Mufasa both died attacking the buffalo]
Nala 4:   *I haven't attacked it, I got to get some water, some food*
Elsa 4:   [pointing at Simba] *It's your fault*
Simba 4:   *How's it my fault? We didn't say you had to attack*

In other groups, some children had clearly learnt little about which types of animals were likely to be appropriate prey:

Elsa 6:   *Let's go right to the fire, there's things like leopards there*
Boys: *We don't need leopards*
Elsa 6:   *But leopards is food*

A subsequent failed attack on the leopard for this girl, however, did lead to her commenting in the final interview that the most effective plan for playing was to go for wildebeest and deer.

Other children had come to develop accurate theories of how the environment would operate and had learnt to predict the success and failure of particular hunting strategies:

Mufasa 6: *Will we go and help* [the girls] *if our attack is successful?*
Simba 6: *Yeah, if its not... well, it probably is, cos wildebeest are easy to kill... yeah... we always win a wildebeest*
[...]
Simba 6: *Yeah, let's attack them over here*
Mufasa 6: *Yeah, wildebeest, they're always successful*
[...]
Simba 6: *I've found a crocodile... Oh no, I attacked a crocodile... I bet I failed* [a buzz on the screen] *yep, bet I'm dead now*

The best and the worst that can be said of children's understanding of lions' hunting strategies after playing Savannah is that it involves a recognition that hunting is a question of numbers. By the end of playing most of the children had developed a conceptual understanding that hunting strategies were a 'numbers game' and that they had to weigh up the size of the target animal against the number of lions that they had. There was also some preliminary understanding that there was an energy cost to attacking particular other animals (such as flies) although this tended not to be discussed as the children simply learnt to avoid dangerous animals, or those that served little purpose in terms of energy.

What became clear through the analysis was that children were focused specifically on understanding only those aspects of the Savannah that directly related to the rules of the game and that the underlying games rules themselves sometimes failed to support their understanding. It wasn't necessary, in the game, to understand why attacking particular animals was risky or gained them little in the way of points, it was only necessary to identify these as dangerous and avoid them. At the same time, it wasn't necessary for the children to understand why particular animals were 'good targets', simply that they proved to be a good hunting strategy. Group 6's almost total reliance in Level 3 on the catfish, for example, meant that they could survive easily without having to think about other strategies or reasons for their survival. What was also noticeable was a distinct simplification in the ways children were thinking about hunting strategies from their ealier discussions at Level 1 (after watching the video) which had concerned complex plans for placement of lions for hunting, and the need not to frighten off animals. Instead, the children learnt to focus primarily on the challenges of the games technology - the need to get all lions to see the picture at the same time.

It is also possible that the games rules were not sufficiently clear to encourage the children's tendency to learn through trial and error. The children were generating hypotheses about what to attack and attempting different strategies, but the feedback seems to have been insufficiently clear, particularly when different children in one group think they have acted in the same way with different results. For example, in Group 3's hippo attack, Aslan attacked on his own too early, and died, while the others succeeded, but this was never fully understood by the children:

Simba 3: *Where are you going? Are you out?*
Aslan 3: *I'm dead*
Mufasa 3: [Aslan]*'s dead*
Nala 3: *How did he die?*
Mufasa: *You get some* [trails off]*... Come on, let's go find some food*

[...]

Elsa 3: *How did* [Aslan] *die? How do you die doing nothing?*

What this point highlights, is that children are drawing conjectures about cause and effect not only from their own actions and feedback as individuals, but from other children's experiences. This means that there is a high level of complexity in the inferences they have to draw from a range of different individuals' actions in moments of heightened emotional engagement. Not only do they need to think about the feedback to their own action, but to their own action in conjunction with others' behaviour, which means they need to understand what others did and when in order to draw accurate deductions about the outcome of a particular action. This also relies on other children providing accurate information about their own actions (which was not always the case as children were reluctant to talk about mistakes and sometimes just said they didn't understand what had happened).

