BIODIVERSITY AND COMPUTER APPLICATIONS: A QUALITATIVE CASE STUDY

TEALEAF Ireland Project Team¹
Dublin City University - St. Patrick’s Campus (IRELAND)

Abstract

We present data from the initial questionnaire of a EU funded project. An online 42-question questionnaire was developed which probed a convenience sample of teachers for their background, use of apps, usefulness of apps and in which subject in the STEM constellation, apps were used through frequency indicators and perceptions of usefulness indicators. As expected 81% of teachers were both female and primary teachers. However, there was a wide variety of scientific education between the cohort in spite of this homogeneity and 25% of the cohort peaking at higher-level high school biology. Examining the use of technology showed how dominant interactive white boards, IWBs, have become, and other major technologies are using desktops/laptops whereas video providing apps and online apps for learning were explored. The 42-question x 52-case dataset was exposed to a simple Pearson correlation calculation, and the significant correlations noted. In such a large questionnaire, there appeared in the correlation table "clusters" of correlations but we have to be cautious as how we express such positive correlations. The teacher cohort was split between those who found the use of APPS in teaching specific content areas either not-applicable - rating of ‘6’; or used the frequency label - 'almost never' and those who did find apps for various topics useful to varying degrees. Non-metric multidimensional scaling, MDS, was also applied to the transposed data matrix using the ASCAL protocol in SPSS Statistics v21.0, which uses the Takane-Young-de Leeuw S-stress – formula 1, and a plot was made of the emerging dimensions. Nearly all the teachers belong to one large cluster, effectively a spectrum with teachers who increasingly used apps or thought them useful at one end and the teachers who increasingly thought the use of apps in teaching problematic or irrelevant.

Keywords: biodiversity, apps, teachers, computer applications, multidimensional scaling

1 INTRODUCTION

This work builds on an earlier European Union funded Comenius project: SOPHIA where Flash™, and other environment, based apps were explored for science learning including ‘ecology’ and focusing on the methodology of dialogic learning associated with ICT [1 - 4]. This present work concerns is a problem refinement within the EU funded Erasmus Plus project: TEALEAF concerning learning about biodiversity through educational ‘serious games’

¹Hugh Gash, Penny Humby, Sandra Austin, Sinéad O'Reilly, Thomas McCloughlin (corresponding author: tom.mccloughlin@dcu.ie)
whether as stand alone apps, online games, or games as projects within coding environments. The TEALEAF project has three 'strands' as its methodology:

i) To determine what existing resources are 'out there' and determine their suitability;
ii) To upskill serving teachers in game coding using a freely available system such as Scratch™;
iii) To work collaboratively in national groups to design a professionally produced game.

The problem refinement concerns whether the world-important concept of biodiversity is given sufficient treatment from an educational technology perspective evidenced by teachers' use of apps which factor-in some aspect of biodiversity. In this work, three broad hypotheses were tested:

1) teachers will think that apps are useful in general, but less so for biodiversity
2) Teachers will not think that there are sufficient resources, including time, for their needs
3) Teachers will think of apps as an occasional use only

1.1 Educational Games

Educational games, whether serious or otherwise, did not come into wide use until the 1990s with the advent of multimedia computers, even though such games were created and used long before; e.g., with Sinclair™, Amstrad™, Commodore™ and Atari™ in the 1980s. Such games typically had a entertainment value and educational applications were seen as quite different, although nowadays such educational applications now appear in retrospect to have some of the features of serious games, e.g., Logic Gate™ [5] for the Sinclair™ ZX Spectrum.

