Active learning and course alignment in thematically complex courses

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ABSTRACT: Over recent decades, natural sciences have become increasingly interdisciplinary, where global change biology and conservation are two examples taken from a range of disciplines that all call for integration of scientific knowledge (Porter and Rafols, 2009). Indeed, the success of complex environmental problem solving is often mirrored by the cross-disciplinary collaborative capability of scientists. However, despite an apparent concomitant need, knowledge of teaching and learning in interdisciplinary higher education is limited (Spelt et al., 2009). Previously, it has been documented that students have problems embracing and integrating knowledge across disciplines (Bradbeer, 1999), which may confront the development of such thinking in higher education. Focusing on teaching in Arctic natural sciences, we provide a selective overview of potential educational tools based upon the theory of Biggs (interacting system: student, learning environment, learning process, learning outcomes) (Biggs and Tang, 2011), for improving the processes of active learning and course alignment in more complex, boundary-crossing courses with multiple instructors and significant field components. We will present a selective view of actual implementation of relevant tools in three different bachelor-level classes at The University Centre in Svalbard, Norway. The classes represent widely different disciplines in the natural sciences of the Arctic covering environmental management, marine biology and snow and ice physics. Existing alignment tools include weekly course notes that are delivered to students that recapture material from the previous week and link ahead to the current week with an overview schedule, list of readings, and relevant notes from the instructor. A learning goal matrix, that links specific learning activities with overarching course goals, is used to align learning activities and assessment methods. These are found to be useful tools for communication between the course responsible and guest lecturers, as well as for outlining expectations to students and helping them understand the motivation for different learning activities. We aim to stimulate a discussion around the unique challenges and opportunities for teaching and learning in the remote Arctic field settings encountered in these courses. We believe many of the tools are relevant to other disciplines and will engage in knowledge sharing with the conference participants.

1 INTRODUCTION

Recently natural sciences have become increasingly interdisciplinary, where global change biology and conservation are two examples taken from a range of disciplines that all call for integration of scientific knowledge (Porter and Rafols 2009). Indeed, the success of complex environmental problem solving is often mirrored by the cross-disciplinary collaborative capability of scientists. However, despite an apparent concomitant need, knowledge of teaching and learning in interdisciplinary higher education is limited (Spelt et al. 2009). Indeed, it has been documented that students have problems embracing and integrating knowledge across disciplines (Bradbeer 1999), which, in turn, may confront the development of such thinking in higher education. The ability to provide optimal constructive alignment may become a rather significant component in thematically diverse courses.

Aligning learning outcomes with assessment strategies through the established learning environment are at the heart of providing optimal quality teaching at university (Biggs and Tang, 2011). Specifically, constructive alignment in teaching connect the constructivist theory with outcome-based teaching, explicitly linking intended learning outcomes to assessments and evaluations through the learning environment (Figure 1a) (Biggs and Tang, 2011).

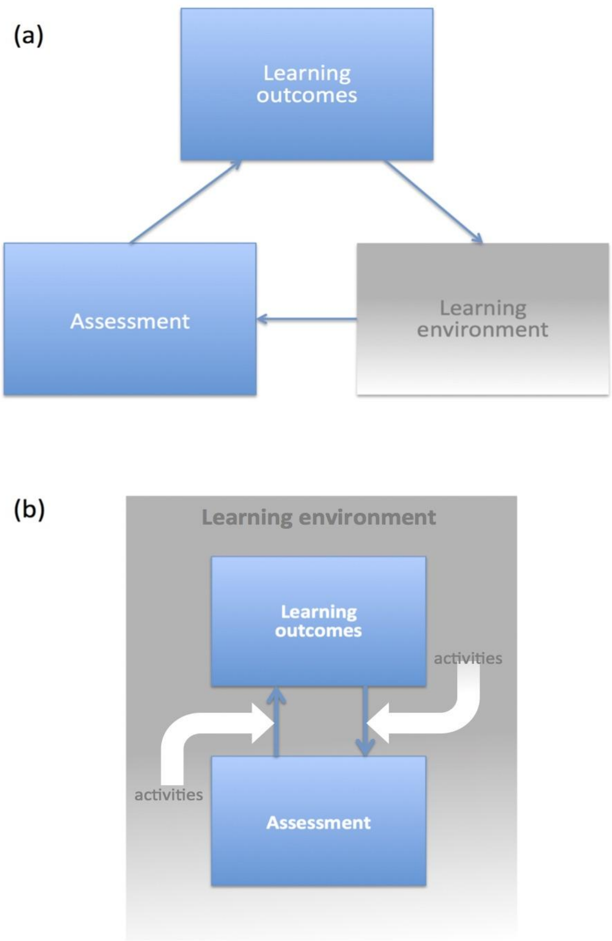

Figure 1. (a) Constructive course alignment in teaching showing the classic connection between learning outcomes (intended), learning environment, assessments/evaluation to actual outcomes. (b) Alternative representation of how the learning environment sets the learning outcomes and assessments through the present faculty and their scientific settings for the course. Course alignment is suggested to happen through the specific teaching activities provided by the learning environment. Hence, activities established by the learning environment may be integrated with course assessments.