At the same time, the buttons changing from nothing to 'attack' to 'eat' also provided red herrings to the children. The fact that a button changed to attack or to eat, suggested to them that this was something they should automatically do, rather than relating this to more complex decisions based on the likelihood of success:

Elsa 3: [looking at her screen] *oh, I can eat now! It just said eat... I found some more hyenas*

After several failures, however, the children clearly became more discriminating and less likely to attack simply because of button changes.

There also seemed to be a few errors in the design of the games rules that mitigated against children's ability to infer generalised rules from trial and error strategies. There was confusion about why energy seemed to go up without children doing anything, and about how this related to hunger also going up - the relationship between the two was not clear. At times, there seemed to be a delay in energy points being awarded which led to interpretations of actions being mistakenly attributed to later actions than those which were actually being rewarded.

Understanding habitat

We questioned Groups 4-6 prior to playing the Savannah game about their understanding of what was in a savannah and how lions behaved. As a rule, they had little understanding of the different environments within the Savannah landscape, and only a general understanding of how lions behaved. There were some exceptions, with a small number of children who were already interested in lion behaviour able to talk in more detail about how lions would hunt. In their work at Key Stage 2, however, they will have already been introduced to the notion of 'habitat' and to the relationships between animals and their environment, and the needs of animals for shelter, water and food.

Through playing the game it was clear that the children had come to have a greater understanding of the different features present in a savannah - they talked in the first level of the different types of environments to be found, referencing 'rocky areas, long grass, short grass, lake, trees' and so on. They also mobilised these conceptions of the terrain in planning where to place their cubs and in developing hunting strategies. The crib sheets, which were written specifically for the trials, and the videos, seemed to provide important structuring resources for children's thinking about the environment. At the same time, the challenge of placing cubs provided an important focus around which the children structured their discussion of the environment, causing them to think about such things as safety, shelter, food, water and proximity to hunting grounds and other threats.

The shift from Level 1 to Levels 2 and 3, however, distracted children from their focus on the environment. Indeed, the move to use the whiteboard after Level 1 often led to children talking not about short grass etc, but about 'light green' areas. The emphasis on hunting led to an almost exclusive focus on animals. As described above, the children's discussions tended to focus on the numbers of lions needed for attacks, rather than the likely areas in which to find prey. It is possible that after several attempts at the game, the children would develop more complex conjectures about the relationship between habitat and prey, but the challenge of mounting successful attacks tended to lead to this relationship being ignored. At the same time, the provision of maps of locations of animals prior to hunting tended to encourage the children to create their own maps that simply identified were animals were. Through providing the level maps in advance (of the second attempt at Level 2 and first attempt at Level 3) we, in fact, removed the need for the children to conjecture about where prey animals were most likely to be in the Savannah. As a result, there was a somewhat shaky understanding of the relationships between animals and their environment:

Elsa 6:   *OK, so where were the baboons then?*
Dandelion 6: *In the middle somewhere?*
Elsa 6:   *Do you remember what background it had?*
Dandelion 6: *It had a kind of purply background?*
Elsa 6:   *But was it in the marsh, was it?*

In fact, there were very few examples of the children mobilising their conception of the Savannah 'space' as a way of finding prey animals. Instead, the purpose of much of the map creation was to create a representation of the physical locations of animals that obviated the need for thinking about the contexts within which these animals would be found. It was a process of locating in the playing field the areas most likely to be useful.

The maps represent areas to avoid, routes to take and the location of prey. The key features of the landscape are marked (gulley, marsh etc), but these are taken directly from the den interface, rather than generated through an understanding of the link between environment and prey animal.

