Open Educational Practices in Scottish Schools

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Executive Summary

This pilot explores the use of simulated science experiments in secondary schools, specifically two small rural secondary schools in the West Highlands of Scotland. The partners were the Open University (OU) in Scotland, Open Educational Practices Scotland, OpenScienceLab (based at the OU), Education Scotland and Highland Council. It is influenced by approaches to practice based issues that focus on working together with partners to develop practical solutions.

OpenScienceLab provides a range of free and open virtual science experiments. Teachers looked at a range of these experiments and picked two they felt fitted best with the Scottish Higher curriculum and enhanced the learning experience, either by providing access to and the experience of using equipment, or novel approaches to integrating different parts of the curriculum they would not otherwise have.

While free to use these experiments they do not afford the freedom to be adapted, and questions arose around how we might ensure they matched the classroom context. The solution to these immutable learning objects was to contextualise by folding them into a learning journey. Thus they were wrapped into a series of face to face teacher led classes along with a step by step open online suite of materials – effectively blended learning. As the pilot developed it became clear that the freedom to use these experiments was not curtailed by the lack of adaptability, the important element in making it work was the ability contextualise.

The focus of most of our effort was on developing an approach that worked for teachers in the classroom. We also observed and recorded the use of the materials in the classroom, we were concerned that simulated science experiments developed for self-directed learners might not translate well to the classroom context where there are a different set of educational expectations.

The Biology experiment allowed pupils to consolidate learning at a critical time (exams were approaching) and provided access to equipment they would not otherwise have. The online and simulated nature of the learning experience was not an issue for the pupils, though interestingly the virtual nature seemed to make them more interested in how the machine worked and the relationship between people and technology in science. For the Chemists this was less about revising existing concepts and disciplinary knowledge and more about the interdisciplinary philosophy that sits behind Scotland’s Curriculum for Excellence (CfE). The pupils were working in teams and in some cases accessing from home, while the spectre of digital access and participation were raised it was noted as something that happened to “other people”.

This is a small pilot which focussed on developing a model “that works”. Further work is required to develop and test the model. Therefore the report recommends a more extensive pilot across a more diverse range of subjects with a more purposeful sample of schools in particular schools in urban and peri-urban areas and those located in areas with traditionally low access to Higher Education.
1. Introduction

This short paper explores the use of virtual and simulated science experiments from the Open University’s (OU) OpenScienceLab¹ in two remote rural secondary schools in the West Highlands of Scotland. It begins with some background to the pilot, looks at how the team from the OU in Scotland and Highland Council² approached the work, and discusses the outcomes of the pilot, before concluding with some reflections on what we might do next.

2. Background and Context

A great deal of the attention paid to Open Educational Practices (OEP) in schools has focussed on content; in the US this has tended to be textbooks (Wiley et.al 2012), and in the UK the sharing and use of free openly licensed “learning objects”³. Indeed our initial relationship with Education Scotland, the executive body of the Scottish Government in charge of supporting and inspecting quality, was about the use of Open Educational Resources (free and openly licensed content, henceforth OER) from our site OpenLearn⁴ within schools. However, alongside this ran a series of discussions about education, about the focus on the Scottish Schools Curriculum for Excellence⁵, on learning through inquiry across disciplines, and our own interest in inquiry based learning and open science (Scanlon 2012). In particular, how simulated and virtual experiments might be used in the classroom, specifically a suite of experiments developed by the OU on a site called OpenScienceLab. Our question was simple, would simulations designed for self directed distance learners work for secondary teachers in the classroom?

3. Methods and Approach

Through Education Scotland we were introduced to Local Authorities, and this led to a pilot being developed with Highland Council. Our experience of working with a wide range of stakeholders on Open Education has led us to approach relationships with organisations as partnerships. The partnership model allows the expertise of each partner to be recognised, supported and utilised (Macintyre 2013; 2014a). We draw heavily on the idea of design thinking in how we structure our