However, instead of considering the learning environment as a separate component connecting outcomes and assessments (Figure 1a), we suggest that the learning environment is a much more integrated property of course alignment embracing the interlinked dynamics of learning outcomes and assessment (Figure 1b). Specifically, course alignment is suggested to happen through the specific teaching activities provided by the learning environment. Hence, activities established by the learning environment may be integrated with course assessments or, in fact, become part of the assessment.

Below we present and discuss learning activities used in three different BSc courses offered by the University Centre in Svalbard (UNIS) aiming at improving teaching through increased course alignment. The UNIS courses, AGF-212 Snow and Ice Processes, AB-202 Marine Arctic Biology and AB-203 Arctic Environmental Management cover a wide range of thematically diversity of subject taught. The courses represent widely different disciplines in the natural sciences of the Arctic covering environmental management, marine biology and snow and ice physics. Existing alignment tools include weekly course notes that are delivered to students that recapture material from the previous week and link ahead to the current week with an overview schedule, list of readings, and relevant notes from the instructor. Preliminary experience with the flipped classroom model has proven promising. A course learning matrix has been developed and tested as a tool for aligning and coordinating course goals and learning objectives delivered by different guest instructors, a unique feature of the teaching environment at UNIS.

2 A COURSE LEARNING MATRIX AS AN ALIGNMENT TOOL

The course AGF-212 Snow and Ice Processes is a bachelor level course that focuses on the Arctic terrestrial Cryosphere and its interaction with the ocean and atmosphere, with an emphasis on glacier dynamics and snow avalanches. The course begins with 6 weeks of classroom activities (lectures, written and computer exercises, discussions) that culminates in a week of field work on local glaciers. Data collected in the field is then analyzed by the students in pairs or small groups, with each group writing a research report that is handed in at the end of the course. The classroom activities are designed to link directly to processes that are observed and measured in the field.

To achieve an alignment of the course goals across the classroom and field activities, and to ensure that they are directly linked to the summative assessment, a "Course Learning Matrix" was introduced (Table 1). Five different Course Goals were delineated, the first three of which are addressed in the classroom phase of the course. These goals divide along disciplinary boundaries, which facilitates instruction from disciplinary experts that are each responsible for one week of guest lecturing. The Learning Matrix is shared with the guest lecturers to give them an overview of the specific learning objectives that they are responsible for, as well as the context of their instruction within the course as a whole. Following the field work, each guest lecturer/instructor is involved in advising students in the analysis and visualization of their field data and the writing of their research reports.

The Course Learning Matrix is communicated to the students at the beginning of the course. Prior to the final exam, the matrix is discussed again with students and framed as a study guide. The students are told that exam questions will be tailored around the listed learning objectives, each of which can be linked back to specific learning activities in the course. The exam questions themselves are written in collaboration with each of the guest instructors, with attention paid to the fact that the students' expectations are framed by the matrix. In this manner, the Course Learning Matrix serves as a framing tool that offers guidance to both students and instructors throughout the course. This promotes the principle of constructive alignment, in that the careful selection of verbs in the course goals and learning objectives clearly suggests specific forms of both instruction and assessment.

The matrix identified in Table 1 has been in use for 2 years in AGF-212 at UNIS. In each case, following the completion of the course the matrix has been revisited and revised as a reflection activity. Individual learning objectives have been modified or replaced when it has been clear that students failed to achieve them, either through a divergence between the learning activities and the learning objective or simply as a result of a poorly articulated or measurable objective. Although individual guest lecturers might stray from the specific objectives outlined in the matrix, experience thus far has shown that this framing tool helps to link together the activities of the different instructors, who do not otherwise overlap and who might otherwise not be aware of what learning activities and topics the students have experienced prior to their arrival. The matrix provides a concrete set of expectations for both the instructors and the students, and has been well received since its implementation.

