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The Concept of In Situ Lecturing

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Abstract. Traditional teaching at university level takes place mainly in lecture rooms without any direct linkage to the real subject. Thus even during well taught lectures the human, in our case students', multi-sense receptivity is stimulated only in a limited way. This means that just a part of the actual subject matter can be transferred. Therefore, students will not learn to observe the whole range of the circumstances and environmental parameters involved in a specific subject. This problem arises especially in natural sciences and, partly, engineering teaching in which the environmental setting is often a key to successfully understand complex processes, proportions and scales as well as human (counter) actions. In our concept "in situ lecturing" we teach at the place which is being studied, hence "in situ". In situ lecturing is a valuable pedagogical concept to develop student's understanding of basic concepts, to enable them to transfer concepts and theory to local conditions, to train practical skills and to promote a comprehensive understanding of processes. This approach is achieved by an integrative combination of pre-courses and practicals in the classroom, followed by in situ lectures, practicals and seminars as well as a final reporting. Examples are presented from geophysics but these may be transferred to many other disciplines.

Keywords: university teaching; field work, teaching method.

Introduction

The curricula of most degree programmes in natural sciences and engineering predominantly involve classroom lectures, practicals for solving exercises, seminars with student presentations and, rarely, excursions or actual fieldwork. Classroom lectures, practicals and seminars account for the by far most part of the higher education. Classroom lecturing is vital for setting a solid base for primary skills such as understanding of theoretical concepts (e.g. mathematics), first principles (e.g. basic physics), taxonomy and laboratory working techniques. However, classroom lectures are mostly passive events for students with a one way communication, although there are many concepts to stimulate the audience (e.g. Laws, 1991, Powell, 2003, Reiber, 2006). There are also many applied courses which concentrate on specific themes, e.g. monitoring of environmental parameters, assessment of hazardous natural processes, construction of buildings, instruments and machines etc. Teaching in some subjects requires indispensably out of classroom instruction, e.g., geosciences (for a review see Butler, 2008 and references therein). In a subsequent professional career such activities require skills which cannot be trained adequately by only classroom lecturing (Lonergan & Andresen, 1988, Kastens et al., 2009).

During lectures the students should learn and understand the necessary theoretical and conceptual basis of a subject. Yet, when examples are displayed in the classroom, students experience only a limited aspect of a study or situation which is presented in a slide or movie. Often a detailed and comprehensive description of a situation or object and its environmental circumstances and parameters is missing (even the lecturer may not know under which circumstances a photo or film was taken). The true scale of objects is often not clear to students, if they do not experience the real objects themselves. In addition, visual material for class room teaching is often biased by well-chosen factors or circumstances: optimum light conditions to illuminate an object, undisturbed environmental conditions etc.

Students should participate actively during practicals where they present their solutions to questions and exercises distributed by the lecturer and where they apply the principles and concepts which were taught during the lectures. Such solutions are mainly developed outside the classroom, sometimes within a small group of students. In the majority of practicals, the students are given real data e.g. measurement curves such as seismograms, rock samples, electronic modules etc. to work on. Such material is often carefully selected to avoid complications due to noisy data, unclear interpretational options etc. The problem of scale arises also in many subjects, e.g. a complete bridge cannot be examined in the lab during an engineering course.

Seminars are conducted in such a way that students learn to present, discuss and think about case studies from articles in the literature (which they read typically in the late evening just before the seminar is be held). Again, links to a realistic situation are given in parts only and experience of the real world is missed.

During many excursions the students are carried from one point of interest to the next one without any active participation. Sometimes even the connection between basic theoretical principles and objects of an excursion are poorly explained and, in this way, the link between them remains obscure. Students may also be confused if there are different lecturers in the classroom and during the excursion who use different ways and concepts to describe the same object or process. Only rarely is actual fieldwork is done by students (e.g. mapping, collecting, measuring in the field or assembling of an instrument). However, well prepared lecturing outside the classroom trains students for their professional career and widens their perspective (Hursh & Borzak, 1979) due to the inherent interdisciplinary nature of outside teaching (Claiborne et al., 2014).