![AND GATE]

Do you need another run? "L"

Figure 2. The post-run screen of a circuit with an AND gate from Logic Gate™

Over time, educational games and other software evolved into “edutainment”. However, interest in edutainment soon decreased, partly because the (poor) quality of the games
themselves, and partly because of a growing interest in the Internet [6]. Resistance encountered to edutainment are reflected in perceptions such as: “edutainment, an awkward combination of educational software lightly sprinkled with game-like interfaces” [7] or: “most existing edutainment products combine the entertainment value of a bad lecture with the educational value of a bad game” [8]. However, the problems perceived in supposed edutainment arose when the game in question did not adhere to one of the following [9] six defining characteristics of digital games:

1. Digital games are rule-based.
2. Digital games have variable, quantifiable (through feedback provided to players) outcomes.
3. Players assign (positive or negative) value to achieved outcomes.
4. Players are making efforts to achieve the intended outcomes.
5. Players are emotionally attached to achieve outcomes.
6. Actions performed by players lead to specific outcomes, which are not necessarily the same each time the game is played.

A similar and perhaps simpler definition of an educational or serious game that also has currency is: “purposeful, goal-oriented, rule-based activity that the players perceive as fun” [10], with rules being sets of instructions, embedded into the design of the game, that define legitimate actions [11 - 12].

With the general renewed interest in serious games in the 2010s, game developers have moved from “skill-and-drill interactive learning paradigms towards situational and constructionist approaches” [13]. Although games in education are gaining acceptance, their use is not widespread, and they remain a controversial issue [6]. Educational games are also faced with the challenge of providing research evidence of the purported benefits, which is currently “complex and thinly spread”. Furthermore, “as a result of the diversity and complexity of games themselves, and the range of perspectives taken by researchers, there are few hard and fast findings in the literature” and the situation remains much the same today. Despite the dearth of rigorous research, what little there is is showing a certain degree of positive effects of games as educational tools. Games have been attributed to the support of the development of a number of various skills such as: strategic thinking, planning, communication, collaboration, group decision-making, and negotiating skills [14], [8]. There are also a number of concerns to consider in order realising the full potential of games as educational tools:

i) Resources (many schools have an aging hardware inventory that is too old for new games, lack/expense of technical support,

ii) Lead-time for teachers to familiarise themselves with the game, etc.),

iii) How to identify the relevance of a game to curricula or syllabi,

iv) Difficulty in persuading school stakeholders, such as parents, other teachers of the potential benefits of computer games [13],[15].
1.2 Serious games

Although serious games are generally considered to increase various skills - using the term in its broadest sense - there is a lack of evidence for such a claim, which poses a potential threat to serious games. Disciplined studies of gaming are few [16], educators "actually know relatively little about the consequences of game play on the cognition of those who play them". What is known is that games, simulated environments and virtual reality/systems, among other forms of gameplay, allow learners to experience situations that are impossible in the real world for reasons of safety, cost, and time [17, 18] and in the primary school all three are particularly pertinent. The three factors of safety, cost, and time are not however mutually exclusive. We also know that analyses have been conducted over the years, consistently showing that games promote learning [19]. At the same time, it seems difficult to draw any firm conclusions from studies on computer and video games due to conflicting outcomes [20].

1.3 ICT-TPCK

Within the context of learning through computer applications, we enter the realm of Information and Communications Technological Pedagogical Content Knowledge (ICT-TPCK). Very often the components of this type of technological pedagogical content knowledge (TPCK or “TPACK”) [21] presents unique challenges in a primary school classroom where competing resources and lack of confidence both in the science content AND the competency is using digital learning are too disparate to synthesize, since synthesis requires components that coalesce at some point. ICT-TPCK was first described by Charoula Angeli and Nicos Valanides [22, 23] as: “the ways knowledge about tools and their affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners or difficult to be represented by teachers can be transformed and taught more effectively with technology in ways that signify its added value”. In this project, we suggest that simple but serious online computer games assist teachers synthesize their ICT-TPCK concerning apps and biodiversity.

