Assessing learning by using focus group interview — a case study

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1. Introduction

The University Centre in Svalbard (UNIS) offers a course *Radar diagnostics of Space Plasma (AGF-304)*. This spring semester radar course is for MSc and PhD students in the field of geophysics. The course includes one week fieldwork at the EISCAT Svalbard Radar (ESR) site where the students have an opportunity to run their own experiment using a full-sized research radar. Based on the recorded data, the students write a short project report with an emphasis on analysis of the ionospheric processes in the upper atmosphere.

The course can include up to 16 students. During the fieldwork, the students operate ESR in pairs while the remaining students wait for their turn. In 2017, we introduced a small "side project" — hands-on radar — to keep everyone busy. While this learning-by-doing activity was well received, it was still not fully aligned with the rest of the course. This lead to several changes for the fieldwork in 2018.

In this case study, I describe the development of the hands-on learning activity for the fieldwork at ESR. The purpose of the activity is to help students in developing their own understanding of radar principles. In order to assess the learning, I used a focus group interview (Krueger, 2002). In my case, eight students participated in the interview at the end of the semester. This made it possible to reflect on the hands-on activity in the context of the whole course content.

2. Fieldwork at the radar site

The maximum number of students on the course is 16. Typically, most of the students are working towards their Master's degree, but there are often a few doctoral students as well. The majority of the students are enrolled in a physics or geophysics degree programme, although there are frequently students from technical universities with interest in space technology and research. The students come from different mainland universities — in Norway and abroad — and comprise many nationalities. This naturally results in a large variety in students' background skills. Generally, students who come to Svalbard are very motivated and keen on carrying out fieldwork. This is also captured in the student feedback that UNIS collects from every course.

The ESR infrastructure with two large radar antennas (32 m and 42 m in diameter) is actively used in ionospheric research. The students appreciate the unique opportunity to use ESR as part of their training. Yet, the radar time allocated to UNIS is limited and that time has to be further divided among the students. This results in only a few hours' slot for each student within the whole week of fieldwork.

There is one additional challenge with the radar course. The radar data are used to analyse the plasma processes in the ionosphere such as northern lights. Having additional optical instruments (auroral cameras and photometers) is very relevant for understanding the physics and interpreting the radar data. We use the instrumentation at the nearby Kjell

Henriksen Observatory to provide the crucial context. However, the optical instruments need sufficiently dark conditions — and clear skies — to record northern lights. In Svalbard, this means that the fieldwork has to be scheduled to January or latest February. As a consequence, several central radar concepts will not be lectured until after the fieldwork.

3. Learning outcomes for “hands-on radars”

For the fieldwork in 2017, we introduced a small side project — *hands-on radars* — where the students would build a small radar when not running their experiment with ESR. My role was to develop the activity and then instruct the students. This also allowed the other instructors to fully concentrate in tutoring the students operating the ESR.

The hands-on radars was based on a radar course at Massachusetts Institute of Technology (Charvat et al., 2011). The students built and tested radar antennas from commonly available food cans and then put together a small yet fully functional radar using electronics components. Measurements could be recorded to laptop computers via audio inputs, after which signal processing could be applied to analyse the data. The feedback from students was mostly positive, although a few of the students questioned the relevance of the hands-on part when thinking of radar diagnostics of space plasma.

To improve the match to the rest of the radar course, the overall learning outcomes for the entire course (Appendix A) were used in developing the hands-on learning part of the fieldwork. An experienced scientist using radar to study the upper atmosphere does not need to be reminded of the fundamental radar operating principles. Meanwhile, at the time of the fieldwork, the students are still processing introductory material from the lectures. This provides an opportunity to strengthen the learning of one or two key topics at the very beginning of the course. Two topics were selected: radar system components and a closer look at the transmitted and received signals.

In a radar (RAdio Detection And Ranging), a radio frequency is transmitted. When the transmitted signal hits a target, some of the signal is reflected back and received by the radar. By analysing the received signal, it is possible to measure, for example, distances to targets. From the instrumentation point of view, all radars share the same building blocks that can be easily identified in system diagrams. Thus, learning how a small and simple radar works helps in understanding not only the ESR but all other radars as well.

