# Scholarship of Teaching and Learning: Assessing prior knowledge

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## 1. Introduction

Students starting on a new university course come with knowledge gained in earlier courses and this prior knowledge can either help or hinder their learning (Ambrose et al., 2010). This prior knowledge can be appropriate for the context of the new course, while some of it may be inaccurate or insufficient for the learning requirements of the course. When prior knowledge is activated, sufficient, appropriate, and accurate it helps learning but when it is inactive, insufficient, inappropriate, or inaccurate it will hinders learning (Ambrose et al., 2010). Much research has been done on the importance of prior knowledge in students and there is a widespread agreement that students must connect new knowledge to previous knowledge in order to learn (e.g. Bransford and Johnson, 1972; Resnick, 1983).

At the University Centre in Svalbard (UNIS) the students come from different universities from all over the world. They stay at UNIS for one or two semesters (mainly bachelor students) or for shorter intensive courses lasting for some weeks (master and PhD students). The students that attend a UNIS course therefore have quite different backgrounds and hence diverse prior knowledge. At the department of Arctic Geophysics (AGF), students must have a minimum of 60 ECTS within the fields of mathematics, physics, and fluid dynamics from their home university before they can attend any given course. Applicants applying for a full semester must choose two courses to get the required 30 ECTS. For bachelor students full semester studies are available with courses at the 200-level.

Generally at a home university the students start in an academic field taking the courses in the order required by that university, from introduction courses to more advanced courses and stay within that field. The situation at UNIS is quite different, since UNIS has a limited number of courses to choose from, very often students have to apply for a course that is somewhat outside of their main field, to get the 30 ECTS they need to stay there for a full semester. That is especially true for the AGF department where there are only three courses to choose from for the autumn semester, one upper space course, one in meteorology, and one in oceanography. The result of this is that many students do not have the adequate background in one of the courses they choose as they would have had if they had taken a similar course at their home university, following their specific academic field. The autumn semester bachelor students at AGF mainly combine the polar meteorology course with the polar oceanography course. The majority of the students that attend these two courses each autumn have a background in meteorology or physics, only a few have some knowledge in oceanography.

For the course in polar oceanography the consequence is that several of the students attending this course each autumn have an insufficient or inappropriate prior knowledge in physical oceanography. Although oceanography is applied physics and many of the processes taking place in the atmosphere are quite similar to those in the ocean, it had been noticed that many students struggle each year with some very important basic concepts of ocean processes and dynamics.

Attending a course in university teaching and learning at UNIS one of the tasks were to "identify a specific moment in your course in which many of your students face a learning bottleneck (something that is essential for their success but which semester after semester large numbers of students fail to grasp)". The first answer that came into my mind was the general lack of basic oceanographic knowledge in some of the students who attended my autumn courses in polar oceanography, and the trouble they often had when having to explain

important topics such as Ekman transport or the baroclinic and barotropic components of geostrophic currents even towards the end of the course. Then "describe as precisely as you can what they are getting wrong (What is the nature of the bottleneck)". The nature of the bottleneck was the insufficient prior knowledge. As a project under Scholarship of Teaching and Learning it was therefore decided to do a small study on what the students on the next course in polar oceanography really knew about some central aspects in physical oceanography at the start of the course and to include some short theoretical introduction to the topics they did not show sufficient knowledge on early in the course.

## 2. The AGF course in polar oceanography

The AGF course in polar oceanography is offered every autumn as a full semester course and gives the students 15 ECTS. The required previous knowledge/specific course requirements are: 60 ECTS within the fields of mathematics, physics, and geophysical fluid dynamics. In addition, it is also recommended that students have a minimum basic knowledge of oceanography corresponding to Chapter 1-6, 8, 9, and 11 in Pond and Pickard (1983): "Introduction to Dynamical Oceanography", Pergamon Press, or to similar texts.

To have some knowledge of oceanography is not required but recommended. In an introduction letter to the students well in advance of the start of the course the students are therefore told that they should use the opportunity before they arrive to prepare and update themselves on physical oceanography before the start of the course. This is done due to the known fact that several of the students that will attend the course do not have the desired background in physical oceanography as is needed to follow the course and for them it is important to acquire this knowledge before they arrive at UNIS. What they are especially recommended to prepare for is to understand the physical meaning and the mathematical expression of the equation of motion, geostrophic currents, Ekman theory, and Kelvin Waves.