In the following section we propose ways to better link theoretical concepts, passive and active learning and real situations by adding to the theory given in lectures to include practicals and seminars where the subject is actually based. This concept can be compared to the idea of learning a language in the country where it is actually spoken. In that case, the language will not only be adopted during the language classes, but also during the rest of the day. In a similar way, during an in situ class, students are confronted with the matter all day long. This stimulates the students to think about the subject in more detail. Such an approach leads to questions (and answers) which would not have been asked (and answered) during a typical classroom lecture. Thus, students get a much deeper and more comprehensive understanding of the subject. An example can be seen in Figure 1, where students give in situ a seminar on the flanks of Stromboli volcano, Italy. The background of our examples is described in Box 1.

Figure 1: Student giving an in situ presentation (step E) about volcanic processes at the slope of Stromboli volcano, Italy. The used screen is the backside of a poster which was displayed earlier for another student presentation. A notebook and a beamer with battery power are utilised for the projection in the open field; volcanic ash plumes from small eruptions could be observed from this place during a pleasant evening lecture (left picture courtesy of J. Käufl).

Concept and Examples

The term "in situ" is the Latin expression for "in the original place" or short "in place". We use in situ to express that teaching is done outside the classroom at a place which is directly linked with the subject matter. Therefore, in situ can be related to a lecture, practicals, exercises or a seminar with student presentations. Our experience from in situ lecturing at bachelor's and master's degree level shows that a balanced combination of lecture presentations, practicals with exercises and seminar-type elements is a meaningful way to educate students in many disciplines. Of course, the subject or theme must be suitable for successful in situ lecturing. Geosciences are obviously very suitable for in situ lecturing, because the study objects such as volcanoes, mines, observatories etc. are obvious targets which should be studied outside the classroom (Thompson, 1982, Butler, 2008). Education in many other disciplines may also benefit from in situ lecturing, e.g. biology (zoos, wilderness), physics (particle accelerators), history (historic sites) and many others.

Table 1: Overview of the concept of in situ lecturing with its main elements A - F.

Step	Type	Main Functions
A	preparatory lecture	• introduction of first principles • theoretical basis • outline and organisation of in situ part
B	preparatory student work	• reading of relevant literature • preparation of presentation, e.g. for classroom presentation or in situ seminars • preparation of handouts or lecture notes for fellow students • organisation of in situ part
C	in situ lecture	• repetition of first principles and basic concepts • presentation of subject matter with direct link to the subject
D	in situ practical	• solving exercises directly linked with the subject • observation, identification and description of elements related to the real subject • onsite training
E	in situ seminar	• presentations directly related with the subject, in the field or during evening seminars
F	post-trip documentation	students: • writing a final report • reflecting on the subject and preparation for exam
		lecturers: • reflecting on the course for further improvement • reflecting on students' comments

Figure 2: Students discussing and working on a short-time exercise during a preparatory lecture (step A). Such exercises increase their attention to the lecture and help the students immediately reflect the lecture subject.

Our pedagogical concept for integrated in situ teaching includes the following elements or steps (Table 1):

A) preparatory classroom lectures on basic concepts and theoretical work,

B) preparatory student work which includes the repetition of the basic concepts, reading of relevant literature, preparation of classroom presentations, in situ seminars and lectures, as well as getting familiar with the specifics (e.g., geology, geophysics, eruption style, vegetation, accessibility) of the location of the field study,

C) in situ lectures in order to reinforce the theoretical background and to transfer the basic principles to real situations,

D) in situ practicals to actively apply the basic theory learnt during the lectures, within the actual situation,

E) in situ seminars with presentations by the students to explain observations in the field, review the background, explain the local history or add details as well as discuss uncertainties and other problems related to the present in situ state of the subject, and

F) post-trip documentation.