A further complication is introduced in the relationship between prey and environment in the shift from wet to dry season. Many of the children remarked that they found animals harder to find in the field in the wet season than the dry season. Group 6, in particular, by focusing almost exclusively on the catfish, were able to find themselves food and drink with relatively little effort. Other groups found more animals clustered together in one location. Again, we provided significant amounts of information 'up front' to the children prior to entering Level 3. We told them that the environment had changed, that the water had shrunk and that there was fire and Masai in other areas. We also told some of the groups that prey would be more likely to be found around the water hole and in the tree areas. Again, this obviated the need for the children to conduct research on the changing patterns of behaviour of animals in the

dry season as compared with the wet season, and so to generate their own understanding of the relationship between animal behaviour and changing landscape. As a rule, Level 3 was seen simply as a more complicated Level 2, with the focus remaining on hunting strategies, counting lions vs size of potential animal target, and simply adding onto this the need to find water (which was little of a challenge at this level as they were all fairly familiar with the locations of the marsh and lake, and so the main challenge was locating these on the field - ie a spatial awareness challenge).

While this sounds critical of the children's understanding, it is also worth emphasising that through play, the children may have developed an understanding of the likely locations of animals in particular areas. While this wasn't developed into a more complex understanding of why these animals were likely to be in different areas, it did contribute to a link between animals and environment. They were effectively developing practical links between location and animals:

Mufasa 6:   *Short grass, there are good animals over here remember?*

In the follow-up interviews with Group 3, for example, after two months gap, one boy was able to clearly locate animals in different locations:

KF: *What sorts of animals do you find in which areas?*
[Aslan 6]:   *Hippos, next to the lake, zebras, in the trees and short grass,*
             antelopes and wildebeest in the same area as the zebras,
             monkeys in the rocky areas and near the water

3.6.2 Evidence of children's development of skills

In the earlier section on collaboration and the previous section on children's content learning, I have highlighted a variety of ways in which children were learning ways of working rather than simply learning content.

The first striking feature of the trials, was the extent to which children shifted from unease and uncertainty about the research process, to confidently exploring the resources available for use in the den. Most groups were confused at first on being set a challenge and told to prepare for this. By the end of the day, children were familiar with taking ownership of planning and discussing what they were going to do in the next level. The children also employed strategies for planning and collaboration - through the development of maps and lists as shared resources. While in some groups, this strategy had to be encouraged by the facilitators (Groups 4 and 3), in other groups the fact that there were flip charts and pens were enough to facilitate the development of this strategy.

In the field, we saw children adopting trial and error approaches to learning, that involved the development of hypotheses about what strategies might work, and attempts to test these. We saw children requesting help from adults, consulting resources that they identified as potentially useful, revising ideas with collective input and discussing strategies as a group. The exchanges between the children were often rich, particularly around the discussion of where to locate cubs.

The challenges were such that we saw children having to find ways of collectively managing a complex set of variables in their planning. Group 6, for example, in preparing for Level 3, were thinking their way through a number of different problems simultaneously: how to mark the territory, how to combine hunting and drinking, how to find out what lions can and can't eat, what hunting strategies to use, how to combine their different ideas. In contrast, Group 3 focused almost exclusively on the assessment of which animals could be attacked by what number of lions, while Group 4 focused on juggling the variables of different hunting strategies

and different locations of likely prey. In the field, we also saw children having to manage competing pressures - their own hunger and thirst, the need for group work, the challenges of the technology. Only by successfully negotiating these different features could the children successfully survive Levels 2 and 3.

3.6.3 Evaluation of Savannah against its stated learning objectives

This section will explore the success of Savannah against our stated learning objectives. There are methodological challenges to understanding the development of children's thinking and practice in a case such as Savannah. What counts as 'evidence' of developing thinking skills? How do we determine the difference between what children bring to the game in terms of dispositions, knowledge and abilities, and what the game actually fosters? How do we elicit children's understanding from myriad overlapping conversations and suggestions, as well as silent reflection on the contents of a computer screen?

