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INFORMING TEACHING PRACTICE: USING KNOWLEDGE OF STUDENTS' PERCEPTION OF GIS AND THEIR GIS-LEARNING STRATEGIES

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1. INTRODUCTION

In the last thirty years Geographical Information Systems (GIS) have increasingly been included in research and education at geography departments worldwide. In recent years this process has accelerated, and GIS has become more and more integrated within the field of geography as a geographical subject in itself. This has accompanied an ongoing debate among professional geographers on how and whether to allow an integration of GIS into the intellectual core of geography (e.g., Sui, 1995; Drennon, 2005). Often these discussions have been overtaken by the real world integration of GIS in geographical curricula and by pressure from job markets (e.g., Kemp et al., 1992). What is happening is a movement from perceiving GIS as a technical expansion of the toolbox of geographers to perceiving GIS as a geographical instrument which educates the students in say spatial thinking (see, e.g. National Research Council, 2006). This movement may be described as turning GIS away from its traditional role as just a technical supplement to the geographical curriculum towards a new role which places it right in the intellectual core of geography. As a result GIS is increasingly becoming a geographical instrument through which students learn central geographical concepts such as for example spatiality and scale and which changes not only how we learn but also what we learn. This new role of GIS creates a need for educational considerations worldwide and it is these considerations that are the focus of the present paper.

The history of GIS-education at the Institute of Geography, University of Copenhagen, is an example of the development from traditional tool towards geographical instrument (Toft and Balstrøm, 2004). Here an introductory course in GIS – along with one in remote sensing – was introduced into the curriculum in 1988. Both were non-compulsory, technically oriented courses placed at the masters level. Over the years more and more specialized courses concerning GIS have arrived and the introductory GIS course has been moved further and further down to the bachelors level. Finally in 2002 the introductory GIS course was merged with a course in cartography and placed as a mandatory course for first year geography students. The course gives the students an introduction and first-hand experience with GIS, and is supplemented by six elective GIS-courses placed later in the curriculum.

An educational development project was initiated in fall 2005 by teachers of the introductory course 'GIS and cartography' and researchers from The Centre for Science Education. One of the projects aims was to study the new challenges that teaching this course faces by examining the students' perception of the course and further, through interviews, tests, and questionnaires, obtain an understanding of how the students learn GIS. The results were used to inform the teaching practice within the course and to reflect upon how knowledge of students' GIS-

learning strategies can be used to adjust GIS-education. The full extend of the project is described in Madsen and Holm (2006).

The results from this project form the empirical basis of this paper. First, the methodology is outlined; this locates the course and situates this analysis within the existing literature. Secondly, the paper presents the results on the students' perception of GIS and their GIS-learning strategies. In this section attention is placed on the role of gender. Based on these observations ways of informing teaching practice are discussed in the third section. Here, focus is on the two issues of activating knowledge in computer-based instruction and linking theoretical and practical knowledge. Finally, a short comment on the research and teaching perspectives of the results concludes the paper.

2. METHODS

2.1. LOCATING THE COURSE

The course in GIS and cartography is taken by just under 100 first year undergraduate geography students. Alongside an introduction to human and physical geography, it is the first subject the students meet when entering university. The course introduces central elements of GIS and cartography. Focus is on how different abstractions of the world can be represented within a GIS through the use of different data models. This is combined with hands-on laboratory classes which concern themselves with various themes of human and physical geography. At the end of the course the students are tested on their theoretical knowledge of GIS and cartography in a written exam.

The course runs for 9 weeks and consists of two weekly lectures (each of 45 minutes) plus two weekly, two-hour computer laboratory classes in ArcGIS, version 9.1. The course is mandatory for all students, both human and physical geography students. The laboratory classes, which are also given by the lecturers of the course use a 'manual' contains practical instructions and exercises. The students are divided into four classes and work two together at a computer. The students can take several GIS courses after this introductory course. GIS is also used in the parallel introductory course in human and physical geography as well as in several later courses in both human and physical geography.