The succession A) – F) is arranged in order to achieve a high transfer of knowledge and skills to the students. Especially the active parts foster the training of competences with a special focus on real professional situations and working environments. Details and examples for steps A) to F) include:

A) Preparatory classroom lecturing: higher education must include instruction in the solid theoretical background of the subject matter. Thus our geophysics teaching includes the presentation of basic physical concepts and equations. These theoretical parts are taught best in a traditional class course where one can concentrate on physics theory and the related mathematics but it should also include practical applications, case studies and quantitative parameter descriptions. For instance during a course on induced seismicity (see Box 1), we explained the theory of tectonic stress with applications to Earth materials and to earthquake fault zones as well as the influence of stress changes generated by humans. In order to overcome their passive status, we introduce student activities such as brief exercises (Figure 2) or pop quizzes or provocative questions which they solve in small teams. By these means, the students are continually motivated. (Powell, 2003, Handelsman et al., 2004). The preparatory classroom lecturing includes also a first introduction to the sites of the in situ lecturing as well as organisational issues.

Figure 3: Students giving a poster presentation on borehole logging methods during preparatory student work (step B). Each student had to prepare and explain a part of the presentation to get familiar with the subject matter discussed in the field.

Figure 4: Local field engineer (left) during an in situ lecture (step C) in a quarry with volcanic rocks, Vogelsberg region, Germany.

B) Preparatory student work: active participation of students is a key element for understanding the subject matter. For the preparation of the in situ part we place a special emphasis on reading the relevant literature. We select mainly articles in scientific journals to force the students to read original science reports and get familiar with scientific approaches and the appropriate language style. Reading well-selected journal articles helps students deepen their knowledge and improve their understanding of the theoretical concepts. Students also learn typical linguistic expressions and the appropriate use of terms used in their fields. Besides, our German students are thus forced to train their skills in English, the main language in science. Another focus is on the region of the in situ part – this means getting familiar with the geography, regional and local geologic framework as well as geophysical field studies and models in our case. For an in situ lecture course on the volcanoes in Southern Italy (see Box 1), each student had to write a chapter of the excursion guide book based on a literature study and prepare a presentation to be given later in situ (Figures 1 & 8). For a course on the volcanic complex of Vogelsberg volcano, Germany, the students had to prepare both, a short chapter for the lecture notes, and a 10-15 minute-long poster presentation about methods used in borehole logging. The posters were presented in the preparatory classroom lecture before the in situ part (Figure 3). Additionally, the students prepared a presentation given at an in situ seminar, either in the field, or during an evening seminar held in the hotel (Figures 9-10).

C) In situ lectures: in situ means that university lecturers or external experts present the learning matter at the specific place where the subject is relevant. In situ lectures can be done in several ways and at different kinds of locations (Figures 4-6). Mobile equipment such as a notebook and a beamer can be used in a hotel, on a ship or even in the open field (Figure 1). Concepts presented earlier during the preparatory classroom lecturing can be repeated and directly linked with the real world. Of course the main point should be the direct inclusion of the local phenomena (e.g. a geoscientific site, major machinery or instrument, a building…). A classic example is the explanation of rock types and the genesis of these rocks and their usage in a quarry (Figure 4). One may also visit a seismic reflection field survey and explain the implementation of recording arrays, the data acquisition and preliminary data interpretation. Such a lecture can be given also by an external expert, e.g. a field engineer of a company, a local geology expert etc. Generally, parts of the in situ lecturing can be done by local experts who have specialised local expertise (Figure 5), specific experience with a production machine or research infrastructure (Figure 6) etc. It is useful to explain to such external lecturers in advance what is the aim of the lecture, what is the state of knowledge of the students and what the students could do as possible practicals.

Figure 5: In situ lecture (step C) at about 700 m depth inside a potash mine. A group of geophysics students is instructed by a local geologist.

D) In situ practicals: during in situ practicals students have the opportunity to experience things that cannot be done in a class room (Figure 7). This may be the exploration of the underground using geophysical equipment, the handling of real production machinery or a realistic field study e.g. for hazard assessment. Especially in geoscience training, it is important to learn techniques for successful fieldwork (Kastens et al., 2009). Compared to laboratory studies, in the field, one has to cope with completely different working conditions: rough, partly extreme weather conditions, varying light conditions (which can cause a different appearance of rocks or minerals for example), identification of often hidden objects (e.g. a mineral vein underneath a vegetation cover), systematic spatial mapping or collection of data or a working environment with an unknown cultural and language background (e.g. archaeological work in a remote area in the Himalayas). It is important that students learn such realistic situations in situ and gather first experience for a later professional career (Kastens et al., 2009).