The objectives below are the first set against which Savannah needs to be evaluated:

Objective 1: To encourage understanding of animal behaviour and longer term survival. By the end of playing Savannah, children should have:

> a) developed an understanding of the key features of the Savannah environment
> b) developed a conceptual understanding of the opportunities and threats faced by lions in the Savannah environment
> c) developed a conceptual understanding of the strategies and choices faced by lions in interaction with the Savannah environment
> d) developed a conceptual understanding of the relationship between individual lion behaviour and longer term survival of the species.

On a very basic level, both of the first two objectives (a & b) can be said to have been met: the evidence of children's map creation, discussions and planning suggest that by the end of playing Savannah children had developed an understanding that the Savannah consists of a number of different types of environment, including trees, grassy areas, marsh/lake areas, and areas of threat, such as rivers, human villages and other lions' territories. The children's discussion of these features while placing cubs and planning hunting, and while out on the field, suggests that this mixed landscape, by the end of the play, had become an underlying assumption in children's planning and play activities. That there were threats and dangers, as well as opportunities for food and water in the environment, and that these threats took a number of different forms was also an underlying assumption by the time children reached the later levels of the game. The children's engagement with the game - the running away from elephants or fire or humans, the attacks on animals - embody in practice children's understanding of these features of the environment and their potential implications for lions. The children's planning activity also evidenced an awareness of different strategies for survival (c), primarily based around different hunting techniques. The dicussions amongst some of the groups about group success, once they entered the den, suggested an awareness that success was not simply individual (d).

However, it is clearly possible, on observing children's play in the Savannah to take a more critical approach to the actual achievements of the experience in supporting children's understanding of the complexity of animal behaviour and relationship with the environment, in particular in respect of objectives 1b-1d. Children's awareness of opportunities and threats in the environment was almost wholly structured around the notion of what might attack them and what they might attack; there was no opportunity to discuss, for example, the different threats to the animals posed by changes in the season, competition for water, and impact of human occupation of the Savannah. Similarly, the strategies explored for survival comprised predominantly of hunting - the focus on conserving energy, for example, was subordinated to the demand to gain food. The key strategy of expending very little energy as a lion was not explored in the game, the negotiation of demands of cubs and hunting was sidelined, the only

choices open to the players were related to hunting and drinking tactics. Indeed, if we consider objectives 1c, 1d, it could be said that the notion of lions as strategists and lions as part of a pride with long term survival as a goal, were almost wholly subordinated to 'game goals', with the children's focus almost exclusively on gameplay rather than linking that gameplay in with a wider conception of animal behaviour, evolution and habitat.

The game very successfully offered the children the opportunity to play at being lions, to experience first-hand some of the challenges and difficulties that lions might experience, but it also encouraged a focus on the mechanics of the gameplay (getting together in one place at one time), on simple games rules and games objectives (to some extent, rules that were significantly more simplistic than the children's pre-existing expectations of animal behaviour). In essence, it offered children the opportunity to learn about the savannah environment in the same way that lions themselves might learn about it. It might not matter, for example, to a lion why particular animals can be found in particular places, how their individual survival is linked with species survival, in what ways human presence can operate as a threat. Ironically, this sort of approach is advocated as an important aspect of games-based learning, drawing for its justification the ways in which animals might learn:

"Games are thus the most ancient and time-honored vehicle for education. They are the original educational technology, the natural one, having received the seal of approval of natural selection. We don't see mother lions lecturing cubs at the chalkboard; we don't see senior lions writing their memoirs for posterity. In light of this, the question, 'Can games have educational value?' becomes absurd. It is not games but schools that are the newfangled notion, the untested fad, the violator of tradition. Game-playing is a vital educational function for any creature capable of learning." (Crawford 1982, Chapter 2)

The den environment successfully offered children the resources and the time to reflect on their success and failure out on the field, but again, this environment was prestructured by the objectives of the game itself. Reflection, then, was organised around achieving games objectives to such an extent that these other questions, the why, the how, and so on, were effectively irrelevant. What is clear is that if we wish children to develop conceptual understanding of these relationships there are two options: 1) model this into the games rules or 2) provide these opportunities for thinking before or after the game in a different environment altogether. Without either of these two, the level of understanding is likely to make for an effective lion, but it won't make for a particularly rich human understanding of these phenomena.