2.2. SITUATING THE ANALYSIS

Students have different perceptions of learning, and studies have shown that these differences have profound significance for the students' learning strategies and their construction of knowledge (Prosser and Trigwell, 1999). Within the field of geography, Kolb's learning style inventory has been influential both as a means of understanding international differences of learning styles among geography students and of designing courses using the different stages of the learning cycle (e.g., Healey and Jenkins, 2000; Healey et al., 2005). These studies are based on pre-classified types into which the students are categorized based on various parameters. In the present study, the approach is different. Here, the students' learning strategies have been studied in relation to a single GIS-course by focusing on what kind of strategies they use to learn GIS and how these strategies are linked to the way the course is taught. The typology of learning strategies is developed by giving the students open questions in a questionnaire and afterwards categorizing their answers into types which reflect the different descriptions of how they have learned GIS. This is done both in relation to the students' descriptions of how they have learned GIS and to their advice to others who are going to learn GIS. The methodology has its origin within cultural geography (Madsen, 2001; Madsen and Adriansen, 2004). Learning strategies are seen as flexible and as constantly being constructed and re-constructed by the individual student in relation to the teaching practice she/he meets, both in the different courses and at the university as a whole. In order to capture this dynamic nature of learning

strategies the typology is developed after the questionnaire and based on the students' answers and not in relation to pre-classified types asked for. The interviews and classroom observations are used to inform the identified types of learning strategies in an iterative process.

The study is based on the following empirical material:

- Classroom observations (25 laboratory classes and 3 lectures).
- Interviews with teachers in 'GIS and cartography' (3 interviews).
- Interviews with students (6 interviews with a total of 9 students, during the course and 8 interviews with a total of 15 students, after examination).
- Questionnaire (62 percent response rate, total 49 students: 27 women and 22 men).

3. STUDENTS' PERCEPTION OF GIS

Generally, the course on GIS and cartography is highly appreciated by the students. Even students that did not expect to find the subject of any interest found that it was very valuable for their education, as indicated by these:

'It has been more fun and more interesting than I thought it would be. It is a very valuable subject in our information society'.

'For me it is a marriage of necessity, it is not something that I have fallen for but something I need to love...I can see that it [GIS] is necessary in many of the jobs that are available for geographers in the future'.

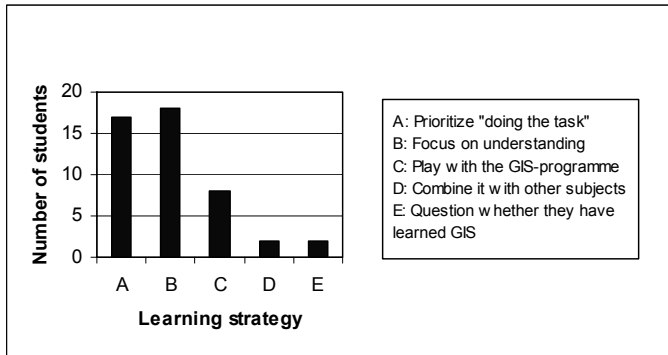
The students see the importance of learning GIS in mainly two ways. First of all, it is seen as a necessity in order to get a job after graduating. Secondly, it is found valuable in the parallel course in human and physical geography as well in later geography courses.

GIS has a high degree of legitimacy among the students. Not all students are fascinated by GIS and its possibilities. Instead they see it more as a necessity. However, none of the students questioned the value of GIS for either their geographical education or their future performance in the job market. Most students tended to describe GIS as something that one can do something with, ranging from a description of a tool that automates the tasks geographers have been doing for years, to a description of GIS that focuses on solving geographical problems and sees GIS as a subject in itself. In that respect, students' perception of GIS is just as varied as professional geographers' (see Drennon, 2005). However, most students see GIS as an integral part of their geographical education. This is important for the teachers to be aware of in their teaching practice, as it may allow them to have quite high expectations of the students' involvement in the course.

4. STUDENTS' STRATEGIES OF LEARNING GIS

In the questionnaire, students were asked to describe how they had learned GIS by focusing on what they had actually done, rather than what they thought they should have done. Based on their descriptions five types of learning strategies were distinguishable among the students. These are shown in Figure 1.