¹ OpenScience Lab is hosted here https://learn5.open.ac.uk/course/view.php?id=2
² Highland Council is the largest unitary authority by area in Europe, the West Highlands are sparsely populated with poor infrastructure and recognised as being an under-developed, see http://en.wikipedia.org/wiki/Scottish_Highlands
³ For example, see this recent conference in England, http://lccdigilit.our.dmu.ac.uk/2015/01/15/oer-schools-conference/
⁴ You can learn more here http://www.open.edu/openlearn/
⁵ You can find out more about it here http://www.educationscotland.gov.uk/learningandteaching/thecurriculum/whatiscurriculumforexcellence/
approach, in particular approaches to participatory design of educational systems that come from Scandinavia (Bjongvinsson et al. 2012; Sanders and Westerlund 2011). Our experience of using OER to co-design emergent learning journeys in the classroom (Macintyre 2014b) led us to emphasise the role of teachers and pupils as action researchers trying to solve practical problems by doing things. This means the focus is not testing what if it works but on the process of making it work and the educational usefulness of the solutions. This paper reports on two small rural secondary schools in the West Highlands and our relationship with two Principal Teachers and a set of Scottish Higher (S5/S6 16-18 years old) Biology (n=8) and Chemistry (n=22) pupils.

4. Discussion

In this section we look at the key themes emerging from our work. The focus is on developmental aspects, on the process as much as the outcomes.

4.1 Developing a Learning Journey

During the initial meetings we showed teachers (n=6) the experiments, and together we explored how they might work in the classroom. The first issue to address was curriculum fit. Teachers have a clear understanding of the curriculum and the capabilities of their students; they also understood what the curriculum meant in practice. We were fortunate in the pilot that the Project Officers had intimate knowledge of the experiments and had used them in their own undergraduate teaching practice. This meant moving beyond reflecting on a textual exercise based on mapping learning outcomes, to a more nuanced discussion about teaching practices, and considerations of what would and would not work.

On this basis the team selected two simulations, see Figure 1 and Figure 2. We spent some time exploring the students’ present learning journey, looking at how the simulations would fit. It became clear the simulations would not work as stand-alone resources. Teachers started mapping out the support pupils would require and the Project Officers were able to draw on the materials they used in their teaching practice. Some of these materials were not presently in the open but part of the OU’s closed accredited curriculum. The OU has a clear policy on the release of closed material into the open through its OpenLearn platform. Though many of the images were the same, textual materials were a base and highly contextualised through an iterative process of documents being shared and revised. Revision was not simply about text, but how the text

6 While this is about process we have left out many of the details relating to the unique issues relating to getting “external” websites to work within schools. We are grateful to the schools, the Local Authority and the OpenScienceLab team for their patient assistance.
operated in the world. The context of the classroom rather than the distance learner was important in designing a learning journey, but so was the sense of equality of experience for those not able to be in the classroom. In the end we designed a learning journey that was a mix of face to face lesson plans and heavily remixed material from the experiments’ original context. In essence, blended learning. We used our openly licensed “sandbox” platform OpenLearnWorks to wrap the materials round the simulations in OpenScienceLab – see Figure 3.

![Figure 1: Analysing DNA using Polymerase Chain Reaction (PCR) to identify Genetic Variation](image)

The polymerase chain reaction (PCR) is an important tool in biology, medicine and in forensics. Each of us holds the genetic description of ourselves in the “double helix” DNA of most cells in our bodies. The genes that direct our bodies at a molecular level are sections of these DNA chains. Often, we have multiple copies on an individual gene – which be the same or they may be different. This genetic variety affects our susceptibility to illness. It means that we differ in our responses to medicines – both in effectiveness and in the side-effects.

The polymerase chain reaction puts DNA plus chemicals through a cycle of temperatures over several hours to generate billions of copies of the selected gene. The machine uses light to monitor each sample during the procedure. This PCR experiment takes the student through the steps of the procedure. They (virtually) prepare the batches of chemicals for the work – each DNA sample has to be packaged with some enzyme, specific chemical markers for identifying the gene on the DNA, and the raw materials for constructing new DNA. The students will also set up some control samples, which will have known
numbers of copies of the gene. These help in the interpretation of the results. They load a batch of samples into the virtual PCR machine, and run the thermal cycling. In the virtual world this takes only a few minutes.

Students observe the development of data from the samples. From their collection of data, they can look at the outputs from individual samples or groups of samples, and determine numbers of gene copies or even the numbers of specific variants of the gene. So the students are able to see directly the genetic differences between individual people.

