Informing course development practice through scholarly exploration

R. Alexandersson, B. Svensson, and S. Andersson, *Uppsala University, Sweden*

ABSTRACT: Development of digital technologies is changing the educational landscape, providing opportunities for new learning experiences. In the natural sciences this includes the ability to replace or complement traditional practical exercises with a virtual reality (De Jong, Linn & Zacharia, 2013). Introducing novel digital tools is becoming a common part of course development at universities, but how well does it work? Do learning activities enable intended goals? This project exemplifies how scholarly investigation can inform and improve course development practices.

The major innovation on the biology course explored in our study was complementing a field session in a nearby forest with a virtual exercise in a computer laboratory using a simulated forest. The intended goal for both sessions was learning methods for sampling species distribution in different habitats. Student and instructor practices during sessions were video recorded, transcribed and analyzed. This allowed us to explore if, and in that case how, students engaged with intended learning objectives in their practice.

During start-up of both sessions, students expressed uncertainty about the intended goals of the activities, which indicate that clearer instructions are needed. This sometimes resulted in a student practice only remotely connected to the intended learning goals, especially during the field session. Both sessions were designed as student-centered learning activities. However, our analysis showed that practice in the field often reverted to a traditional lecturing pattern when students interacted with the instructor. Students were more focused on the intended learning objective during the simulation exercise. They discussed the methodology in detail, but generally without connecting to previous practical experiences or a broader disciplinary context. Our analysis shows that both sessions provide valuable learning opportunities, but that the virtual session should be scheduled first and that both sessions need further development regarding instruction and framing.

1 INTRODUCTION

In teaching is it important to understand how the learning processes may work in different situations, to increase the possibility for a positive outcome. The teacher will by his or her action (on purpose or accidentally) direct students in different ways during a lesson or a teaching sequence (*e.g.*, Lundqvist 2009, Lidar 2010). The teacher has a major role, but also artefacts (Lidar 2010) and the teaching environment (such as outdoors, in the laboratory or in a virtual reality) may direct the students' learning process and therefore affect their achievements. Marton and Booth (1997) introduced intended, enacted and lived objects of learning to discuss why intended goals of teaching do not automatically turn up in the students' heads.

A number of studies have shown that the teacher's aim might be hard to communicate to the students (*e.g.*, Kathard *et al.* 2015) as a result of the often monologic interactions between teacher and student. One way to move away from this is to introduce alternative teaching methods. For example, the development of digital technologies is changing the educational landscape, providing opportunities for new learning experiences. This gives the possibility of making intended goals of teaching more accessible by allowing novel ways for students to approach the subject and thereby changing their perspectives in a positive manner. Thus, digital technology introduces the possibility to replace or complement traditional practical exercises with virtual reality (de Jong *et al*. 2013).

Teaching in natural sciences, such as biology, generally contains practicals, such as laboratory exercises, in combination with theory (lectures and paper discussion seminars). For many teachers and biologists these practical elements are essential and more or less define the subject. It is also very much motivated in the curriculum throughout our education system.

In ecology field trips are traditionally considered to be an important part of the curriculum. For example, vegetation analyses are a common exercise during field trips where students try to understand plant species distributions in relation to the biotic and abiotic environment. Why are some species more common than others? Why is this species so abundant and another present only with a few individuals? To be able to answer these questions students collect data during their field trips and do follow-up statistical analyses back in the classroom.

Outdoor teaching is often said to have a great potential for learning, as all your senses will be involved in teaching (Dahlgren and Szczepanski 2004, Szczepanski 2007). Studies have indicated that field trips are positive in terms of social relationships among students and between students and teachers (Fields 2009), understand scientific work (Fields 2009) and positive for "environmental attitudes" (Magntorn and Helldén 2007, Ballantyne and Packer 2009, Ballantyne *et al*. 2010). However, few studies have actually demonstrated that students learn more (but see Hamilton-Ekeke 2007).

There are some problems with outdoor teaching that are often mentioned in interviews with teachers, *e.g.*, it takes time, less control, no good field sites nearby and that the teacher does not feel comfortable in the environment (Rickinson *et al.* 2004, Tilling 2004, Lock 2010). A group of students that encounter non-classroom teaching is often more heterogeneous in their former experience of such teaching (Ballantyne & Packer 2009), compared with classroom teaching. This may result in different outcomes because of different starting points for the students. Interestingly, different outdoor experience may make the outdoor environment work as a selective agent by itself, by navigating students in various directions. The outdoor environment might for some students be more of holiday, picnic or relaxing, while for others it can be more scary with nasty animals (such as mosquitos, wasps), freezing cold or wet and swampy and for a third group amazingly interesting. To summarize, it might be less of a teaching arena for many students and either way the value of the outdoor environment as an arena for good learning will differ between students.