The course consists of three parts: lectures, field work, and individual work. For the individual work each student is given a research task where they have to analyze data collected during the field work. They have to present their results for their co-students and also write a scientific report. The lectures and field work (scientific cruise) are scheduled for the first half of the semester while the students' individual research work takes up much of the second. An example of such a research task is as follows:

*Hydrographic patterns in Isfjorden:* Investigate the distribution of temperature, salinity, and water masses within Isfjorden and discuss the coupling with Billefjorden at the head of the fjord and the shelf area at the mouth of the fjord. Describe the water masses present in the Isfjorden system (definition and TS-plot). Do we see Atlantic Water in Isfjorden this year? How does this compare with other years? What are the important freshwater sources and how does this influence the circulation? Calculate the freshwater content. Calculate the geostrophic velocities from the cross section.

The student doing this research task will be given the temperature and salinity data from Isfjorden taken during the scientific cruise that is part of the course. The student will analyze the data, fulfill the requirements of the task description, and discuss the results based on dynamic theory. For this task knowledge on geostrophic currents and Ekman theory is quite important in addition to the concepts of water masses and the effect of freshwater input to the fjords.

Normally the students choose their topic from a list of possible task that are given to them and briefly described at the beginning of the course, without any explanation of what e.g. geostrophic current is, since this is assumed as prior knowledge that the student has. Before going to the cruise each student must have selected a topic for their research work from this list and two students cannot have the same topic. Hence, each student gets a

different data set, either from different instruments or different areas. The cruise take place during the third week of the course and the students are given their data set during the cruise as soon as they are collect. The student can then already on the ship start working on their task.

### 3. Assessing the students prior knowledge

Several different methods exist to assess prior knowledge and skills in students. One can use direct measures, such as tests, concept maps, portfolios, and auditions, or others that are more indirect, such as self-reports, inventory of prior courses and experiences. In this case, it was decided to make a pre-assessment test on a few important topics in oceanography as shown in Figure 1.

**AGF-214 pre-course assessment** Name.....

| | | Yes | No |
|---|---|---|---|
| 1 | Are you familiar with the equation of motion? | | |
| | Can you write it down (or at least the names of the different terms)? | | |
| 2 | Do you know what a geostrophic current is? | | |
| | Can you name the forces involved? | | |
| | Can you explain the difference between a barotropic and a baroclinic current? | | |
| 3 | Do you know what we mean when we talk about volume transport? | | |
| | Can you write down the equation for how to calculate it? | | |
| | Can you write down the unit we use for the volume transport? | | |
| 4 | Have you heard about Ekman? | | |
| | Can you explain Ekman transport? | | |
| 5 | Do you know what a Kelvin wave is? | | |
| | Can you explain how a Kelvin wave travels? | | |
| | Can you draw the form of a Kelvin wave? | | |
| 6 | Are you familiar with water masses? | | |
| | Can you name some of the water masses we have up here? | | |
| 7 | Do you know what we mean with sources and sinks? | | |
| | Can you name the different sources we have for freshwater? | | |
| | Can you name the different sinks we have for freshwater? | | |

**Figure 1.** The pre-assessment questionnaire given to the students.

The questionnaire included the topics that they had been recommended to update themselves on before starting on the course in addition to some other important oceanographic concepts that were essential for them to know to be able to do a good work with their individual research tasks. Some of these topics were also the same topics that we knew the students often struggled with during the course. Seven topics were included in the questionnaire. The first question for each topic is just of the type "are you familiar with", "do you know", or "heard of" and required only a yes or no answer. After that there were one or two more specific questions in each category that they should answer.

Twelve students attended the next polar oceanography course and took part in this study. During the first lecture hour of the course each student presented themselves and told which university they came from and what their general background study was (i.e. oceanography, meteorology, physics, or other). Five of the students were from Norwegian universities and seven from different European universities. The majority had a background in meteorology, a few in physics, and only one student had some oceanography background. After the presentations and a following introduction lecture on the course content, the students were then given the pre-assessment questionnaire.

