

## Investigating attitudes towards Physics aligned with Sustainability and the effectiveness of educational games as learning materials

### 1. Methods

A questionnaire was designed to assess local school pupils' attitudes towards the concept of sustainability, or sustainable development (SD). Little was given by way of an introduction to the topic, since the purpose of this survey was to ascertain levels of *a priori* knowledge.

A total of 40 pupils from Years '12' and '13' (ranging in age from 16-18 years old) participated in the survey at two co-educational secondary schools in Leicestershire: Wreake Valley Community College (WVCC), a comprehensive school of c1600 pupils, and Leicester Grammar School (LGS), an independent school of c700 pupils. Only those pupils studying Physics were asked to complete the questionnaire, as this met with the project's primary research question: *can Physics be made more attractive to potential students by engagement with the SD agenda?*

During a later visit, pupils were asked to 'play-test' four different educational games created by Physics undergraduates at the University of Leicester. The games were designed to: (1) be fun to play, (2) convey the complex scientific relationships between factors within an ecosystem, (3) illustrate how players' actions interact with external events to affect the overall environment, and (4) highlight the importance of sustainability in any system.

A second questionnaire was then produced that asked the respondent to rate the game(s) they had played, as well as to provide suggestions for improvement. Informal discussions with the pupils resulted in additional recommendations.

### 2. Results

#### 2.1 Pre-test survey

The findings from the initial questionnaire were, on the whole, encouraging, with the majority of pupils demonstrating a satisfactory understanding of the notion of SD (Table 1).

		<b>WVCC Yr 12 = 19 pupils</b>	<b>WVCC Yr 13 = 11 pupils</b>	<b>LGS Yr 12 = 6 pupils</b>	<b>LGS Yr 13 = 4 pupils</b>
<b>1</b>	<b><i>Had you heard of the term 'sustainable development' or 'sustainability' before today?</i></b>				
	Yes	<b>79%</b>	<b>73%</b>	<b>83%</b>	<b>100%</b>
	No	21%	27%	17%	0%
	Don't know	-	-	-	-
<b>2a</b>	<b><i>In which areas of the world do you think SD is important?</i></b>				
	UK and Europe	11%	-	33%	-
	Africa	37%	9%	-	-
	Asia	32%	9%	-	25%
	North America	5%	-	17%	-
	South America	16%	9%	-	-
	Australasia	-	-	17%	-
	<b>All of the above</b>	<b>63%</b>	<b>81%</b>	<b>67%</b>	<b>75%</b>
<b>2b</b>	<b><i>And to whom?</i></b>				
	Farmers	32%	54%	17%	75%
	Small business owners	26%	27%	33%	50%
	Multinational companies	21%	64%	50%	50%
	Government	16%	54%	33%	75%
	Celebrities	-	-	-	-
	Local people	37%	45%	33%	50%
	<b>All of the above</b>	<b>53%</b>	<b>18%</b>	<b>50%</b>	<b>25%</b>

Table 1: Responses to the first three questions asked on the initial survey.

An average of 84% of all pupils had already heard of the term ‘sustainable development’ or ‘sustainability’, 72% recognised its importance in all areas of the world, yet only 37% considered the concept to be applicable across all sectors of society (Table 1). This last statistic suggests that school leavers may not recognise the importance of sustainability to *everybody*.

As regards attitudes to Physics aligned with SD, an average of 65% of the pupils agreed either ‘slightly’ or ‘strongly’ that the subject “plays an important role in the development of sustainable practices.” However, less than half (48%) answered that they would like to see topics such as SD be included as part of their education. This may relate to a degree of unfamiliarity with the concept of sustainability and thus a ‘fear of the unknown’.

## 2.2 Learning experience

<i>Game</i>	<i>Ease of play</i>	<i>Clarity of rules</i>	<i>Promotes team work</i>	<i>Fun to play</i>	<i>Could be applicable in Africa</i>	<i>Conveys concept of SD</i>	<i>Physics more attractive</i>
Fish Eagle	+1	+1	69%	94%	94%	94%	66%
Survival	-2	0	57%	79%	93%	93%	14%
Henry’s Game	-2	-1	100%	100%	100%	100%	50%
Jumbe	-5	-5	100%	0%	100%	100%	0%

Table 2: Feedback received from pupils who tested the learning materials.

Pupils were asked to rate the games in terms of their ease of play (-5 being very difficult, +5 being very easy) and the clarity of the instructions (-5 being very confusing, +5 being very clear); the highest scoring game was ‘Fish Eagle’ ( $1+1 = 2$ ), the lowest scoring design ‘D’ ( $-5+-5 = -10$ ).