3 ACTIVE LEARNING AND ALIGNING ASSESSMENT WITH LEARNING OUTCOMES

The course AB-202 Marine Arctic Biology is a 15 ECTS bachelor course which gives the students an introduction to the most common arctic marine organisms and their adaptations to the marine arctic physical and biological environment. In addition to acquiring theoretical knowledge at different cognitive levels, the intended learning outcomes from the course include skills and general competencies such as being able to sample, process and analyse marine ecological data, problem solving, and communicating results to the scientific community. The learning activities include classroom activities (lectures, discussions and student presentations), laboratory activities, and field sampling along with analysing and reporting on the results obtained during the field cruise. Whereas the learning outcomes and activities are fairly well aligned, the course assessment was previously purely summative with a written, graded test. To sit for the test the students had to have their field report approved, but the report did not contribute towards their grades. The incongruencies between the learning outcomes and activities with the assessment probably limited student learning (cf. Biggs & Tang, 2011), and it was remarked upon also in student evaluations that they would like not only their theoretical knowledge to be graded. Aiming to improve student learning by a better alignment of

	Course Goal	Related Learning Objectives			
Course Responsible	*Summarize* the scientific consensus and *argue* about the truth and importance of climate change in the Arctic	*Differentiate* between dominant processes and scales of change in the Arctic and Antarctic	...	...	...
Guest Lecturer 1/2	*Observe* the processes of snow metamorphism and their link to snow mechanics and avalanches	*Predict* the thermodynamic evolution of a snowpack based on snowpit observations	...	...	...
Guest Lecturer 3/4	*Examine* the processes of glacier dynamics and feedbacks with the ocean and atmosphere	*Apply* a surface mass balance model to study the impact of climate change on a glacier in Svalbard	...	...	...
Field Work (2-3 Guest Field Instructors)	*Demonstrate* field skills in Arctic snow and ice research	*Dig* a snow pit and *classify* snow stratigraphy following international standards	...	...	...
Remote assistance from all Lecturers	*Integrate* data collected in the field into a scientific research report	*Teach* fellow students about component-level expertise gained in each group project	...	...	...

Table 1. Format of Course Learning Matrix used in AGF-212 Snow and Ice Processes at UNIS. Verbs associated with specific course-level and lesson-level objectives are indicated in italics. Each Course Goal is associated with 4-5 Related Learning Objectives; one example for each is shown here for illustration.

assessment and learning outcomes, more of the students´ acquired skills and competencies were assessed and also included in their final grade. In addition to the final test (which counts 50% of the grade), the students cruise reports were graded (counting 20% of the grade) as was an additional task of preparing a poster based on data the students themselves obtained, analysed and presented (counting 20% of the grade). All students had the possibility to get feedback on earlier versions of both the cruise report and the posters prior to preparing the final version which was graded. The improved alignment between the learning outcomes, the learning activities and the assessment allowed assessing more of the intended learning outcomes than purely theoretical knowledge. In their evaluations, the students commented that in addition to the assessments better evaluating their knowledge and skills, the changed course assessment improved their learning as well as the learning environment.

As student active learning methods have been shown to improve learning, a potential improvement of the AB-202 learning environment was to test how a flipped classroom approach would work compared to a traditional lecturing approach. For this experiment, it was focused on a topic that students often find difficult to understand. Prior to the classroom time, the students were asked to prepare for the class by looking at three short (8-9 min) videos covering the topic. In addition the slides discussed in the videos and the curriculum (a book chapter) was available. For the classroom activities, the students were divided in groups (4-5 students in each group). The groups were presented data of relevance to the topic from an ongoing UNIS research project. The students were asked to describe/discuss the data, and were given a total of 7 questions for group discussion. The students discussed in groups and shared their discussions with the class afterwards. This approach, using problem-based learning in a flipped classroom setting, led to more classroom discussions than in any previous class covering the same topic. The students showed strong interest in the topic, discussed the data they were given in large detail and were positive to share their interpretations with the rest of the class. As it was a fairly small group of students (18), and it was not possible to use a control group, the students were asked after the class to share their experience from the flipped classroom approach. The students were very enthusiastic about learning in a flipped classroom, and they had a very positive response towards solving problems based on questions and data from ongoing research projects. There was a general agreement that their attention span had lasted for much longer than in a typical lecture situation, and thus that they had learned more from the flipped classroom approach. Although the effect of the change towards a more student active learning environment was not possible to test rigorously, it was clear that the students felt that it improved their understanding of the topic.

4 COURSE ALIGNMENT IN INTERDISCIPLINARY COURSES

The course AB-203 Arctic Environmental Management is a 15 ECTS BSc course offered annually at UNIS. In AB-203, the development of management strategies and practice is presented against the basic knowledge of the geophysical and biological processes together with the politics characterizing the Arctic (Figure 2). The course presents an introduction to the Svalbard community; the Svalbard Treaty; international conventions, and legal regulations as a framework for managerial rule in the Svalbard region, Arctic Council and international organizations; structure, legal basis and fields of responsibilities for institutions involved in the management of Arctic natural resources; the philosophy of Arctic management, basic information on the Arctic geophysical environment, ecosystems and resource dynamics, human presence in the Arctic geophysical environmental, ecosystem, and natural resources; challenges and conflict scenarios relating to resource management in the Arctic including environmental impact assessment protocols.