**Table 1.** Results of the pre-assessment test.

| | | Yes | No | wrong | ½ correct | correct |
|---|---|---|---|---|---|---|
| **The Equation of motion** | | | | | | |
| 1 | Familiar with | 10 | 2 | | | |
| | Write the equation | | 4 | 4 | 2 | 2 |
| **Geostrophic current** | | | | | | |
| 2 | Know what it is | 10 | 2 | | | |
| | Name the forces | | 2 | 1 | 4 | 5 |
| | Explain difference barotropic/baroclinic | | 5 | 4 | 2 | 1 |
| **Volume transport** | | | | | | |
| 3 | Know what we mean | 5 | 7 | | | |
| | Write the equation | | 10 | | | 2 |
| | What is the unit | | 8 | 2 | | 2 |
| **Ekman** | | | | | | |
| 4 | Heard about Ekman | 9 | 3 | | | |
| | Explain Ekman transport | | 6 | 1 | 1 | 4 |
| **Kelvin waves** | | | | | | |
| 5 | Know what it is | 6 | 6 | | | |
| | Explain how they travel | | 9 | 1 | 1 | 1 |
| | Draw the form | | 11 | | 1 | |
| **Water masses** | | | | | | |
| 6 | Familiar with | 3 | 9 | | | |
| | Name some | | 11 | | 1 | |
| **Sources and sinks** | | | | | | |
| 7 | Know what we mean | 7 | 5 | | | |
| | Source for freshwater | | 6 | | 3 | 3 |
| | Sinks for freshwater | | 7 | | 2 | 3 |

The numbers indicate number of students. The first general question in each category, marked in blue, only required a yes or no answer. The answers from the additional questions in each of the topics were divided into four groups: No, when there was no answer; wrong, when what they had written was wrong; ½ correct when some of it was correct; and correct, if they had given the correct answer.

Before they were given the pre-assessment they were told that in previous year we had seen that there were topics that many students had difficulties with during the course. It was emphasized strongly that the information from the pre-assessments would not have any influence on their final grade; it was just to get some information on their background before the start of the course and to be used to make instructional decisions. Also, that it was quite ok to answer no on all the questions if that was the case. This latter was especially important since they had to write their names on the form. The plan was that they would get them back at the end of the course, although that information was not given to the students.

The results from the pre-assessment are summarized in Table 1. The different topics are highlighted and the first general question in each category, marked in blue, is the yes or no question. This was just to see if they had heard about it or touched upon it in former courses. Under each topic they also had one or two additional questions where they could write down the answer and show their knowledge. The questions were typical questions given to students on an exam for first year students in oceanography and did not require long explanations. The answers from the pre-assessment were divided into four groups: No, when there was no answer; wrong, when what they had written was wrong; ½ correct when some of it was correct; and correct, if they had given the correct answer.

For the general questions half or more of the students had "heard" about the topic in five of the seven questions. But when it came to answering the additional questions, the number of students that could give a correct answer under the different topics was quite low, varying from no students on water masses to five students on forces involved in geostrophic currents.

To get an overview of the different students' knowledge their answers to the additional questions were given a score (see Figure 2). For a correct answer they were given two points, for half correct one point, and for wrong answer or no answer zero points. With 11 additional questions the total score possible was 22.

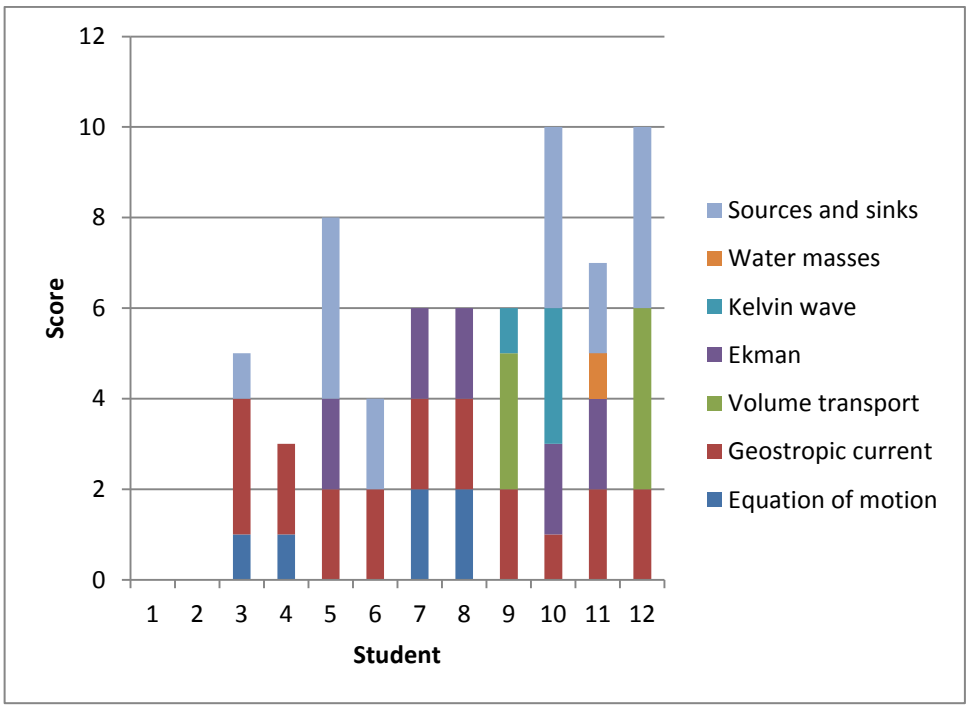


**Figure 2.** The score achieved by the different students on the additional questions in the pre-assessment.

Student 1 and 2 did not answer any of the additional questions. Student 4 and 6 could answer two of the topics, student 10 and 11 four and the rest could answer something on three topics. The topics they knew something about varied between the students except that all the students 3 -12 had some knowledge on geostrophic current. Figure 3 shows how many students that had some prior knowledge (either correct or half correct) on the different topics.