The primary reason for ‘Jumbe’ scoring so poorly was perhaps that the rules of play lacked both clarity and simplicity, likely reflecting a lack of thorough testing on the behalf of the designers. The instructions for ‘Fish Eagle’, on the other hand, appeared well thought-out. Furthermore, the latter had a strong visual representation, whereas the former relied on a sometimes confusing assembly of components.

Overall, however, it appears that the majority of pupils found the experience enjoyable<sup>[1]</sup>, expressed belief that the games could be used as educational tools in Africa<sup>[2]</sup> and, importantly, were stimulated to think about sustainability<sup>[3]</sup>. Crucially, an awareness of SD gained from the learning

experience “made the prospect of studying Physics more appealing” to around a third of all pupils<sup>[4]</sup>.

### **3. Discussion**

The experience provided a great deal of information concerning appropriate techniques for the creation of effective learning materials. Various suggestions were put forward by the pupils during the play-testing and many of these recommendations were subsequently implemented into the games' instructions and designs:

1) A critical flaw was discovered in the number of starting counters required in the 'intermediate' and 'advanced' levels of play in 'Fish Eagle'. As presented, the figures given made certain rules obsolete; the numbers were subsequently amended, much to the benefit of the game's educational value. Additionally, the visual representations of the game's elements were rearranged into a hierarchical fashion so as to better convey the 'food-chain' relationship alluded to in the game's design.

2) Significant changes were made to the tables detailing interrelationships between the elements of play in Part 1 of 'Survival'. As presented, the tables were deemed too complicated with the result that a great deal of time was wasted on their interpretation. Moreover, players were able to 'cheat' by maximising their resources early on in the game, at the cost of learning the value of a particular resource relative to another. The interrelationships were thus simplified and the two tables merged into one, with a limit imposed on how many changes a player can make per turn (in order to prevent any 'cheating'). In Part 2, the factors introduced by the roll of dice were altered to make certain consequences more realistic - for example, the occurrence of 'war' was changed with the result of costing a player two of their 'workers'. Similar changes were made in Part 3, in effect simplifying the mathematics required - players commented that, as presented, this part of the game distracted them from the choices they had made without obvious necessity.

3) 'Henry's Game' was, on the whole, well received, however it was generally agreed that there were not enough question cards supplied to allow the game to continue for long enough to teach players a great deal about sustainability; the answers to the questions could also be memorised and thus the system 'cheated'. Secondly, the grid of squares that form the board should be numbered from 0-20 along each axis so as to make calculating one's score easier. The first of these changes remains to be made.

4) 'Jumbe' received the most criticism since the rules were simply too complicated to be followed. Those playing the game barely achieved more than setting up the board to the best of their understanding; indeed, from

Table 2 it can be seen that not one pupil faced with this design enjoyed the experience. The design requires considerable revision.

Carefully designed and educationally-relevant games (such as 'Fish Eagle') can thus be seen to form appropriate learning materials<sup>[5]</sup> and, when aligning Physics with SD, may indeed make studying the subject more attractive to potential students. On the other hand, poorly-devised games that lack simplicity (such as 'Jumbe') can cause frustration amongst players<sup>[6]</sup> and thus fail to highlight the relevance of sustainability in education.

The information received from the school visits was, to some extent, validated during the Higher Education Academy's conference "Sustainability and the Curriculum: Progress and Potential" (University of Bradford, 10-11 July, 2007) where amended versions of the games were presented as part of the project's overall presentation. Several of those who attended expressed interest in the games' potential for application in other areas of education and further suggestions for their modification arose from the interesting discussions that took place.

Given more time and greater cross-discipline collaboration, these designs could certainly be expanded on and improved in many ways, but the experience, in the very least, shows how learning materials of this type can successfully stimulate people to think about, and engage in, issues as diverse and complex as sustainability.

#### **4. References**

[1] "[It was] good fun and worked well" - Year 12 pupil at LGS

[2] "Because there is a lack of awareness in self-provision. If games could teach [Africans] ideas that link to the bigger picture of living and becoming self-sufficient, [Africa] would be able to boost its economy and plan for the future" - Year 12 pupil at WVCC

[3] An average of 97% ( $94+93+100+100/4 = 96.75$ ) of all pupils answered 'yes' when asked 'Will you now be thinking more about sustainability in your future?' - Table 2

[4] An average of 33% ( $66+14+50+0/4 = 32.5$ ) of all pupils answered 'yes' when asked 'Has an awareness of sustainability made the prospect of studying Physics more appealing to you?' - Table 2

[5] "It was different from other games and it's about an interesting subject" - Year 12 pupil at WVCC playing 'Fish Eagle'