2 METHODOLOGY

An online 42-question questionnaire was developed which probed a convenience sample of teachers for their background, use of apps, usefulness of apps and in which subject in the STEM constellation, apps were used through frequency indicators and perceptions of usefulness indicators. Respondees could decide if certain questions were not applicable, and non-responses were treated as 'not applicable'. The questionnaire is available from: http://bit.ly/1JEC9eB - short URL.
3 RESULTS

3.1 Basic data

The basic data may be extracted from the questions that detailed background, education, and career pathways, Figure 2 and Figure 3. As expected most teachers are female and primary teachers, i.e., 81% of the cohort, so a comparison between primary and post-primary teachers is not feasible. However, there was a wide variety of scientific education among the cohort in spite of this homogeneity, although 25% of the cohort peaked at studying higher-level high school biology, Figure 2.

![Qualifications in science](image)

Figure 2. The qualifications in science of the cohort, n=52.

Examining the use of technology showed how dominant interactive white boards, IWBs, have become, and other major technologies are using desktops/laptops - most likely in conjunction with the IWBs whereas YouTube and other video providing apps and online apps for learning were explored.
3.2 Correlations

The 42-question dataset was exposed to a simple Pearson correlation calculation, and the significant correlations noted. In such a large questionnaire, there appeared in the correlation table "clusters" of correlations and we have tabulated the larger ones in Table 1 and the relevant questions in Table 2. We have to be cautious as how we express such positive correlations. For example, the way the responses to Q8 formed correlates to the way the responses to Q9, 10, 11, and 12 is significant at the 0.01 level, i.e., two-tailed. The teacher cohort was split between those who found the use of APPS in teaching specific content areas either not-applicable - rating of '6'; or used the frequency label - 'almost never' and those who did find apps for various topics useful to varying degrees.

Table 1. Clusters of significant correlations

<table>
<thead>
<tr>
<th>§1</th>
<th>Responses to questions correlated</th>
<th>Positive or Negative correlations</th>
<th>One or Two-tailed</th>
</tr>
</thead>
<tbody>
<tr>
<td>§1</td>
<td>Q8 : Q9, 10, 11, 12</td>
<td>+ve</td>
<td>**</td>
</tr>
<tr>
<td>§2</td>
<td>Q9 : Q8, 10, 28, 29</td>
<td>+ve</td>
<td>**</td>
</tr>
<tr>
<td>§3</td>
<td>Q9 : Q2, 27, 37</td>
<td>+ve</td>
<td>*</td>
</tr>
<tr>
<td>§4</td>
<td>Q10 : Q29, 8, 9, 11, 12</td>
<td>+ve</td>
<td>**</td>
</tr>
<tr>
<td>§5</td>
<td>Q13 : Q14, 15, 16, 17, 19, 20</td>
<td>+ve</td>
<td>**</td>
</tr>
</tbody>
</table>

§1This would suggest that the teachers concerned used apps in their science lesson in order to increase student motivation, to develop science concepts / content drilling skills, and as an aid in formative assessment.
§2 This 'cluster' was similar to §1 except that using apps in science lessons to increase motivation was linked to the availability of hardware and the idea that apps deepened and broadened knowledge.

§3 This set of correlations would suggest that whereas apps are used in science lessons to increase student motivation, this will be dependent on how many years I have been teaching. 50% of the cohort had been teaching for more than 15 years. This is further linked to the perception of serious games as not being purely entertainment - 83% - and the link to the preference - 62% - that students would be mentored to develop their own resources.

§4 This is the same as §1, except that this 'cluster' was linked to Q29, which expressed whether teachers felt they sufficient hardware to teach science and thus increase motivation - 69% did not.

§5 This segment relates to specific content areas including the critical topic of 'biodiversity' pertinent to this paper. There was a significant correlation between Q13 through Q17 and Q19, Q20. Respondents typically found that if apps were considered or perceived as useful in teaching concepts in one topic, they were considered or perceived useful in other topics. Only a few teachers, considered each question on its own merits.