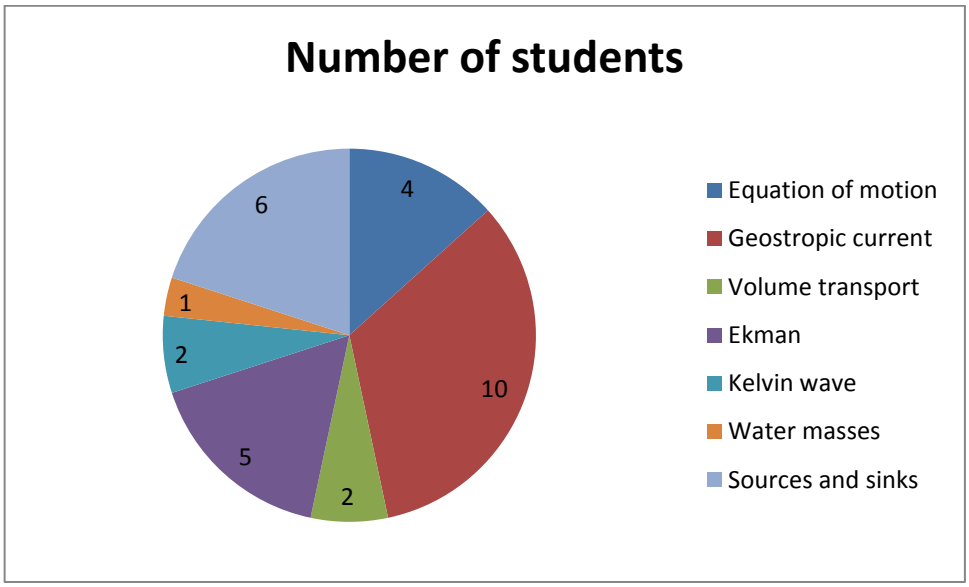


**Figure 3.** The number of students that had some prior knowledge on each topic.

The results from the pre-assessment showed that the pre-knowledge of the students was generally not adequate for most of them and that it could be hard for some of them to start working on their separate tasks without more knowledge early in the course. Several of the topics covered in the pre-assessment was content that they would need to know and use to be able to analyze and discuss the data they would collect during the field work and work on for their report. It was clear that many of them would benefit from gaining more knowledge on some of these topics before starting working on their tasks.

The plan was to use the next day (two lecture hours) to briefly explain these theoretic concepts during the presentation of the tasks. In this way the student could get an insight or repetition on the subject at the same time as it was shown why it was necessary for them to understand a certain topic in a profound manner to be able to a good work with their research work. For each task therefore the necessary background (theory to understand, equations to use, etc.) was explained as one would do in an introduction course in physical oceanography. The students were quite active asking a lot of question, so we ended up using two days (four lecture hours) instead. Hopefully, some of them were now more prepared and able to start on the course and to do their research work than what would otherwise have been the case.

## 4. Feedback at the end of the course

On the last day of the course the students were handed back their pre-assessment questionnaire. They were very happy to get it back and found it quite amusing what they had answered on the first day. To get some impression of what the students thought about the pre-assessment and possible effects on their learning the questions below were discussed in plenum:

*Was it ok to get the pre-assessment the first day of the course?*

All the students said it was ok to have been given the test, especially since it was clearly stated in advance that this was just to see the level the students had in oceanography before the start of the course and that it had no influence what so ever on the final grade and that it was quite ok to answer no on all the questions.

*Did you pay special attention to these topics during the rest of the course?*

They all agreed that the test had made them pay more attention to these topics during the lectures. The students had also understood that these topics were essential parts of the course and that many of them were necessary for them to understand well to perform a good job with their research tasks and probably would be important on the exam.

*During the two days when we went through the different tasks I tried to give you a brief introduction to these topics, was that helpful for you?*

They all agreed that that had been very helpful. And that combining presenting the tasks with the background theory was a good way to do it and should be done also for future students on the course.