The design of the actual radar transmission signal will be discussed in several lectures in much detail after the fieldwork. However, more often than not, the transmitted signal is a cleverly coded waveform rather than a simple pulse. Nevertheless, the principle stays the same: we want to detect an echo from the target. For short distances, we can use ultrasonic transducers instead of operating at radio frequencies. Technically, this transforms a radar into a sonar (SOund NAvigation and Ranging), but the principles remain the same. It takes approximately 7 nanoseconds for radio signals to reflect back from a target at a distance of one metre. If we use sound waves, the time increases to about 6 milliseconds, or, in other words, everything happens one million times slower. Now it becomes possible to use an oscilloscope to examine both the transmitted and received signals in real time. A simple setup on a laboratory bench offers many interesting quick hands-on experiments with the results being immediately observable.

The derived learning outcomes for the hands-on radar part of the fieldwork are provided in detail in Appendix B. The outcomes are centred on the fundamentals of radar and provide a framework for planning the activity. There are clear connections to the learning outcomes of the entire course.

4. Planning the learning activities

4.1 Environment

Each fieldwork day starts with a car transport from UNIS to ESR in late afternoon with a return back to town roughly at midnight. The unusual working hours are chosen to have the best opportunities to observe and measure the northern lights during the evening and early night. For each student, two nights are scheduled for hands-on radars.

The students doing hands-on radar are divided into two student groups with one working on the MIT radar and the other on sonar. While much of the work is carried out in an electronic workshop at the radar site, there is a possibility to use the lounge for breaks or individual and small-group work.

The desired atmosphere is easy going and relaxed. Any (radar) topic that is of particular interest — or not fully understood — is open for discussion. While the students are expected to write a report about their own radar experiment, the hands-on part of the fieldwork is not evaluated at all.

4.2 Hands-on activities

As there are two groups doing different things at the same time and only one instructor, the activity is a mixture of *problem-based learning* (Nilson, 2010) with students working autonomously and *active learning* under guidance from the instructor.

There is a short introduction to each topic as well intermediate summary discussions. The introductions refresh the central topics discussed during lectures before the fieldwork. Intermediate and final summary discussions collect the students' findings as well as provide opportunities to emphasise and possibly correct key concepts (*formative assessment, Nilson, 2010*).

Experiment 1: building a radar

Building the radar includes introducing radar hardware from antennas to amplifiers and filters. Each system component is an off-the-shelf radio frequency component and the students build one complete radar by connecting the components together in a correct way. The system diagram of the simple radar is used as a guide. The system diagram is also compared to that of ESR: the signal paths are identified to demonstrate that both radars are, in fact, very similar and the knowledge of the simple system is applicable to scientific radars as well.

Experiment 2: radar pulses

The design of radar transmission pulses is a complex signal processing topic with non-trivial mathematics. The principles can, however, be demonstrated with a simple two-part experiment.

In the first part, the students would use an oscilloscope to look at the transmitted and received signals and to measure key parameters such as pulse repetition frequencies. The setup comprises a small electronics board with ultrasonic transducers. The transmitted "pulse" is actually a coded pulse sequence. Coded sequences are taught later in the semester and the aim is to introduce the students to the topic already during the fieldwork.

The second part of the radar pulse experiment uses a common off-the-shelf ultrasonic range finder. The students construct a small distance measurement device and then carry out simple experiments using the range finder with a laptop.The measured distances are displayed on the computer screen and additional tasks include comparing the results to those obtained by a taper ruler and determining the transmission beam width.

5. Pedagogical observations during the fieldwork

In 2018, the fieldwork for the radar course was scheduled for 19-23 February. For the hands-on radars, there was a short introduction to both experiments, after which the students worked in small groups (5-6 persons) mostly on their own.

I noticed that my explanations, or mini-lectures, of different topics developed during the fieldwork as I got a better feel for the students' background knowledge. A major challenge was that I was practically alone with the majority of all students: there were two student groups working on two different topics and I was able to help only one group at a time.

The students were a bit hesitant at first. I believe much of this can be explained by considering that almost all presented material was new to all and the students' understanding of radar fundamentals was not yet mature. During the fieldwork, I regularly returned "back to the basics" to repeat and emphasise crucial concepts. It was very rewarding to notice the reduction in humming and hawing, when we revisited selected key topics at the end of each day.

The Experiment 1 (building a radar) appeared to be an interesting topic and the students appreciated being able to have a concrete example of a working radar in front of them to play with. I also felt that, once the basic building blocks were explained, the signal paths through a much more complex system diagram for the ESR began to make sense to most of the students.