Table 2. The questions selected in the analysis in this paper.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Question text</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2</td>
<td>How many years are you teaching?</td>
</tr>
<tr>
<td>Q8</td>
<td>I use apps in my science lessons</td>
</tr>
<tr>
<td>Q9</td>
<td>I use apps to increase student motivation</td>
</tr>
<tr>
<td>Q10</td>
<td>I use apps to help students develop science concepts</td>
</tr>
<tr>
<td>Q11</td>
<td>I use apps to aid in formative assessment</td>
</tr>
<tr>
<td>Q12</td>
<td>I use apps to aid in science content drilling skills</td>
</tr>
<tr>
<td>Q13</td>
<td>I find apps most useful in teaching concept relating to MATHEMATICS</td>
</tr>
<tr>
<td>Q14</td>
<td>I find apps most useful in teaching concepts relating to CHEMISTRY / MATERIALS.</td>
</tr>
<tr>
<td>Q15</td>
<td>I find apps most useful in teaching concepts relating to PHYSICS / ENERGY &amp; FORCES</td>
</tr>
<tr>
<td>Q16</td>
<td>I find apps most useful in teaching concepts relating to BIOLOGY / LIVING THINGS</td>
</tr>
<tr>
<td>Q17</td>
<td>I find apps most useful in teaching concepts relating to THE ENVIRONMENT / ENVIRONMENTAL AWARENESS &amp; CARE</td>
</tr>
<tr>
<td>Q19</td>
<td>I find apps most useful in teaching concepts relating to BIODIVERSITY</td>
</tr>
<tr>
<td>Q20</td>
<td>I find apps most useful in teaching concepts relating to DIGITAL TECHNOLOGY / ICT</td>
</tr>
<tr>
<td>Q27</td>
<td>Serious games are entertainment, not tools for learning</td>
</tr>
</tbody>
</table>
Serious games are suitable for deepening and broadening knowledge.

One of the obstacles for me in using apps in teaching is the lack of hardware I need.

I would prefer to mentor my students in developing their own serious games / apps.

3.3 Multidimensional Scaling

Non-metric multidimensional scaling, MDS, also known as principal co-ordinates analysis, PCA, was applied to the transposed data matrix using the ASCAL protocol in SPSS Statistics v21.0, which uses the Takane-Young-de Leeuw S-stress – formula 1, and a plot was made of the emerging dimensions. The statistic allows any measure of similarity to be examined, MDS can use any distance matrix and as a result, the analysis focuses on the cases, the teachers: no information is provided about the contribution of individual questions answered [24]. Since the data are non-metric, they are interpreted as ‘distance-like’, but not actual distance. The aim of the MDS is to transform such data into a set of genuine Euclidean distances. The solution consists of an arrangement of points in a small number of dimensions, located such that the distances between the points represents the dissimilarities between the objects as closely as possible. In non-metric MDS, only the rank order of entries in the data matrix (not the actual dissimilarities) is assumed to contain the significant information. Hence, the distances of the final configuration should as far as possible be in the same rank order as the original data. Thus, the purpose of the non-metric MDS algorithm is to find a configuration of points whose distances reflect as closely as possible the rank order of the data.

It is important to note that a perfect ordinal re-scaling of the data into distances is usually not possible. What is required is optimal scaling. This involves finding a series of configurations, in which the inter-point distances have the closest conformity with the data. The question is, therefore, how to construct the best possible re-scaling? This can be done through monotonic regression, which involves the calculation of a new set of distances, usually called pseudo-distances \( d^{(0)} \), since they are not actual distances corresponding to any real configuration. They are also called fitted distances or disparities. The given dissimilarities \( \delta \) are used to generate a set of distances \( d \), which are approximately related to the given dissimilarities \( \delta \) by a monotonic increasing function \( f \). Note that only the rank order is important, and the scaling is ordinal. The most common approach to determine the elements \( d \) and the underlying configuration is an iterative process, commonly referred to as the Sheppard-Kruskal algorithm. A simplified view of the MDS algorithm is as follows [25, 26]:

1. Assign points to arbitrary coordinates in a p-dimensional space.
2. Compute Euclidean distances among all pairs of points, to form the DHAT matrix.
3. Compare the DHAT matrix with the input \( D \) matrix by evaluating the stress function.
4. Adjust coordinates of each point in the direction that maximally reduces the stress.