*Do you think you paid more attention to Joe's lectures than what you would have done without having had this test at the beginning of the course?*

Joe's lectures were on fluid dynamics, where most of the theory is explained. The majority of the students confirmed that the test had made them pay more attention to these lectures than they else would have done; only a few said that they did not think they would have paid less attention.

*Did you ask Joe to go more in detail into some of these topics?*

Here most of the students answered yes, which was also confirmed by this guest lecture.

*Do you think that you could answer all these questions correct today?*

They all answered confirmative.

## 5. Results and discussion

The overall impression at the end of the course was that the students this year showed a better understanding of the topics that earlier students had struggled with, such as Ekman transport and differences in baroclinic and barotropic currents. They were able to explain it when presenting their reports to the other students and also in the written reports there was an improvement compared to earlier years. No time had to be used on explaining this again during their presentations or the time used for individual feedback on the reports.

Applying the pre-assessment on the students in this AGF course really helped to get an idea of what the student's knowledge of prerequisite facts and concepts actually were. The results from the pre-assessment made it clear that the prior knowledge of some of the students where below the level oceanography students normally have when they take courses at the 200-level. It also showed that few if any of the students had followed the recommendation in the email sent out in advance of the course to prepare their oceanographic skills before starting on the course. Although one can say that it is the students' responsibilities to see if they have the relevant prior knowledge for a course and if not act accordingly, they generally don't do that. This may have hindered the learning for several of the students attending previous courses, and this has to be taken into account in future courses.

This year's short introduction to basic oceanography at the beginning of the course had a good effect on the students. To give them this introduction during the next two days when they had the pre-assessment test in fresh memory, they could see for themselves if they had answered correctly, which most had not, and hopefully they would realize their insufficient knowledge of these important concepts. To do it during the presentation of the individual research tasks was probably a good choice. This way made them see the important need they would have in understanding these basic concepts as soon as possible to do a good job with

their research task. After finalizing the presentation of the tasks, the students had also been told that more thorough explanations of the different theories would be given by the guest lecturer in fluid dynamics later in the course and that they should pay good attention to him, especially on the subjects they had not been able to answer during the pre-assessment.

During this AGF course the students have one week (10 lecture hours) with a guest lecturer on fluid dynamics. After finishing the week his feedback was that he was very enthusiastic about this year's students. He said he had never had such motivated and active students in all the years he had been part of this course. In earlier years the students had mainly just been sitting making notes and not asking nearly any questions. But this year's students were very eager and asked him also to go through several topics he normally did not or to have him explain some in more detail. He saw a quite different attitude in this year's students than in previous years. When he gave this feedback, he had no knowledge of the pre-assessment test that the students had taken.

It is difficult to say if it was the pre-assessment that made the student this year to be so much more active during the fluid dynamic classes than in earlier years or that it was just very eager and motivated students that participated in this year course. To be able to say anything about that they would have had to be subjected to both situations (with and without pre-assessment), and this is of course not possible. But according to the student's feedback at the end of the course, the pre-assessment clearly made most of them to be more attentive and active. One can assume that they had realized their lack of knowledge on relevant topics from the pre-assessment and that they had by then also seen how essential a good understanding of these topics were for them in the course and for their individual work, and used this opportunity to get a much more detailed explanation of these concepts.

Another reason for the students this year to be more active during the fluid dynamic classes can also have been that this lecturer normally comes quite early in the course but due to different reasons had to come some weeks later this year. That could have given the students more time to realize the need they had to understand the fluid dynamics better to be able to do a good analysis and discussion of their data. Discussing why the reason could be with the guest lecturer in question, he agreed that the pre-assessment could have been a great initiative for the students but also that maybe the students now at a later state of the course more clearly saw their insufficient prior knowledge and their need to understand these topics better. Whatever the reason, the lecturer was very thrilled and decided he wanted to come later in the course also next year.

## 6. Conclusions

The pre-assessment showed that there was insufficient prior knowledge in many of the students. Since this has probably been a recurring fact every year, although not tested before, some measurements have to be taken in future courses. The polar oceanography course is not an introductory course and the time schedule for the course is quite tight as it is, with not much spear time to help students without the necessary pre-knowledge. Having established that the student's knowledge of prerequisite facts and concepts are generally not at an adequate level, one could for the next year skip the pre-assessment and just include some short description on the theory as was done this year. The students this year suggested that this should be done in future courses, since it had been of great help to them. On the other hand, the pre-assessment test made the students see their own shortcomings which resulted in them paying more attention and use more effort to achieve a good understanding of these central concepts than what they otherwise would have.

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