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This paper will discuss a pedagogical approach to integrating the humanities and the natural sciences. Our approach calls for extended collaboration between the two fields and a capacity to integrate the experimental and deductive lines of reasoning within the natural sciences with the holistic and critical perspectives of the humanities. This paper will describe and discuss how this notion is applied to the construction of a pedagogical framework or a learning environment constituted from landscape theory, GIS, and pedagogical principles derived from EBL and PL. The paper highlights how a landscape approach in combination with the interactive and dynamic properties of GIS can be used as an active learning environment crossing the interfaces of the disciplines.

Landscape; archaeology; landscape analysis; GIS; pedagogy; Uppsala University.

1 Introduction

Landscape analysis, here referring to the overall activity of describing and interpreting landscapes drawing on information from the social sciences, humanities, and natural sciences, requires extended collaboration between different research subjects. Moreover, it requires the capacity to integrate the experimental and deductive lines of reasoning within the natural sciences with the holistic and critical perspectives of the humanities and the social sciences. Landscape research and teaching in the Department of Archaeology and Ancient History (AAH) at Uppsala University rests on the philosophy that landscape is both the medium and the outcome of a collaborative learning process, and that students and researchers alike are co-learners in that process. As will be argued here, the integrated research and pedagogy that landscape analysis provides bridges the conventional dichotomy between the humanities and the natural sciences and allows researchers and students to test ideas and interpretations, as well as to build integrative projects. Geographical Information Systems (GIS) are excellent tools in that learning process and can be a pedagogic tool in visualizing and testing ideas and building new research projects.

This paper will describe and discuss a pedagogical framework or learning environment constituted of landscape analysis, geographical information systems (GIS) and pedagogical principles derived from experience-based learning (EBL) and peer learning (PL). The paper highlights how a landscape approach, in combination with the interactive and dynamic properties of GIS, can be used as an active learning environment crossing the interface of the humanities and the natural sciences. The examples discussed in the paper are derived from the GIS pedagogy developed by the department and applied at both the basic and advanced levels.[1] The objective of the approach is to facilitate students' own learning and training in landscape archaeology, GIS, and project-based research. The landscape – here considered as the total sum of the social and natural dynamics of the

1 Lindholm 2004.

environment and as constituted by social, biological, and physical relations – is a crucial component of the pedagogy. The general idea is that the training in landscape analysis, archaeology, and GIS should have a clear theoretical foundation in the landscape: as the students learn and acquire the ability to work with landscape interpretations and GIS, they simultaneously develop tools for analyzing and understanding landscapes. Hence, the landscape constitutes both the medium and the outcome of the learning process.

We will provide a short background below, through an introduction to landscape archaeology and GIS directly followed by a brief presentation of the department and the courses in landscape archaeology and GIS. The individual courses are not included in a formal program block, but are linked through the pedagogy and the progression of skills acquired by the students. Landscape, EBL, and PL are the three largest conceptual components in the theoretical and pedagogical framing of the courses, as will be presented in detail below. Next, the paper will present the procedure of a basic GIS course in archaeology, which provides an illustration of how the theoretical and pedagogical frameworks are applied in the coursework. Finally we will conclude the paper by looking into the results of the teaching philosophy by following the progression of the course work in landscape analysis and GIS from the basic to the advanced levels. At the advanced levels, the students become members of the research group Rethinking Human Nature (RHN), which consists of researchers, postgraduates, and instructors with an interest in GIS and landscape research. The RHN group aims to develop an integrated approach to research, teaching, and networking in GIS and landscape analysis, i. e., the overall activity of describing and interpreting landscapes while drawing on information from the social sciences, humanities, and natural sciences. This gives the MA students engagement in a dedicated seminar series, practical work experience, and links to international research networks. Advanced students are also affiliated to the Mind & Nature research node, a larger interdisciplinary collaboration within the Faculty of Arts that studies the relations between humans, nature, and landscapes.