After determining the dissimilarity matrix \( D \) and the corresponding scaling matrix \( A \), an iterative process begins, which successively revises the dissimilarities and object coordinates until an adequate fit is obtained. The objective of the iterative process is to obtain a spatial representation in \( p \) dimensions such that the Euclidean distances among the objects are monotonically related to the original dissimilarities.

The iterative process comprises four steps:

- **Step 1 - Initial phase** - selects the dimensions (\( p \)) and determines the initial configuration and the resulting distances.
- **Step 2 - Non-metric phase** - uses monotone regression to relate \( d^{(0)}_{ij} \) to the \( d_{ij} \). The estimated regression produces a new set of dissimilarities, called disparities that are monotonically related to the \( d_{ij} \).
- **Step 3 - Metric phase** - revises the spatial configuration to obtain new distances, \( d^{(1)}_{ij} \), which are more closely related to the disparities, \( \hat{d}^{(0)}_{ij} \), generated in step 2.
- **Step 4 - Evaluation phase** - determines the goodness of fit of the distances, \( d^{(1)}_{ij} \), and the disparities, \( \hat{d}^{(0)}_{ij} \).

If the fit is not adequate, Steps 2 and 3 are repeated. The resultant plot is produced in Figure 4.

![Derived Stimulus Configuration](image)

Figure 4. Scatterplot of calculated dimensions from MDS of the teachers' responses
Apart from the outliers on the left hand side, nearly all the teachers belong to one large cluster. The blue arrow represents how the teachers increasingly used apps or thought them useful; and the red arrow represents how the teachers increasingly thought the use of apps in teaching problematic or irrelevant.

**Conclusion**

The results indicated the need to move away from app-use as an extra, and to embed digital technology within the 'standard' lesson. When we return to the hypotheses outlined in the introduction, and as the MDS analysis showed, the teachers tended to be on a 'spectrum' between believing apps to be useful on the one hand, or absolutely not, on the other, apropos hypothesis §1. Hardware appeared to be a greater issue for teachers than availability of appropriate apps, hypothesis §2. One final point, but pertinent to hypothesis §3, on the results is that anecdotal comments by participants suggest that teachers may have answered 'aspirationally'; i.e., they might state that apps are useful and their use is 'occasional' but over the course of several years, this might amount to 2 attempts, where the intention would be to use it more, since overall in spite of their own practice, there would be a belief that one should use them more. More research would be needed to build that into any data.

On the one hand, the results cannot be surprising; however, given that midway through the second decade of the 21st century 'traditional' didactics hold sway with ICT viewed as an 'add-on', little wonder teachers feel overloaded with the 'extra' workload. The results also indicate that biology, and biodiversity in particular, is poorly served by the use of digital technology in the classroom, the majority of teachers felt that apps were irrelevant to teaching concepts relating to the environment, ecosystems, and biodiversity. If this indeed the case, then investment in schools in digital technology has been a fundamental waste, since of anything a child learns, her relationship with the environment and life around him is fundamental. Lack of understanding of this 'primitive' will condemn much of the planet to adverse climatic phenomena including a significant mega-extinction unless all the resources at a teacher's disposal are put to full use to allay ignorance of the environment and active in environmental and biodiversity education.

**Acknowledgement**

This work is funded by the EU Erasmus Plus TEALEAF project: 2014-FR01-KA201-008559

The graphic in Figure 1. was obtained from [http://www.worldofsspectrum.org/infoseekid.cgi?id=0017720](http://www.worldofsspectrum.org/infoseekid.cgi?id=0017720)
REFERENCES