Considering the three components of course alignment (Figure 1), AB-203 has an embracive learning outcome: "an understanding of the complexity of Arctic management embracing the cross-disciplinary aspects of fisheries, minerals, pollutants, environmental impact assessments, Svalbard Treaty and Svalbard Environmental Act, international law and relations". Furthermore, the learning environment comprises a range of different teaching activities including classic lectures, flipped classrooms, student-led teaching, assessed presentations, workshops, seminars and role-play. Finally, the assessment/evaluation strategies for AB-203 include elements common with teaching activities, namely student-led teaching (non-graded), role-play (non-graded), flipped classrooms (non-graded), assessed presentation (graded 20%) and oral exam (graded 80%).

Given the complexity of the learning environment of AB-203, the course has an unusually number of guest lectures, each with an expertise in the different scientific themes of AB-203 (Figure 2). This teaching setup presents dichotomy, where on one hand the students are taught by the best scientists within their respective fields of expertise; on the other hand, the great number of guest lectures introduces heterogeneity in the course teaching as each lecturer has her or his inherent way of teaching, which becomes a constant source of confusing to the students and requires special means of alignment activities. For many years, the only alignment has been an elaborate course compendium, with detailed information of the teachers and the areas they teach in. However, this has not been enough and students complain repeatedly that they lose track of learning outcomes and the assessment. Hence, in 2016 and 2017, two addition alignment activities were introduced to AB-203: weekly course notes which summarised last week's teaching and introduced next week's teaching; and (2) a series of course seminars/workshops recapitulating teaching activities so far.

The weekly course notes managed to align the activities for the students, but provided no real active learning. The notes were perceived in a passive context. The introduced seminar-series, however, were specifically course alignment activities focusing on the concept of active learning (Biggs and Tang, 2011). The series consisted of five 2-3 hour seminars, where aspects covered so far were addressed by looking back on all material they had been presented for. One way to activate the student was to focus, for example on the papers they have read so far but with a main focus on learning how to read scientific papers in general. At other times, they were challenged to embrace a large amount of literature through group-work to establish their causal connectedness in an environmental management perspective, then spread to other groups and discuss similarities and differences in their approach. The clue is that there is no straight correct answer in how to tie the different papers together but by discussing their different approaches they were able to create a consensus of understanding across widely diverse themes of AB-203.

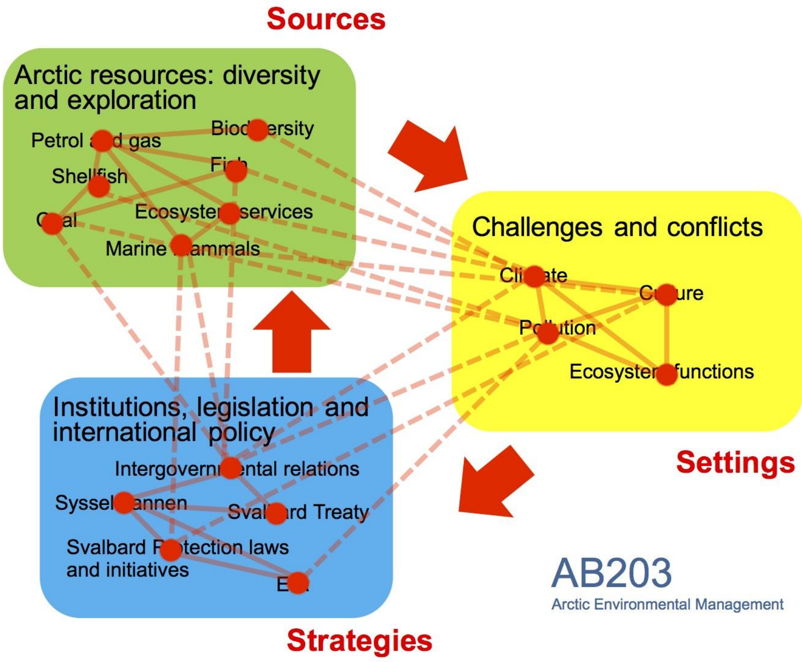

Figure 2. The interdisciplinary complexity of AB-203 divided into three major themes: Arctic resources, Challenges and conflicts and Institutions, legislation and international policy. All three themes are intimately connected; for example, managing marine ecosystems requires considerable ecological knowledge of marine species and their environment, as well as climate impacts, pollution, and intergovernmental relations. The trinity Sources, Settings and Strategies provides the students with overall causal pathway, when working as an environmental manager in the Arctic.

Finally, the students found that using a learning environment where actual teaching activities, such as student-led teachings, also are assessment/evaluation strategies to be very useful in connecting the dots across the very diverse and interdisciplinary course AB-203. Hence, we believe, that using Figure 1b rather than the classic view (Figure 1a) provides a more optimal merger of students, intended learning outcomes, learning environment and activities, assessment strategies and, eventually, actual learning outcomes.

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