2 Background

The department consists of the disciplines of global archaeology, Nordic archaeology, classical archaeology and ancient history, egyptology, and osteology. A number of cross-cutting research themes in the department are related to landscape analysis, such as historical ecology, environmental history, urbanism and agro-urban landscapes, archaeobotany, osteology, contract archaeology, and information retrieval and spatial analysis of complex landscapes. Because of the strong departmental interest in landscape analysis, GIS resources have been built up since the 1980s, initially as part of two African research projects, *Urban Origins* and *Human Responses and Contributions to Environmental Change in Africa*.[2] The current pedagogy in GIS has been built up since 1999. Today GIS-based landscape archaeology can be considered a sub-field that informs all of the departments' landscape research and provides an integrative platform for joint research and teaching between the disciplines.

GIS is a computer-aided system for the collection, storage, retrieval, analysis, and presentation of spatial data.[3] Computer-aided documentation and GIS has increased researchers' capacity to collect, handle, and analyze large bodies of spatial data. This, coupled with the spatial nature of much of archaeological data – for example artefact distribution within a site location, the distribution of sites within a region or across specific

2 Sinclair 1997.
3 Clarke 1986.

landforms – explains why GIS methods were quickly adopted by archaeologists.[4] Indeed, the full potential of archaeological spatial analysis and modelling is probably not feasible without the use of a GIS frame of reference, largely because the size and the applicability of the digital archaeological databases increases over time. With the current exponential growth in the availability of archaeological information through online resources, the archaeologists of today and tomorrow are faced with a situation approaching that of 'Big Data,' where huge quantities of information will be readily available. This will allow archaeologists to investigate complex socio-environmental dynamics at a multitude of scales simultaneously and will open up new lines of archaeological research.[5] It also requires archaeologists to work more closely with experts in information technology, mathematics, and statistics.

As elsewhere, there was an increased interest in landscape archaeology in AAH in the beginning of the 1990s. A number of landscape-oriented PhD theses were produced, and research projects were formulated with spatial analysis as a specific sub-theme. The development of the current course structure and pedagogical framework started in 1999 with a pedagogical reformulation of the courses based on the notion that the very concept of landscape is not only a research field, but also a good pedagogic frame for teaching archaeology and allowing students to gain experience in the archaeological research process by practicing different interpretative approaches, tools, and analysis. Before the reformulation, our courses were technically oriented, as many GIS courses seem to be, and not directly attached to archaeological source materials or landscape archaeological theory. Students criticized this aspect in their course assessments,[6] calling the courses too technical and too focused on the natural sciences, with few connections to the archeological research process. Hence, it seemed necessary to develop an integrated approach accommodating the full potential of landscape as a pedagogic frame and using the GIS tool as a way to build research projects and test archaeological questions.

After the first revision and the testing of a more applied approach, integrating both method training, landscape theory, and project work, the course received more positive reviews in the student assessments. Over time, our landscape archaeology and GIS courses have increased their focus on PL and team building. Landscape theory and spatial analysis have also become more integrated into all courses. Even at the basic undergraduate level, students are already being prepared to build and execute research projects, and undergraduate researchers in the department can begin to 'plant' and test research ideas through student-driven projects. The department has also started cross-disciplinary courses within the Faculty of Arts for graduate students based on the same principles, where course exercises have been built as small research projects by master's level students from a number of different disciplines, and is collaborating with other individual departments in their GIS training.

3 The theoretical frame

The overall conceptual frame is based on the notion that landscapes are constituted by relations between biological agents and processes and are shaped and reshaped from the experience, knowledge, and practice of individuals and social groups. Landscapes are spatial and temporal manifestations of these interactions between humans and their environment; they provide a framework for a fruitful meeting between disciplines engaged

4 Allen, Green, and Zubrow 1990; Gaffney and Ztancic 1996; Gillings, Mattingly, and Dalen 1999; Conolly and Lake 2006.

5 Austin and Mitcham 2007; Löwenborg 2006; von Hackwitz and Stenbäck 2013.

6 Lindholm 2004.

in integrated research.[7] This makes the landscape an effective theoretical framework for facilitating a learning process, since the landscape allows for the integration of data and information from various areas and perspectives by allowing the research question to become central in building analyses and choosing tools and perspectives. In our research and in the curriculum framework we use the concept of 'landscape analysis' to refer to the general activity of describing and interpreting landscapes drawing on information from the social sciences, humanities, and natural sciences.