- Planning and undertaking practical investigations, testing hypotheses and analysing results
- Applying knowledge, understanding and skills in unfamiliar contexts
- Developing an approach to problem solving through applying scientific inquiry, scientific analytical thinking and problem solving skills
- Processing information using calculations and units
- Developing skills of independent working
- Developing an understanding of biology's role in scientific issues and relevant applications of biology, including the impact these could have on society

The PCR experiment is appropriate for Higher Biology and Higher Human Biology in Scotland’s Curriculum for Excellence. Students gain an appreciation of the nature and use of the expensive PCR instrument, in a time-efficient, free and safe way. The experiment helps students develop insight into the fundamental process of DNA replication and into how an individual’s genetics affect their health and the suitability of medical treatments. They gain skills in relating tabular and graphical outputs from the experimental apparatus to characteristics of the genome.
Figure 2: Analysing pesticides in the environment using GC-MS (gas chromatography with mass spectroscopy)

An experiment for Higher Chemistry students

This experiment uses the techniques of gas chromatography and mass spectroscopy to analyse pesticide content in the water of a tidal bay in China. Students develop their own hypotheses about how pesticides are distributed across the bay and test them by devising a sampling plan. The analysis is both qualitative and quantitative, involving matching samples with a library of mass spectra and calculating concentrations using the gas chromatograms.

The associated materials look at the principles behind gas chromatography which form part of the Scottish CSE Higher Chemistry Curriculum. Additionally, students learn a little about mass spectroscopy, giving them a taster of studies at a higher level. The associated materials also ask students to examine the chemical structure of the pesticides, so revising the ideas of structural and molecular formulas and valency. Environmental issues associated with pesticide contamination are also touched on.

By working through the investigation, both the experiment and associated materials, students will learn about the techniques of gas chromatography, mass spectroscopy and their uses. They will also consolidate their understanding of chemical formulas and valency. The activities develop a number of key skills including:
• Planning and undertaking practical investigations, testing hypotheses and analysing results
• Applying knowledge, understanding and skills in unfamiliar contexts
• Developing an approach to problem solving through applying scientific inquiry, scientific analytical thinking and problem solving skills
• Processing information using calculations and units
• Developing skills of independent working
• Developing an understanding of chemistry’s role in scientific issues and relevant applications of chemistry, including the impact these could make in society and the environment

In the context of the CfE Higher Chemistry Curriculum these skills all form part of the assessment criteria. They will particularly benefit students as they approach the ‘Researching Chemistry’ unit, and will also prepare them for tackling problem solving exam questions.
4.2 Use and ReUse Value

In addition to aligning with the curriculum and fitting open content into classroom practice we also needed to address where learners were in their learning journey. This was woven into the design process, but it is worth teasing out here. In Biology the pupils had already covered DNA and sequencing which was the basis of the experiment (see Figure 1) in the classroom. The pilot sessions ran just before the winter break and the Higher Preliminary Exams. It was revision, but revision through a different lens, rather than repetition, pupils needed to refresh and apply existing subject knowledge to an experiment that they knew “in theory but not in practice”.

What we observed was that pupils moved quickly through the content in the classroom, sometimes quietly reading, sometimes asking their teacher but often talking and discussing items with their peers. When it came to the simulation things slowed, pupils became less certain and more curious. In developing the journey we had focussed on content that supported the interpretation of the results. What we did not anticipate was the questions about the PCR machine. We had provided support on the why and some on the what, but not enough on how it performed these functions, the mechanics of it. Afterwards we reflected that even though the simulation was mediated through a PC, pupils were thinking about the embodied actions of doing the experiment and the socio-material relationships (Fenwick 2010). The experiment is a simulation, it is about computers in classrooms, but in projecting the learner into the lab it seemed to have highlighted distance and the lack of materiality in a useful way. The learners wanted to cross that distance, through learning more about the machines. To use an analogy from the visual arts, closing that interpretive space becomes part of the experience (Clark 2006), of the learning journey, and something we need to account for in future iterations.

The chemists knew most of the scientific processes (see Figure 2) but were unfamiliar with the context and some of the ideas. Just as we had done for the Biology class we created a suite of online materials based on the revised content from the formal curriculum. As well as this textual wrapping the teacher felt the unfamiliarity and the interdisciplinary nature meant that pupils needed to work through the ideas in detail in the classroom over a number of lessons. They were grouped in pairs and worked together; generally in the classroom, though some also worked at home. The teacher had embedded the process and the simulation guidance in a series of lessons; the unfamiliar area was interpretation of the results and inter-disciplinary knowledge. As we looked at the results what emerged in the classroom were a series of discussions on Estuarine pollutants that drew on ideas of flows from Physics, on landforms from
Geography, and of environmental impact from Biology. These varied with each encounter as different pupils were more or less familiar with ideas from these subjects, so each brought a different perspective. Reflecting on this afterwards we realised that each of us brought different things, as between us we covered these disciplinary areas. We were left with a question, ought we to go back and revise again based on our observations of teaching practice, or given the context, a teacher in a classroom, do these “gaps” create a useful space for discussion. It is our sense, just as for the PCR example above, that they do, and rather than add in extra, we ought to look at how we build on the lesson plans and produce a “teachers’ pack” with material to aid those discussions.