The first part of Experiment 2 (radar pulses) was challenging because few of the students had used an oscilloscope before and simply configuring the instrument to show the sonar signals in a meaningful way was not easy for them. Usually, most physics students have done some laboratory work at their home universities, so I was not expecting the need to provide detailed instructions on measurement techniques. Sorting this out took only a few minutes' explanation, fortunately.

The second part of Experiment 2 involved programming. Both in 2017 and 2018, the programming skills of the students varied a lot: some had little experience while a few were very proficient. To limit the need for programming I had selected very commonly available hardware components. I expected the students to find a fully working piece of software written by somebody else in the internet, which they inevitably did. Many of the students were obviously feeling a bit guilty for "cheating" rather than writing the code by themselves, but they recovered quickly when I stated that it is a good engineering practice to use a solution that is known to work.

Some of the groups were more collaborative in doing the experiments than others. Also, the interests of individual students varied. For example, in Experiment 1 (building a radar) the plan was to use commercial antennas. One of the students absolutely wanted to build the antennas from cans instead, so I gave her references to the relevant equations and the opportunity to do an extra side project at the radar site.

6. Collecting feedback using a focus group interview

UNIS collects student feedback using an online questionnaire at the end of each semester. The questionnaire is identical for all courses with only small changes between years so that comparison to previous years is meaningful. For the radar course, the largest change in feedback between the years 2016 and 2017 was that the fairly negative comments about “waiting while the others run their experiments” had almost disappeared. At the same time, for 2017, some students found building a radar somewhat irrelevant (engineering rather than space physics) while others really enjoyed doing something with their hands. As one of the main points of the hands-on radar activity is to support learning, I wanted to evaluate the success more formally. A *focus group interview* offers an interesting method to collect qualitative feedback directly from students (Krueger, 2002; Breen, 2006; Dilshad and Latif, 2013).

A focus group interview is a moderated, yet informal, group discussion with focus on a specific topic. The group is brought together by a moderator who introduces the topic, guides the exchange of views to maintain focus and to delve deeper. The participants are encouraged to reflect on other’s comments and are thus influencing each other. Capturing this social interaction is a key task for the moderator: some, but not all, strong reactions or even arguments can reveal important findings.

Krueger (2002) provides a very practical guideline for the planning and executing of a focus group interview. Breen (2006) expands the recommended practices by analysing several interviews. Even National Oceanic and Atmospheric Administration, NOAA (2015), has prepared an easily accessible how-to guide to help their experts in conducting a focus interview. All of these studies emphasise the importance of the moderator’s role and provide suggestions for the types of effective questions.

7. Carrying out the focus group interview

As the interview took place after all lectures in late May, the students were able to look back to everything they learnt (or did not learn) during the course. I sent an email to all students asking for their help in developing the hands-on part of the fieldwork by participating in an interview. Roughly half of all students volunteered and I had a group of eight people in the interview.

The venue was set in a classroom with circular seating. By this time the students knew each other very well. I brought freshly baked treats from the local bakery for every volunteer. All students appreciate free food and enjoying a surprise treat contributed to the informal atmosphere. For documenting the discussion, I used a small unobtrusive digital recorder.

At the start, I welcomed everyone and gave a brief introduction to the purpose of the interview. I had prepared the opening words (an excerpt below) carefully to provide a clear focus for the discussion. At the same time, I asked the students to think back and reflect on all they had gone through.

"I invited you because I'd like to know what you think about the hands-on part of the fieldwork now that you've seen all the lectures. I will be asking questions but please remember that there are no correct answers: your experience may have been different from others, so you may respectfully disagree as much as you want. I encourage you to voice your opinions and observations freely. So, talk to each other! I am interested in both positive and negative opinions; sometimes the negatives are the most helpful ones."

— Excerpt from the introduction

The opening question was to be answered by everybody with the intent of reflecting on all topics during the course and bringing everybody back to the fieldwork. The students were asked to comment on their experience considering their expectations of the course and possibly name their favourite or least favourite topics. Once everybody had said a few words, I had prepared 26 additional questions to delve deeper into the hands-on radars. All questions were categorised into introductory and key questions: my plan was to cover all key questions and the introductory ones would act as bridges between different topics.