The second set of objectives were related to providing a resource that would enable children to develop strategies for working with problems as a team. By the end of playing Savannah, it was intended that children should be able to use a range of different strategies for problem solving, including:

   a) research
   b) discussion
   c) hypothesis generation and testing
   d) revision of ideas
   e) requesting expert advice
   f) listening to each other and building on each others' ideas.

Again, at a relatively superficial level we can confidently say that Savannah provided an opportunity for children to practice these different skills. It provided sufficient challenge to encourage children to research, to talk about different strategies, to ask for help, to listen to each other (with some prompting), to test out ideas on the field and to refine them. We clearly saw all of these activities taking place.

However, what was clear was that the experience as currently structured provided little scaffolding to encourage children to develop these skills further and to reflect upon them. The injunction to 'research' at the outset and throughout, for example, was not accompanied by support in reflecting on what 'research' actually means. There was little help in formulating

specific questions or hypotheses and defining how these could be explored. Similarly, although the children were encouraged to consider listening to each other and to work as a team, we provided few structuring elements in the environment to facilitate this amongst children who had little experience of this way of working before they started. From the three more detailed case studies, there seems to have been little progression in problem-solving strategies or collaboration skills from those that they brought into the room with them.

Again, if we are to encourage these skills, it is clear that some degree of reflection on the processes of working together and of problem solving needs to be made explicit. The emphasis in the scoring system on lion survival and the somewhat haphazard 'team work scores' would need to be revised, and opportunities for reflection on these processes offered before or after participation in the experience.

4. CHILDREN'S VIEWS OF SAVANNAH

4.1 Children's reported enjoyment of the experience

During the debrief interviews after play, children were asked to mark on a line how much they enjoyed 'playing Savannah', 'school', and 'weekends'. The following provides a summary of the children's responses:

Group	Savannah	School	Weekends
Total	9.4	3.2	9
Boys	9.5	2.5	9
Girls	9.3	3.9	9.1
Year 7	9.3	3.9	9.1
Year 8	9.6	3.5	9.2
Monks Park	9.4	0.8	9.2
St Bede's	8.9	2.9	9.2
Cotham	9.6	3.5	9.2
Brislington	10.1	1.5	9.7
Fairfield	9	5.9	7.6

On this basis, we could happily argue that participating in the Savannah trials can be considered a more enjoyable experience for children than the average school day, and at least as enjoyable as time outside school. What makes it enjoyable, and what children considered 'Savannah' to be, however, are slightly more difficult to ascertain. Many of the children when talking about 'Savannah' in the final interviews, for example, only talked about the gameplay experience outside. It's not, therefore, clear, whether these positive comments referred only to the outdoors play or to the whole experience. Second, some of the children referred to the most enjoyable feature of the day being the opportunity to use the new technology, or being involved in a trial in which so many people paid attention to them, or the absence of teachers. Some degree of caution, therefore, should be taken in assuming that these positive responses would necessarily translate to positive experiences if Savannah were located as part of normal schooling and when the technologies have become less exotic.

4.2 Children's recall of the Savannah experience

To date, it has only been possible to conduct interviews at a later date with one group of children in order to explore their recall of the Savannah experience. This group (Group 3, Thursday morning) was the group who demonstrated least collaboration, planning and research skills, and who brought to the experience the most challenges in terms of their own abilities and expectations. They were the group identified in their school as under-achieving (not necessarily struggling, but not achieving what they ought to when compared with SATs scores at Year 6). They included children who were having difficulty fitting into schools and one boy who was on the verge of being excluded. In principle, then, this was our most challenging group.

The interviews were conducted two months after the Savannah trials, for 15 minutes with five of the children in the group (one boy was attending a case conference and so couldn't be interviewed). These interviews produced a number of key findings.