There have been a number of attempts to do virtual laboratory exercises (*e.g.*, Reece and Butler 2017), where students experiment in a controlled setting with the possibility to go back and repeat certain steps without ruining their samples. Although laboratory work is important in science teaching it is often discussed how it should be done and how much it is actually worth in terms of theoretical knowledge (e.g. Abrahams 2009). However, few attempts have been made to compare real forest trips with virtual forest exercises and we feel that a similar discussion is warranted for these kinds of learning activities (but see Rickinson *et al.* 2004).

In our project, we compare and discuss student and teacher behaviour during a field trip in a real forest and a virtual forest exercise on an ecology course. Our initial aim was to provide a scholarly foundation for further course development.

2 METHODS

This study was done during a teacher training course in Biology and science at Uppsala University, Sweden. We followed the students during the population- and landscape ecology part (October 2016) in their first biology course: *Biology A: patterns, processes and didactics 22,5 credits* (1BG026). We filmed and took audio recordings of indoor and outdoor practical exercises as well as the lecture associated with these. Students and instructors were informed about the project and gave their consent to be documented. We recorded both students and instructors to make correlations between student reflections, comments and discussions with teacher interventions.

Before the practical exercises the students had lectures in population and community ecology to get the necessary background for ecological field studies, as well as for the computer lab. In this aspect all the students had the same background. However, some students had previously taken a course in floristics and were therefore more skilled than other students in plant species identification.

In the first practical session the students did a vegetation analysis in a nearby forest; this has been a regular part of the course. The second practical session was a virtual study in a computer laboratory, which had been introduced for this instance of the course. In both exercises the students investigated plant species distributions by sampling a number of plots and noting each species' presence/absence and frequency for each plot.

Fig. 1. Students in the real forest

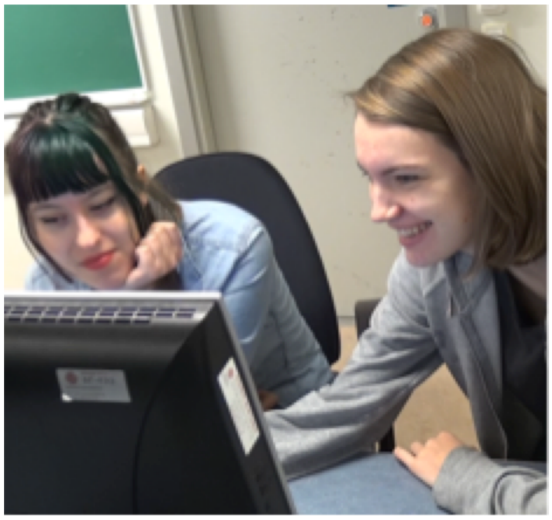

Fig. 2. Students working with the virtual forest

In the real forest the class were divided in four groups (3-4 students/group). Vegetation analysis was done along a transect stretching from an old clear-cutting into a coniferous forest. In six plots (0.5 m × 0.5 m) along the transect the students identified different species and noted their abundance. Each group also documented and named all trees growing within two metres on each side of the transect. Light intensity and humus (soil organic matter) depth in each plot were also measured.

In the computer laboratory, the students worked in pairs engaging with a virtual forest. They were also shown a map of a forest together with photos to visualise it. The exercise was developed at Bucknell University and is based on sampling of North American tree species (Abrahamson & Weaver, 2015). By varying how plots were selected (haphazardly, randomly or systematic) the students could compare the result of the three sampling techniques with the actual number of tree species. The website also contains information about the different tree species in the forest; making it possible for the students to make ecological conclusions regarding tree species distributions.

Both exercises were video-recorded. In the real forest we used one hand-held camera only allowing us to film one group at a time. However, as all work was repeated a number of times it probably did not have any marked effect for the results. In the virtual exercise, students worked in pairs and four pairs were filmed simultaneously with four cameras arranged on tripods. This gave us the possibility to film from start to end of the practice.

Films were transcribed and qualitatively analysed. The practice of students and instructors was iteratively coded to identify common practices and recurring patterns.

3 RESULTS

Our analysis identified five major practices occurring during the sessions:

- discussions on practical questions
- discussions relating to the aim (ecology and sampling strategies)
- solving the problem by themselves
- interacting with the instructor
- dealing with identification of plants

By comparing how these practices occurred, we could identify differences between the two sessions. In general students were more subject-oriented in their discussions when working in the virtual forest compared to the real forest.

3.1 Real forest

The practice in the real forest was primarily concerned with practical issues. The exercise contained many, especially for first-year students, unfamiliar practical moments, such as placing transects and plots or estimating plant abundance. Although these activities are central to the sampling practice, students rarely discussed them, but often struggled with practical problems. This was further enhanced by the weather in the forest where it was quite wet. Experienced students would have been prepared for this, for example by bringing water-proof paper and pencils and by being properly dressed. Practical issues dominated the discussion between students, such as:

> "One of the things I hate most is wet forms"

In other situations the discussions were quite active. However, the focus was on *what* students were supposed to do or *how* they should do it, instead of *why* they were doing it. This is exemplified by a discussion about which trees to measure that turned out to be quite chaotic:

> Student A: We shouldn't measure them, just count
>
> Student B: one, two – two spruces
>
> Student A: (points at a tree) that one is also…mm…that's also…
>
> Student C: one, two, three, four spruces
>
> Student A: All of these behind the spruce we should also include because they are two metres
>
> Student C: Rowan. One rowan.
>
> Student B: Two junipers
>
> Student D: But, they are not two metres
>
> Student B: mmm
>
> Student D: How many rowans? Was it one rowan?
>
> Student A (towards Student D): Is there time for you to write?
>
> Student D: NO, I have no idea what we are counting now. Is there one rowan? Does that mean that there is one rowan or that you are counting rowans?