Our teaching philosophy is consequent with our understanding of landscape and to a large extent inspired by constructivism and social interactionism.[8] Bateson's notion of deutero-learning,[9] meaning 'learning how to learn', has also been influential, not only in formulating an active learner theory when it comes to the pedagogy, but also in providing the means for an interdisciplinary and bridging learning environment. Basically, we cherish a view where reality is not comprised of systems to be systematically described; rather, reality is a complex problem that requires a systemic approach. The theoretical framework, together with the ambition to bridge the nature-culture dichotomy, asserts the importance of creating a method for active learners who are acting within a dynamic collaborative learning milieu and in a problem- or experience-based learning process.[10] Learning and knowledge is perceived as constituted in the practice of individual learners through their interaction with other learners and their engagement with research problems. Active learning and learning by experience is fundamental in research. Our approach has garnered interest from researchers studying how institutional agendas are constructed and reproduced by social interaction.[11] A number of meta-analyses based on students' marks and assessments have shown that active, cooperative, and collaborative learning improves the ability of students to remember, makes them more engaged in their learning process, and improves the development of higher academic skills such as argumentation, analysis, and synthesis.[12]

The vast majority of published evaluations of collaborative learning have been done in the natural sciences, engineering, and mathematics fields, as well as in the social sciences. In the humanities, there have been few similar meta-analyses of teaching based on active learning and collaborative learning. Active learning theories are well suited for the humanities, but it is difficult to find examples of them in the literature. We have also noted that there is caution in the humanities about going beyond the conventional 'discussion seminar' to implement active and collaborative learning. Instructors have too few hours for teaching and are anxious to cover a topic or theme, i. e., to reach the learning outcomes, as effectively as possible. However, it is our experience that collaborative learning and EBL do allow students not only to 'learn how to learn' but also to build an understanding of the archaeological practice and the nature of research. Our learning environment allows them to attain higher academic skills in collecting, analysing, interpreting, and theorising the archaeological materials more broadly, as well as in gaining a better understanding of their own role in facilitating a learning process. This, we find, allows students to be better prepared and confident for both professional and academic life, an experience that is transferable to other disciplines in humanities besides archaeology (see similar discussion in Gordon 2004 based on media studies).

7 Ingold 1993; Balée 2006; C. L. Crumley 2007; Costanza, Graumlich, and Steffen 2007; Meyer and C. Crumley 2011

8 Berger and Luckmann 1967; Bourdieu 1977; Giddens 1984; von Glasersfeld 1989; Jaworski 1993

9 Bateson 2000 (1972), 166–168.

10 McKeachie 2002.

11 Nyroos 2012.

12 Hattie 2012; Gibbs 1992; D. Johnson, R. Johnson, and Stanne 2000; Prince 2004; Smith et al. 2005; Freeman et al. 2013.

In our case, knowledge of the landscape is based on and constantly modified by the students' own interpretations, facilitated by their project-based case studies and the instructors that act as supervisors and also co-learners. The landscape increases understanding of scales, analogues, and source criticism; underlines the importance of perspectives and theoretical frames in building research questions; and enhances the theorization of the selection of data and data types and their subsequent interpretation. Hence, as stated in the introduction to this paper, the landscape becomes both the medium and the outcome of a systemic learning process. This learning process follows a number of steps, and we use principles derived from EBL theory, Problem-Based-Learning (PBL), and PL to extend our landscape and learning theory into the coursework.