1) All of the children had very positive recollections of the Savannah experience, reported that they would do it again, and demonstrated detailed memories of what had taken place. These are some of their memories of the experience:

KF: What can you remember doing when you did the Savannah trials?

First we planned out our places, where to save the cubs and when we went out we had to get like food and drink and survive on the land. We had to protect our cubs and get food and water and just like [...]. We had to look around, scan the area and see where we would get most food from and where our cubs would be? [...] We looked for an empty space and selected it [...]. It was the paw thing [...]. Oh yeah, we had to claim what was ours and so that the other animals would know not to go there. (Dandelion)

We had these things... they were called, P... [PDAs]... and they were like touchscreens and they were linked up to the computer. You go out and there's three mission things and you go out to the field for each task. For the first task you have to find somewhere to put your children, then you have to pee wherever you're going to put them. On the second one [level] you had to, it was raining, you had to - it was the start of fighting prey and you had to find cubs as well. In the third one, you had to survive in the hot weather and you had to kill a lot of things, and we have to kill the hippo. There's some teamwork to kill things, we could eat and drink and just stay safe. (Elsa)

Researching, going out, coming back and seeing how you did. When you were outside you'd go round and look for food and drink and mark your territory. (Nala)

We had to survive in the savannah in different, like, stages... spring, summer, autumn and winter. We had to hunt, we had to survive, we had to do all the things to survive, we had to mark territory. To hunt, we had to decide what to hunt. We preferred the hippo. We sprayed the land to mark territory - if you get near a tribe they'd attack you or you'd get away, sometimes there was another lion's territory. (Aslan)

2) The key concept retained by all the children was that size was an issue in determining animals that should be attacked (and for some the need to work as a team to take on larger animals):

KF: Which animals should you attack?

Not too big, not bees cos they just fly away. Like wildebeest you can attack by yourself and you get the energy. If you've got a lot of other lions you can attack bigger animals. (Elsa)

Hunt with more lions if it's a big animal. (Dandelion)

If you get a leopard or a hippo - it's best to be in a group, like we did with the hippo... like one of them like little ones with horns, like antelopes, it's better to do it with someone else - there's more change of getting it. (Nala)

Small animals, like monkeys, birds and wildebeest. (Mufasa)

Not attack big animals, and if you fail attacking a big animal, don't attack it again. (Aslan)

3) There was also reasonably good recollection of the features of the Savannah environment and the location of animals within this environment, although this was patchy with some children finding this more easy to explain than others:

KF: Can you describe what's in the Savannah to me? - what sorts of areas are there?

The wet environment had water and lakes, the dry environment had birds, other lions, more deers - antelopes [after prompting to remember the name]. *Every place had its own different way - there was forest, wet place, dry grassy areas, short grass, long grass. Lions would mark territory in the long grass* [...]. *Antelopes weren't in the forest or water, in the long grass. Water was crocodiles and hippos* [...]. *In the dry season, lions need more water, there's less water around, they had to keep drinking, there's more antelope and hippos drinking water. In the wet season there's too much rain, they needed dry places.* (Aslan)

Rocky areas, tree places, forests, lakes, other prides territories, people and huts and stuff [...]. *Hippos, next to the lake, zebras, in the trees and short grass, antelopes and wildebeest in the same area as the zebras, monkeys in the rocky areas and near the water, elephants, birds, other lions, cheetahs? Tigers? Crocodiles* [...]. *Wet season it just like constantly rains, in the dry season humans come in, water evaporates, there's no water and there's tigers I think?* (Mufasa)

Lakes and hippos, trees and leopards. There was shady bits. I think some bits were grass and some bits like mud... Birds, hippos, leopards, I dunno, wildebeest [only after prompting] *and them little like... with horns* [antelopes]. *Wet season like you get more water, but in dry season your energy goes down because you're hot. In the hot season it was dry and stuff... the lake got smaller. There were leopards and stuff... I can't remember.* (Nala)

Lake and drinking area and some areas with some humans and there was like some rocks where the birds were... some of it was long grass and short grass. It was mostly grass [...]. *Cheetahs I think, deers, a hippo, birds* [...]. *In the dry season you have to get more drink to survive. In the wet season you don't have to drink that much.* (Dandelion)

4) Many of the children had forgotten the vocabulary to describe the different animals in the environment and had to be prompted. Some could not remember after prompting, but could talk about general groupings such as 'deer'.