I knew already in the interview situation that I would obtain good material for developing the hands-on radars part. We had been at the radar site doing fieldwork together and I felt that none of the students hesitated in expressing their own opinions. There was lots of laughter and gentle teasing if somebody appeared to really like topics that all others found uninteresting or difficult.

For this group, the moderator's workload was small as other students often provided the follow-up questions themselves ("why do you say that?"; "what do you mean?"). I could sit back, observe reactions and make notes. However, it was obvious that while all had enjoyed the fieldwork, there were strong opinions about the rest of the radar course as well. There was a clear desire to provide more general feedback for the whole course and to discuss all lectures and lecturers. Fortunately, it was not difficult to steer the discussion back to the hands-on radars and urge them to fill in the general course feedback forms online.

After about one hour, it was time to conclude the interview. I used these three ending questions:

1. (Reflection on discussion, all to answer individually) "*What would be the most important change in the hands-on radar part that would make it better for you?*"

2. (Summary) After shortly stating the main points from my interview notes: "*Is this an adequate and good summary?*"

3. (Review the purpose) "The hands-on radar is there to help all students in learning about the basics of radars, have we missed anything?"

8. Discussion

The students on the course *Radar diagnostics of space plasma* have very varied interests. The course itself covers a range of topics and, for many, a central challenge is to “stay on the map”. Based on the interview, the hands-on radar activity was considered a useful activity by the students, although there is definitely room for improvement. Although, as the focus group interview collected data from a subset of all students, I feel that one should not make too radical conclusions.

Based on the UNIS course feedback as well as the interview, signal processing is generally considered one of the most difficult topics due to its mathematics. Interestingly, physics uses mathematics all the time and space physics is no exception: yet the challenges in mathematical treatment of, for example, scattering of electromagnetic waves in plasma were not mentioned. Perhaps, this comes from small differences in the mathematical methods, which are sufficiently dissimilar to create confusion. It is also possible that, because signal processing is often associated with engineering sciences, it is shunned by physics students or not even included in the curriculum in their study programme.

The interview itself was very enjoyable and inspiring. For me, transcribing the audio record was a very slow and arduous process, which I stopped at roughly 30 minute mark, or at the midpoint of the interview record. For the final 30 minutes I simply used an audio player to re-listen relevant parts of discussion to make additional notes. Undoubtedly, it was much easier to peruse a text document containing everything from the first half of the interview, but I still think I captured all essential data from the non-transcribed part as well. In fact, the interview alone with the notes I scribbled around my questions while listening to the discussion would have provided the main findings.

For the hands-on radars part, I identified two specific areas for improvement.

1. **Provide more formal instructions to create structure**. While some students really enjoyed exploring and discovering things themselves, others were frustrated when the next steps were not known in advance. A good compromise suggested by the students would be a work sheet listing all planned experiments. A piece of paper would also let the students to make their own notes when we discuss each topic. On the other hand, the work sheet could be ignored if not needed nor desired. In retrospect, if I had had such a work sheet for all students, it would have been easier for me, too. While I had mini-lectures to introduce a particular new detail or topic, these could have been implemented in a flipped classroom (Wikipedia, 2018) fashion leaving more time to discuss ill-understood areas.

2. **Analyse data from the simple radar in more detail**. Going through the process of building a physical and fully working small radar was greatly appreciated by the students, but that also consumed valuable time. One option would be to concentrate only on Experiment 1 (building a radar) and leave Experiment 2 (radar pulses) completely out. This option was discussed during the interview, but abandoned as Experiment 2 does demonstrate the operation of radar with coded transmissions in a very tangible way. In my opinion, the best way might be to connect the data analysis to the computer laboratory exercises during the rest of the course. Optimally, we could process sample data in the computer laboratory before the fieldwork. The same piece of software would then be used to analyse fresh data during the fieldwork. Also, there is a possibility to record data during the fieldwork to be used later in the spring when dealing with, for example, pulse coding and detection probabilities.

I discussed the fieldwork with the other two instructors tutoring students running the ESR as well as my external observers. I had asked two colleagues to stop by to both observe the hands-on activity and to ask the students to explain what they were doing. One of the colleagues was a scientist with strong competence in radar science as well as interest in teaching. The other observer was a PhD-student who had done the same course already in 2016; in other words, before any hands-on activity.