EBL draws heavily on Experiential Learning Cycle theory,[13] which suggests that adult learning consists of four successive stages. The first three, *Concrete Experience*, *Reflection*, and *Abstract Conceptualization*, consist of having, reviewing, and describing an experience, for example by applying known theories to the phenomena. The final stage, defined as *Active Experimentation*, enables students to construct ways of modifying their knowledge. This experimentation, in turn, leads to a new *Concrete Experience*, etc.[14] The whole GIS course is presented in the initial seminar as constituting one full loop, but there may also be several smaller loops, for example certain tasks carried out within the course or as part of the projects. For the teaching and tutoring activities, the conceptualization of the loop has been an important element in creating a shared language and facilitating the students round the loop by encouraging reflection, conceptualization, and new ways of experimenting with GIS tools and landscape concepts.

PBL, an extension of EBL, assumes that humans are motivated to solve problems. As such, the problem-solver will seek and learn whatever knowledge is needed for successful problem-solving.[15] Judging from our experiences with the coursework, PBL seems to be more successful when the problem is 'owned' by the problem-solver(s): the original problem should be defined by the students to the greatest extent possible, which some might call a radical form of PBL.[16] The instructor's role is mainly to ensure that the definition of the problem will require students to acquire as much as possible of the knowledge, skills, and attitudes articulated as the aim of the course. It has to be said that this form of PBL necessitates a high tolerance for uncertain outcomes.

PL, if facilitated well, can contribute to an even more active role for students. This in turn helps to create an enriched learning environment. One way to facilitate this is to openly discuss group dynamics and invite the students to reflect upon the issue. The result of this tends to be that the students define their own role more clearly as facilitators of a learning process, in addition to their role as experience-seekers and problem-solvers.

We consider GIS to be one of the most important tools in our pedagogical toolbox, especially when facilitating an active learning environment. Relatively early in the course, the students are able to interact with and integrate various landscape data set qualities and experiment with questions and theories. The student group's 'home-base computer' in the laboratory becomes a node or platform for the experiential learning loops and PBL. The students are able to gain direct experiences and to visualize the effects of their conceptualizations. The visual representations of these, in turn, constitute an important tool for reflection and further experimentation. They also become a good medium for enhancing intra-group discussions and the tutoring activities. Several people working around one or two computers requires good communicative skills and gives students a

13 Kolb 1984.
14 Kolb 1984.
15 McKeachie 2002, 197.
16 Atherton 2013.

concrete impression of the importance of beneficial group dynamics, which stimulates PL and peer instruction.

4 Landscape archaeology in GIS analyses

4.1 Landscape as a through line in the curriculum

The courses currently provided by the department are presented in Fig. 1. The AAH curriculum has recently been modified by the introduction of a bachelor's program, where students first take a general introduction year and then choose a subject in which to specialize. Those who choose archaeology go on to the first subject year in archaeology, which can also be taken by non-program students and as individual courses. In the first program year, as well as in the course of the first subject year, landscape archaeology and spatial analysis are integrated into all the courses as one-time lectures. In the second term, students in their first subject year take a course in GIS and archaeology, as well as a course in landscape archaeology. The idea is for these courses to complement each other in a pedagogic progression. The courses are discussed in more detail in this paper. The basic level of undergraduate study concludes with the submission of a BA thesis; supervisors are available to support students who choose a subject related to landscape analysis and/or GIS. Since the courses at the undergraduate level can be taken as individual courses and are not linked through an established program, it has been necessary to define three levels of progression through undergraduate training. We teach the basics of archaeological theory and method in the first introductory program year and the subject year courses by introducing landscape archaeology and spatial analysis. The basic courses in GIS and landscape archaeology are meant to boost the students' interest in landscape studies and GIS, enhance their understanding of theory and capacity for building archaeological research questions and interpreting archaeological data, and develop their general knowledge and skills in landscape theory, analysis, and GIS. The BA thesis is intended to identify students with an interest in landscape and GIS and prepare them for advanced-level studies. At the advanced (graduate) level, we aim to facilitate the students' specialization through supervision and integration into the RHN and Mind & Nature groups described above. The students select their thesis subject early and work on their MA dissertation for almost two years.