5) There was some confusion about differences between male and female lions, when asked about the differences, they answered:

Male lions go and hunt? I can't remember. (Nala)

Male lions find territories, female lions hunt. I was surprised by that, I thought it was males who hunted. (Elsa)

Female lions have no mane and hunt, male lions have mane and don't hunt, I'm not sure who looks after the cubs. (Mufasa)

Male lions have more power over females. Females do the hunting. (Aslan)

6) There was some evidence that these recollections were based not only on Savannah, but on

a combination of common sense and other information resources, as the children struggled to answer some questions, and provide information not available in Savannah:

In the dry season there's more places for your cubs to be because it's safer for them to be kept dry instead of being in damp wet places. (Dandelion)

7) Very few of the children reported having thought about lions or Savannah since playing it, with the exception of the two boys Aslan and Mufasa, who had had a conversation about how they could play Savannah if it were in their school. Notably, this conversation was about how they would design the Savannah game to fit into their playing field:

The PE office would be the entrance to the game, the field would be the short grass, the trees the forest, the fence the fire, and the far side would be where you'd get them to mark their territory.

8) For one of the boys, Aslan, Savannah seems to have sparked an interest in animals and wildlife that he hadn't had before. He talked enthusiastically about the experience, had clearly remembered it in some detail, and discussed how he had been keeping an eye on Discovery Channel documentaries to see if there was a documentary on lions coming up. When asked, he said he had no interest in this before playing Savannah.

Reflections

It isn't possible, as always with this project, to identify exactly what the children had learned from the Savannah experience and what they had picked up from other sources of information about lions and the Savannah. What was noticeable was the detail of recollection of their experience, and the retention of the key concept of attack strategies. Clearly, there were different levels of understanding, that tended to reflect the levels of engagement with the game during the trials. There were also some misunderstandings that we didn't pick up during the group interviews. My hunch, and it is only a hunch, is that this level of recollection is remarkable considering the experience was two months prior to this follow-up interview and that the children weren't advised in advance that I would be asking them these questions. The only way to test this hunch would be to show a documentary or provide a lesson for a similar group of children over a three-hour period and then two months later ascertain levels of recollection.

5. SUMMARY OF REFLECTIONS ON SAVANNAH

Savannah clearly offers children the opportunity to learn through experience, through trial and error, and through reflection on gameplay strategies. The whole experience (den and field combined) offers a rich opportunity to explore what it might feel like to 'be a lion', and to come to some level of understanding of the features of a lion's environment. What is clearly important from this analysis, however, is that the process of learning through games play involves a distillation of the complexity of real life into a set of abstract rules. These rules will drive all the learning in the experience, and if these are incorrect or inadequate to describe the phenomena that is being taught, then it is unlikely that players will develop an accurate picture of the phenomenon. However, it is also possible, if we view learning through games as a 'distillation process', that this feature can be mobilised to the designers' advantage. We might wish to consider for example, whether key principles (the rules of the game) might not in fact offer more helpful ways of learning that can be mobilised in other settings. The follow-up interview with one of the boys from Group 3, for example, demonstrates how such 'key principles' might be mobilised in other somewhat unlikely domains:

We saw this guy in a fight, there was one guy and he was going for three others and we saw them and we thought of lions - cos one of you wouldn't go up against three of them. (Aslan, 3)

The opportunity offered in Savannah to learn through experience, and to learn with others as part of a team also clearly has potential. Children tended to help each other, to offer up suggestions and ideas, and to try things out through practice. If we are attempting to encourage more skilled strategies for problem solving and collaboration, however, it is clear that we need to locate within such experiences a 'more experienced other', ideally someone who has struggled with and played the game themselves, who is able to provide a critical eye on the processes of teamwork. We need to begin to seriously consider the benefits of a 'spiral curriculum', in which children act both as players and mentors, and are offered support and advice to act as these more expert others (in the ways that advisors in online games develop for example).