E) In situ seminars: students present a seminar talk in situ while incorporating the study object directly in their presentation. As media posters or computer presentations can be taken along and displayed at the hotel or in the open field (Figures 8-10). Subsequent to the preparation of such a presentation, the students are well prepared for the in situ subject, because they are forced to actually read the required literature and to think about the main relevant topics for the presentation. The shorter the allowed time for the presentation, the higher the pressure for focussing on the main facts and background information. This is a valuable exercise for students to learn to concentrate on the basic principles.

Figure 6: In situ lecture (step C) in the museum of historical seismometers of the University of Strasbourg, France. The main principles of seismometry are explained to the students and the operating mode of the mechanical components can be demonstrated at real objects.

F) Post-trip documentation: After the in situ phase, students should write up what they saw, experienced and learnt in a final report. Due to our experience, we recommend giving the students a clear limit for the length of the final report (the shorter the better: students learn to concentrate on relevant parts and lecturers are protected from reading numerous endless essays) and we tell them which main points should be covered. Individual final reports may be combined to manuscript-like lecture notes which cover different aspects of the subject matter and may serve e.g. as preparation material for an examination or for a future in situ course.

Box 1: Case Studies

Our in situ lecturing experience is based on the following geophysical topics and examples:

a: *(Geo-)Physical Volcanology and Hazard Assessment*: volcanic eruptions are a major hazard to society in many regions of our planet. We travelled to the volcanic islands of Lipari, Vulcano and Stromboli in the Tyrrhenian Sea and to Mt. Vesuvius (Italy). In these places we studied volcanic edifices, volcanic rocks, volcanic activity, monitoring concepts and monitoring instruments. We determined and estimated hazards related with the volcanic activity including the identification of vulnerabilities and the estimation of values at risks.

b: *Geophysical Exploration of Volcanic Fields*: deep geophysical exploration (down to several hundred kilometres depth) of volcanic regions is necessary to understand the origin and history of magmatic processes inside the Earth and for understanding future volcanic activity. We went to the Eifel volcanic field in Germany to explain such approaches. Geophysical models were presented and discussed for a thorough understanding of the deep magmatic processes underneath the Eifel. In addition many surface expressions of volcanology can be studied including rock types, gas emissions or current vulnerable infrastructure.

c: *Induced Seismicity*: induced seismicity embraces man-made earthquakes and related processes which are mainly due to mining operations and water injections into the Earth. We travelled to geothermal power plants, deep mines and water reservoirs which are potential sources of induced seismicity. Monitoring concepts were explained to the students as well as the destroying impact of induced seismicity to infrastructure.

d: *Historic Seismicity and its Use for Seismic Hazard Analysis*: historic seismicity deals with earthquakes and their impact on society and nature in the past (mainly the time before instrumental seismicity started at around 1900). We explained the relevance of historic seismicity for estimating the hazard and risk by future earthquakes in the preparatory course and then visited a museum with historic seismic instruments as well as a town near to our university which suffered from destructive earthquakes in the past.

e: *Geophysical Investigations at a Complex Miocene Volcanic Structure*: this lecture deals with questions such as how can we use geophysical exploration and measurements in order to investigate a complex volcanic structure. We went to the extinct Vogelsberg volcanic complex near Frankfurt, Germany and visited quarries, geotopes and borehole sites. There we explained the use of geophysical measurements which are needed to understand the volcanic structure at depth. In the preparatory lectures, students worked on poster presentations about borehole logging methods, and in the field we discussed the results of geophysical measurements conducted in the region. Students conducted geomagnetic measurements and had to identify anomalies of the local magnetic field.