The advanced-level courses related to landscape archaeology are: Landscape Archaeology, GIS for the Humanities, Historical Ecology, and Cultural Heritage Management. We also offer the possibility of practical training courses in other forms of landscape analysis, such as archaeobotany, vegetation history, and other methods from the natural sciences, as well as practice-based internships in contract archaeology organizations. We consider the ten-week course in landscape archaeology to be the 'flagship course' of our course structure. This course is highly research-oriented and offers in-depth insights into current landscape research, as well as training in advanced GIS and statistics. A field-based GIS course is currently under development; in this course we will aim to address data collection, prospection techniques, and GIS in the field more thoroughly than as currently taught in the conventional field course.

4.2 Landscape archaeology: Course procedures

Though we will focus primarily on the GIS course in this section, we will also briefly introduce the landscape archaeology course that was originally given in the second term of the first subject year in archaeology. The course had an individual written exam in which students were tasked with interpreting an archaeological site from a certain perspective, e. g.,

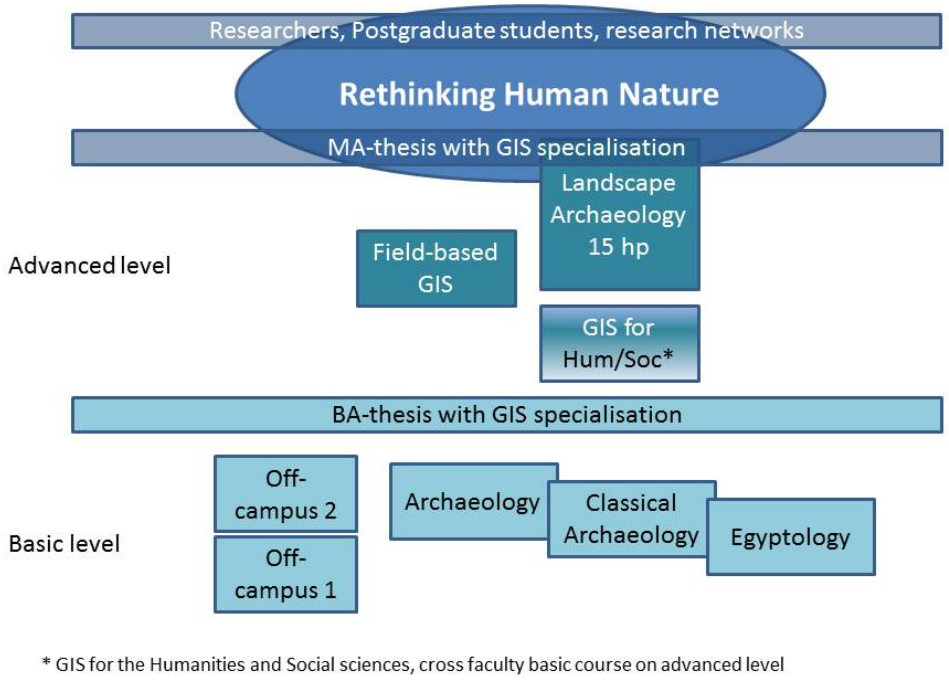

Fig. 1 | The course structure of the GIS training in the Department of Archaeology and Ancient History at Uppsala University, and the relationship to the research group Rethinking Human Nature.

phenomenology, gender, historical ecology, etc. Course literature on different approaches in landscape archaeology and lectures from instructors in the department provided inspiration for the students' individual interpretations, which were to be written in essay form. Earlier in the course, students were assigned a particular site and the landscape around it. They worked together in groups of four to five students to research the site, assigning roles and tasks in the group and sometimes designating different people to specialize in different aspects of the field site (the burial area, or dwelling area, or environmental data or age divisions of the site) or to cover different literature (e. g., field reports or scientific publications). This research was reported back to the group as summaries that could be used by the other students in the group. Each group then discussed possible interpretations and approaches on the basis of the available material and the character of the landscape and site. This allowed students to more directly contextualize theoretical approaches in a place/landscape and gave them the opportunity to critically assess the archaeological material and the possibilities of interpretation. The student groups presented their different approaches to each other before the submission of the individual assignments, and as a final course event, students assessed each other's work through formal review interviews. Because this course ran just before the GIS course, it sometimes also allowed students to raise questions that could be explored further in the GIS course.