This example illustrates how two students (B and C) focus on different things to count (rowans vs junipers) while the other two students (A and D) focus on the method (which trees to count). There are no comments regarding why there are these three species growing together, *i.e.*, ecological patterns and processes.

Much time was spent on identifying plant species. In some groups more than one student had studied floristics. This turned sometimes out to be problematic, as they were discussing details about how to distinguish species, while the other students, less skilled in floristics, were just standing inactive.

Despite the aim to be student-active teaching it often turned out to be fairly traditional. Students often called the teacher for help instead of discussing within the group and try to solve problems by themselves. It often turned out that the teacher provided the answer instead of challenging the students.

3.2 Virtual forest

The exercise started with a long period where the students read the instructions. They often returned to the manual, all along the excercise, to be able to move further in the exercise. It was interesting to note that students more often made comments related to ecology in the virtual lab than in the real forest. The teacher was not called upon as often as in the real forest. During the sampling of trees and reading the characteristics about the species they referred to earlier lectures in community ecology.

> "…shade tolerant…ahh…wasn't it like that, that late succession species were more shade tolerant…"

They also discussed processes referring to ecological theory.

> Student A: "constant disturbances will stop the natural succession"
>
> Student B: "Yes, and we will only see the early ones" [*i.e.*, pioneer species early in succession]

The connection between the virtual forest and a real forest was not clear for the students. Species in the exercise were sometimes treated as actual species, but mostly as just digital markers. In this situation students said: "*There is a blue one*" or "*I want a blue*". There were almost no instances where students referred back to experiences from the practical exercise in the real forest

This indicates that it is important to increase the connection between these two exercises.

4 DISCUSSION

From the perspective of an instructor, this project exemplified how a scholarly investigation of course practice can be a valuable tool for professional reflection. It is very valuable to see how your students are acting when they are left alone, as well as observing yourself in the teacher role. Our analysis showed that interaction with an instructor often turned the practice into a traditional teaching situation, despite the aim of the sessions being practical exercises with active student engagement. This illustrates the importance of being aware of you own behaviour during teaching. You may, as teacher, have a view of your own way to acting and interacting. Scholarly reflection, assisted by the video recordings, enables you to become aware about, reflect upon and improve your way to teach and interact with students.

For course developers, the study provides valuable information on how the curriculum works and how it could be improved. Analysis of the recorded practices revealed that the intended learning goal for the students was not fulfilled with these two exercises. Most time was spent on practical issues, while the idea was to study and get a better understanding of ecological patterns and processes. The students worked actively but they were not prepared enough for the intended work, which was revealed by both filmed exercises.

Students discussed ecological theory to a larger extent in the virtual lab than in the real forest. From the recorded discussions we conclude that this was due to the many obstacles encountered in the field. Instead of the intended learning regarding ecological theory, it provided students with experience in how to handle practical issues, such as wet notepaper and measuring tools. Interestingly enough, students reported after the course that they appreciated the outdoor exercise much more and they claim to have learnt more from this than from the virtual exercise.

The connection between the two exercises was not clear for the students. There was hardly anyone connecting the virtual forest to a real forest or experiences from the outdoor exercise. Our analysis shows that both the real and the virtual forest provide valuable learning opportunities, but these need to be better coordinated. The outdoor session contains so many new tools and new practices, which makes it important for the students to be more prepared. A number of studies have shown that combinations of virtual and real laboratory can enhance learning compared to either only a virtual or a real exercise (de Jong et al. 2013). Toth et al. (2009) tested if the order of the exercises were important in a DNA-lab and found a small, but not significant, difference in the post-test for students starting with the virtual lab compared to students starting with the hands-on lab. However, students in their study were very positive to both exercises.

In our studied course, we think it might be well worth to first let students work with the virtual exercise to make them better understand how different sampling techniques affect the result. Although sampling might be new for the students, the virtual environment (*i.e.*, in front of a computer screen) is for many students more familiar and makes it easier to focus on the intended goal. By introducing the tools for the outdoor exercise and discuss how and why this is to be done before going out might help the students to focus more on ecology and less on practical issues in the outdoor setting.

In a broader perspective, this study exemplifies how different settings affect student practice. The use of research methods to document and analyse what actually occurs can be of great value both to enhance the professional reflection of instructors and to inform course development practice.

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