Discussion

We introduce an extensive concept in which a part of the traditional classroom teaching is transferred to the actual places where the subject matter can be studied directly and under realistic conditions. Compared to other teaching approaches such as excursions or fieldwork, we propose to lecture and practise comprehensively in situ (Table 1). Whereas students often follow passively the visited sites during an excursion, we motivate and force them to actively contribute to the lecturing. This active contribution goes beyond typical fieldwork, as the students are involved e.g. in preparing the lecture notes or giving presentations. Basic concepts and skills are taught and learnt ahead of the in situ part during preparatory classroom activities. During the in situ part, lectures are done to repeat these basics and deepen the students' knowledge. In addition new learning matter is introduced by including a direct link to local specialities, some of which can never be presented in a realistic manner inside a classroom (Figures 4-7). Active application of the freshly trained skills will admit students an even deeper insight to the subject during the in situ practicals and in situ seminars. This comprehensive learning cycle helps students acquire a wide range of competences, even exceeding the main subject.

When the complete preparatory and in situ lecturing is prepared and executed by the same lecturer or lecturer team, the subject matter can be presented in a coherent way to the students. This avoids confusing students due to different descriptions or parameter abbreviations of the same object as it can happen when different lecturers use their own teaching material.

Figure 7: Students exploring hot fumaroles inside the Fossa crater on Vulcano island, Italy. The students measured the temperature of the emissive gas and liquid sulphur (up to 270 °C), analysed rock samples and identified endangered infrastructure during the in situ practical (step D).

The in situ lecturing is suited for bachelor's as well as master's level teaching, we also applied it to mixed groups (from first year bachelor's to second year master's students). Of course, exercises and themes for seminar presentations should be adjusted individually to the different students according to their background and experience.

The in situ lecturing requires significant input and active contribution from the students: both, the preparatory and in situ phases include practicals which can be quite time consuming. Especially the preparation of the in situ seminar presentation, including the generation of hand-out material for fellow students, may take some time. An example for a work plan can be outlined as follows: we plan about 40-60 working hours for the active preparatory phase and 10-20 hours for the preparatory lecturing. Depending on the subject and site, the in situ part can last another 30 hours (3 days) to 120 hours (12 days). For the final report about 20-40 hours may be required. This corresponds to an overall work load of 200-300 hours or 7-10 credit points of the European Credit Transfer System (ECTS, with 1 ECTS credit point equivalent to 30 hours of student work).

An important point is to make clear to the students what is expected from them. Especially presentation material (posters, handouts, computer presentations …) prepared for the in situ part must be done thoroughly by the students, because missing background material may not be available during travel. If the students prepare material for in situ lecturing, then flaws must be avoided as it may be also difficult to conduct revisions during travel.

The students can be included in the organisation of the in situ part in order to learn the organisational side of their subject. For instance students may organise the travel to a starting point of the in situ part. We told our students that the in situ part of a volcanism-related lecture series will start at the port of Naples (Italy) at a specific pier, day and time. It was their own responsibility of get to this place in time which is about 1000 km away from their usual classroom.

Figure 8: Students giving an in situ seminar presentation on the mechanism and volcanic hazard of the 1944 lava flow at Mt. Vesuvius, Italy. The group stands on this specific lava flow and the city of Naples with one million inhabitants is seen in the background (step E).

Figure 9: Students giving an in situ poster presentation (step E) on a magnetic anomaly at the Geiselstein volcanic intrusion, Vogelsberg region, Germany. The group stands on top of the magmatic rocks which were also studied with geomagnetic measurements during an in situ practical (step D).

Most students are highly motivated during our in situ lecturing. The students' seminar presentations, hand-out material and their final reports were prepared predominantly in an excellent way. The average grades assigned to the in situ courses were better compared to other classroom lectures. We interpret this positive outcome to be the result of high motivation due to our concept of in situ lecturing.

Likewise our in situ courses were evaluated very positively by the students within the regular anonymous evaluation procedure which is conducted at our university (KIT) (Craanen, 2010). The overall grade of the students' evaluation was always very high (between 1 and 1.5 with 1 as the best grade on a scale between 1 as excellent and 5 as deficient). Furthermore, the students provided helpful comments to improve this kind of lecturing method. Students commended for example "that they liked to talk to local experts", "that they could go to sites which are not publicly accessible", "that they were demonstrated the subject in accordance with practical needs" or "that they could evidently realise the relationship between theory and real measurement instruments". We are encouraged by this positive feedback to further conduct and develop in situ lecturing as well as recommend this concept to other lecturers.

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