4.3 GIS and landscape analysis: Course procedures

The courses in GIS and landscape analysis, no matter their discipline or level, are divided into two blocks (Fig. 2). A general rule is that the basic levels are more group-oriented; the advanced level is more individualized and contains more technical training. Below we will use the basic course in the second term of the first subject year in archaeology as

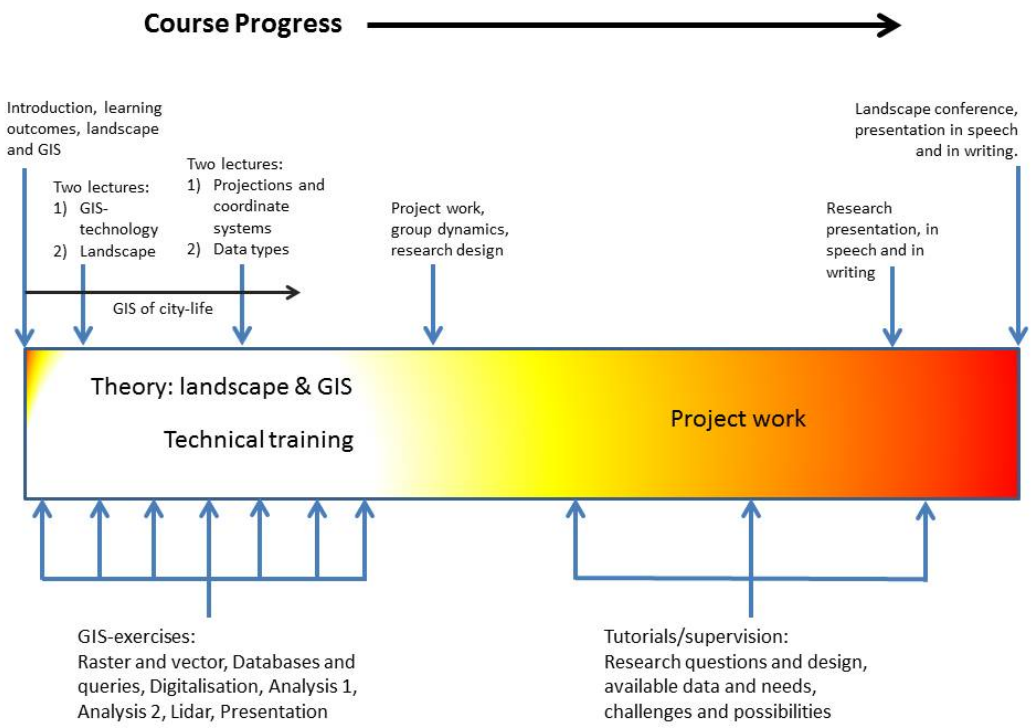

Fig. 2 | Course procedure for a course in GIS and landscape analysis.

an example of the course procedure. The purpose of the first block is for students to gain theoretical understanding and technical skills. The objective of the second block is to let the students apply their theoretical understanding and practical skills to a project.

The first two-week block consists of technical training and a series of key lectures. The first introductory lecture introduces the learning outcomes, experiential learning theory, the PL concept, and the general course outline. The second lecture introduces GIS technology and provides an overview of the technical training and GIS exercises. These exercises incorporate the basic functions of GIS: data compilation, queries, analysis, and presentation. One key lecture addresses the conceptual framework of landscape analysis, repeating aspects of the previous landscape courses as well as highlighting links between landscape theory and GIS. Two lectures are dedicated to projections and coordinate systems and to various archaeological and geographical information systems or data sets for landscape analysis, e. g., stray finds, soils, historical maps, and archaeological databases.