In general, the consensus is that the hands-on radar activity has been a positive addition to the course content, even though there is little new information about radars per se. Much of the content is something that the students have already learnt or will learn later during the course. The two other instructors commented that their teaching during the fieldwork has become much easier, because the hands-on radar activity allows them to fully focus on one-on-one tutoring during the student's ESR experiment.

When reflecting on the hands-on radar, my observers and I did note that the programming part in Experiment 2 (radar pulses) had a tendency to converge into one programmer doing the work while others were watching. This might be avoided by re-designing parts of the tasks to concentrate more on the data analysis. Alternatively, the experiment software could be fully provided and the task would simply be to collect data to be analysed later in the spring using when more complex signal processing techniques are taught. In particular, the data could be used for studying the effects of pulse coding in radar.

9. Summary

The fieldwork at the EISCAT Svalbard Radar is an essential part of the *Radar diagnostics of space plasma* course. A hands-on activity was introduced in the fieldwork in 2017 and further developed in 2018. This *hands-on radars* learning activity is designed to help students in learning the basic principles of radars.

In order to assess the learning, I used a focus group interview. A small group of students participated in a moderated discussion with the focus on the hands-on activities. The emphasis was on the experience: for example, which activities helped the students later during the course. The main finding is that the hands-on radars is a useful activity which made radars more concrete for students. In addition, the activity itself was an enjoyable experience. The focus group interview also generated ideas about using the data from the hands-on radar experiments when discussing signal processing later during the course. This could make that topic more approachable as well.

There exist good guidelines with practical hints for implementing a focus group interview. Most of the authors discussing the method emphasise the importance of a full and detailed transcript of the entire interview. In my opinion, for course development, much of the benefit comes from identifying key interview questions well in advance and being able to engage the students in the interview. The former creates a focus for the interviewer/moderator and makes it easy to keep the discussion going. For the latter, I feel that the choice to carry out the interview at the end of the whole course worked really well: the students had already formed a social group, into which all belonged. Honest disagreement with your close colleagues and friends is not only easier to accept but also easier to communicate.

For educators who do not have time to do the transcript — or who cannot have it done by somebody else — it can be worth considering using only the notes from the focus group interview supplemented by an audio record. This will save a lot of time without necessarily changing the results of the analysis.

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Appendix A: Learning outcomes

The learning outcomes for the course AGF-304 Radar diagnostics of space plasma can be found at https://www.unis.no/course/agf-304-radar-diagnostics-of-space-plasma/

In the following, underlined topics were identified as central topics for the hands-on radar activity during the fieldwork.

Knowledge
Upon completing the course, the students will:

- Have detailed knowledge of radar techniques employed in the field of space plasma and ionospheric physics research, including radar design, incoherent scatter plasma theory, pulse coding techniques, and signal processing.
- Understand the methodology by which ionospheric plasma parameters can be derived from an auto-correlation function.
- Understand mathematical descriptions of plasma density fluctuations and statistical methods utilized in signal analysis.

Skills
Upon completing the course, the students will be able to:

- Operate an incoherent scatter radar independently.
- Utilise the radar data analysis package (GUISDAP) in analysing multiple data sets.
- Analyse data and recognise the different analysis techniques used.

General competences
Upon completing the course, the students will be able to:

- Discuss and describe orally the underlying physical principles surrounding incoherent scatter theory, pulse coding and signal analysis techniques.
- Identify signatures of different ionospheric processes in incoherent scatter radar data.
- Discuss a scientific case study utilising multiple data with your peers.
- Produce a short written report detailing radar analysis techniques.

Appendix B: Hands-on radar learning outcomes

Radar design, signal processing and pulse coding were identified as core elements of understanding radars. The following learning outcomes and ideas for activities were derived.

1. Radar fundamentals
    - Learn to know the central building blocks of any radar
    - Understand the function of amplifiers, oscillators, filters and mixers in the signal processing of transmitted and received signals
    - Understand the “big picture” of radar system by identifying these common elements
2. Pulse coding
    - Link theory from lectures to practice: learn to identify key parameters such as pulse repetition frequency in a radar signal
    - Introduce pulse coding (i.e. examine real signals)
3. Signal processing
    - Introduce the concept of frequency mixing using a local oscillator, which is a central RF technique both in hardware and software
    - Understand the role of filters in the signal processing path, especially in connection with the frequency mixer