If we were to evaluate Savannah solely against narrowly defined learning 'content' objectives then we might come to the conclusion that the game offered an inefficient way of communicating a little subject knowledge. If we consider, however, the levels of engagement of the children in the activity, the extent to which they were able to achieve high levels of success while managing complex competing variables, the extent to which it offered authentic challenges to children and that they (in the most part) stayed on task and engaged during a very lengthy period of time, then the experience looks significantly more successful. That all of the children reported being interested in playing again, in playing it with friends, that some asked whether it would be possible to buy it commercially, that most of them compared it favourably against leisure activities (let alone schoolwork) suggests that the experience, while requiring more work to ensure that it achieves its learning objectives, is valuable and worth pursuing.

Savannah has provided an interesting testbed for exploring ideas in the three areas of mobility, collaborative learning and games. It would seem appropriate to build on this for further projects. I believe that Savannah has highlighted the real strengths and weaknesses of games-based learning, in particular, it has emphasised the real engagement and enthusiasm that children demonstrate in these environments, but also the relative limitations of rules-based worlds for teaching complex issues where children act as participants within rather than manipulators of the games world (ie where they cannot control or reflect upon the rules of the world). I also believe that Savannah has highlighted real strengths in mobile learning - although it is impossible to prove this, the requirement upon children to explore an environment physically as opposed to cognitively, I believe, has an effect upon the retention of knowledge. Given recent debates on children's obesity levels, there is also an increasingly urgent need to understand how we can combine physical activity as part of the learning process. The simple fact of being able to move around, also seems to have a very strong appeal to children, in particular boys. Finally, Savannah highlights the familiar strengths and weaknesses of collaborative, group-based learning environments, in that children were clearly able to pool knowledge and to learn from each other, at the same time, others were able to 'coast', or to simply follow others.

Next steps for such resources could comprise detailed work with teachers to provide a curriculum within which the game can sit. It is likely that the most beneficial and workable site is going to be in school settings, or CLCs. Given the necessary constraints on numbers it is unlikely that the resource will be able to be used as a 'day trip' to a science centre and so on. If it were to be used in schools, it would be possible to consider the resource as something that could be explored by groups over a two-week period, and around which a teacher could structure an entire scheme of work on 'habitat/interdependence/energy/ evolution'. Within this context, Savannah would be seen as an activity that would enable children to experience 'life as an animal' (which cannot be done any other way using any other resources), and stimulate interest in the subject area.

Practical next steps in respect of development of Savannah or similar resources could include:

1. Whole team scoring system to introduce engagement with issues of evolution and to overcome some of the tensions between individual and group success, currently weighted in the game too far towards the individual.

2. Development of simulation tools within the den site to enable rapid hypothesis generation and testing prior to outside gameplay.

3. Development of 'training levels' to enable children to develop necessary games skills and enable focus on substantive challenges later in the game.

4. Provision of information resources tailored to reading and ability levels of target users.

5. Development of a map creation facility that would allow rapid transfer of whiteboard maps, annotated, to hand-held devices.

6. In the longer term, exploration of the role of 'intelligent' physical artefacts that could be placed in the field space may be beneficial.

Finally, the Savannah experience suggests that children are also interested in creating and shaping games themselves, a beneficial future development would be the creation of toolkits that would allow both children and teachers to create mobile games-based environments themselves. This would enable teachers to tailor content to their own needs, and children to engage at a more systematic level with the knowledge domain.