In parallel to the key lectures and the GIS training, the students carry out a minor case study, which is a study of contemporary city life based on structuration theory and theories of the social production of space.[17] The students are given a paper map over a square in the city with a coordinate system. In addition, they are given a short manual that describes a research process and quantitative and qualitative research methods in general terms, as well as how to establish spatial control, how to transcribe spatial information to a database, and other necessary background. The students then carry out a pilot study, which helps them to define the research problem, develop methods, and plan their fieldwork. The second day is dedicated to fieldwork in the city. Since the students have gained basic skills in the GIS software from their technical training, they are able to undertake some basic

17 Giddens 1984; Soja 1985; Engelstad 1989.

operations such as adding a map layer, linking a database, querying the database, and creating a new layer based on a selection. The result of this introductory study is basically a GIS of current city life, and the students present their results in open space presentations on the final day. The project gives students an introductory understanding, in a playful way, of how to undertake a research project. One benefit of the city project is that it will serve as a blueprint for an authentic research process and the extended three-week project carried out in the second block.

The second block of the course is based on a three-week authentic archaeological landscape research project. The core lecture, "Project Work", introduces the project by discussing research design and group dynamics, and presents some basic strategies for maintaining a sustainable project work environment. The students work together in groups of three to six members. The group members all work on the same case, as would be the case in working on a professional archaeological project, for example in a contract archaeology setting. Even so, and similarly to the preceding landscape course, the projects requires that individual group members carry out their own tasks within the frame of the project, e. g., literature reviews, archival research, visits to archaeological collections, digitization work, etc. The students independently define areas of research, formulate research questions, and select the kinds of data and the most appropriate ways of collecting the data. This gives the students practice in evaluating the relevance of different archaeological and geographical data in relation to a research problem. In order for them to practice accommodating and integrating information from various sources, it is important that they are able to define and conceptualize a coherent theoretical framework. The student projects, which are always based on authentic archaeological materials, either existing or digitized by the students, provide the frameworks within the curriculum; all other learning within the block is related to these projects.

The finale of the course is a landscape conference (with 'registration', name tags, and timed paper presentations), in which the students present their projects to departmental staff and in poster sessions. The MA-level students are also encouraged to attend and present at academic conferences and to build personal academic networks.

5 Landscape as a frame of collaborative learning

The landscape and GIS instruction is closely related to ongoing research projects and also incorporates existing and new archaeological results from contract archaeology. Many student projects in archaeology have focused on the ongoing research project of Gamla Uppsala (Old Uppsala). The integration of learning and research is further developed at the BA and MA levels, when students who opt for landscape analysis are integrated into a broader research network, such as the RHN and Mind & Nature groups. Our ambition is to establish a collaborative learning environment incorporating both students and instructors and based on the sense that we are all co-learners, albeit with differences in experience.

6 Conclusion

In this paper we have described a learning environment constituted from landscape theory, geographical information systems (GIS) and pedagogical principles derived from experience-based learning (EBL) and peer learning (PL). We have discussed how a landscape approach, in combination with the interactive and dynamic properties of GIS, can be used as an active learning environment crossing the interface of the humanities and the natural sciences. The examples discussed in the paper are derived from a GIS pedagogy, applied at both the basic and advanced levels, which aims to facilitate students' own

learning and training in landscape archaeology, GIS, and project-based research. The main idea of the pedagogy is that the training in landscape archaeology and GIS should have a clear theoretical foundation in the landscape. We conceptualize 'landscape' as the total sum of the social and natural dynamics of the environment and as constituted by social, biological, and physical relations. Through landscape and GIS, the students acquire the ability to work as active learners. With landscape interpretations, they simultaneously develop tools for analyzing and understanding landscapes. GIS is an excellent tool in that learning process, since it is a dynamic and integrative pedagogic tool with the capacity to visualize and test ideas, as well as to build new research projects. We have highlighted that landscape research and teaching is a collaborative learning process, and that students and researchers alike are co-learners in that process.

Landscape analysis requires extended collaboration between different research subjects and the capacity to integrate the experimental and deductive lines of reasoning within the natural sciences with the holistic and critical perspectives of the humanities and social sciences. We believe that the integrated research and pedagogy that landscape analysis provides bridges the conventional dichotomy between the humanities and the natural sciences and allows researchers and students to test ideas and interpretations as they build integrative projects. The landscape constitutes both the medium and the outcome of learning processes, and we consider it a crucial platform for research and teaching in the interface between nature and culture.

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