4.3 Its Online so What

Alongside our observations and ongoing conversations about the learning journey, its form and function and how it might be reformed, we also wanted to look at how the pupils experienced and understood online learning. What was interesting was the non-response; it was as if we had asked if they liked sitting on chairs. Pupils volunteered issues, for example, poor rural broadband meant some people might not be able to access it, or lack of home access to PC’s. Though when you asked for examples, aside from one pupil whose parents did not allow home access, it was something that happened to other people elsewhere. Indeed it seemed like the pupils were pulling out abstract examples of digital exclusion to meet our expectations rather than to represent their experience. It was a normal way to learn and as rural residents it might be constrained by infrastructure or socio-economic factors, but for them the question was never pedagogic,

Our sense was the pupils saw these online resources as an extension of the classroom. The computers were part of the socio-material assemblages (Fenwich 2010) in the class, creating a binary separation between learning in the classroom and learning on the screen lacked meaning. One might be tempted to evoke the idea of “digital natives”, however, a more useful frame is to think about digital residents and digital visitors (White and Le Cornu 2011). Perhaps extending the metaphor to reflect on what constitutes an educational space, and coming to think of these online resources as part of the physical spaces we occupy as we learn (Macintyre In Progress).
5. Looking Forward

We learnt some very practical things through this pilot. Early on we learnt that while these online simulations were free and open, the degree to which those freedoms could be exercised was constrained. These constraints were not just technical but mostly contextual, they related to teaching practice, to imagining how they might be used. As an open object an experiment or simulation is very different from openly licensed textual content, it cannot afford all of the 5R's; for example often functionality is based on a structural integrity that means it cannot easily or affordably be revised or remixed. While the OpenScienceLab could possibly have changed the experiments, we wanted to learn by doing what typical open users might do, therefore we did not use our privileged access and tried to act like any other user. We learnt about the use of these found objects through the classroom, through the teachers and through the pupils, our focus was not on the technical barriers to use and reuse practices, but on the pedagogical solutions.

Our solution to an immutable learning object is a simple one, wrap the simulations in a VLE based learning journey. However, this was not just a fix for a simulation that was open for use but not for remixing, it was about how it might be used. We noted that in openly releasing objects we often free them from their context, in decontextualising and releasing things openly we might actually rob the learning object of its usefulness, and restrict the freedoms we wish to promote as we remove the cues that allow educators to interpret them within their own teaching practice. The lesson for us was the importance of context; in releasing things openly we need think about the educational contexts in which they might be useful and used. This is not a call for the creation of highly contextualised OER, rather it is observation on how we place free and open content, its place, its role is for doing (Kemmis 2010), and if we are to realise educational freedoms afforded by openness we need to address educational practice directly. In addressing those educational practices we can begin to see what Open Educational Practices ought to explore and it is clear as the OEP/OER field matures we need a sharper focus on the practice of education (Macintyre 2014a; 2014c). This means engaging in practice based research, a focus on doing things that help us unpick how to enable openness and what openness enables.
6. Recommendations

The pilot was took an iterative approach to investigating the role of virtual experiments in the classroom and working with teachers looked for practical solutions. However, this was a relatively small pilot aimed at developing an approach “that work”. Based on discussions with Education Scotland and Highland Council we make the following recommendations:

A more extensive pilot Scotland’s Central Belt using a purposeful sample technique to ensure we cover a broad range of curriculum “pinch points” and a broad range of school contexts. In particular urban and peri-urban locales and communities where participation in Higher Education is traditionally low.

Share what we have learnt from this phase, sharing the lesson plans and approaches on the education network Glow, and working with Highland Council's to run workshops at Principal Science Teachers to cascade these through Highland Schools.

7. Acknowledgement

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8. References


- (In Progress) Towards a ReSpatialisation of Learning Design


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