FIGURE 1
STUDENTS GIS-LEARNING STRATEGIES



Three types dominate the picture namely type A, B and C, whereas type D and E were almost non-existent. Type A is students who prioritize doing the task (i.e., all the literature, exercises and lectures), type B is students who prioritize understanding in their approach to GIS, and type C is students who prefer playing with the ArcGIS-program in order to learn GIS. Type D students indicate that they learn GIS when they use it in the adjacent course in human and physical geography. Finally, type E students question whether they have learned GIS at all. Here are examples of the three main types:

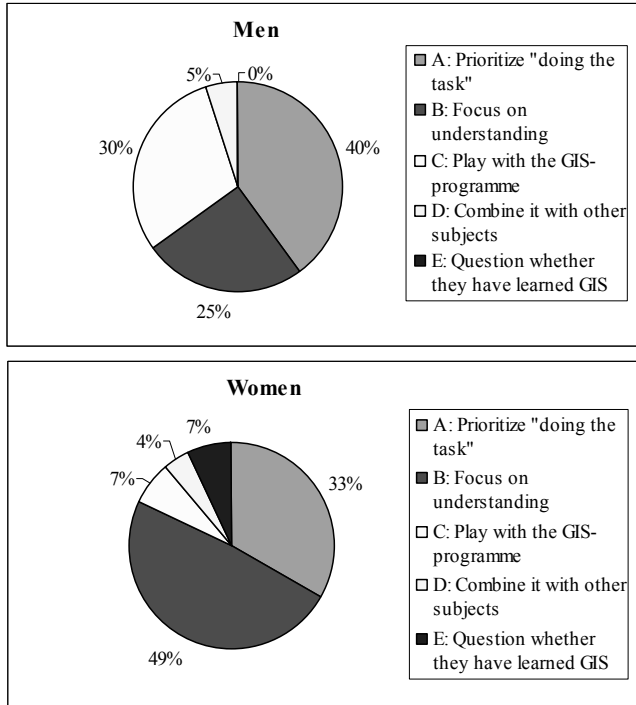
Type A student: *'I attended the lectures, wrote notes and printed the hand-outs out. Before the final exam I read all the assignments including the hand-outs. I made notes so I had an overview of the different concepts and expressions. I wrote down where in the assignments the different concepts were defined. I marked the text and made tables of content to the texts for which we did not receive tables of content. I put the texts and notes in a ring-binder organized in accordance with the lectures. I attended all the classroom exercises and the ones that we didn't finish in class we made sure we finished later'.*

Type B student: *'I went to both the lectures and the labs. In the labs I focused on understanding what we were doing and not just go along [and finish the exercise]. I read all the course assignments, but only once.... I sat down in the exam preparation period and discussed different topics with the other students'.*

Type C student: *'I sat many hours with ArcMap/ArcCatalog [the computer program ArcGIS] both at home and in the labs. That has given me a pretty good overview to understand what the lectures were about'.*

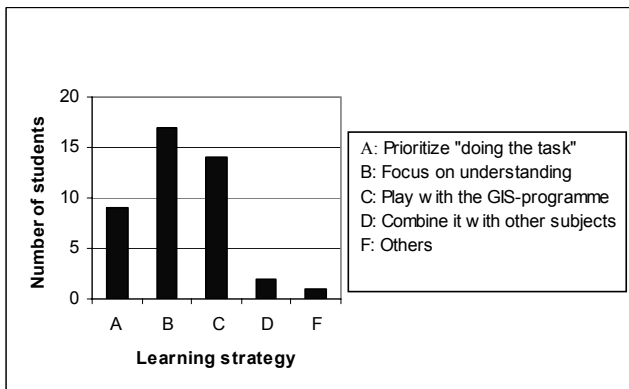
Concerning gender differences in each of the different learning strategies, within type A slightly more men than women prioritize 'doing the task' (Figure 2). More distinctly, more women than men seek understanding (type B), while more men than women play with the ArcGIS-program (type C) in order to learn GIS.

FIGURE 2
GIS-LEARNING STRATEGIES – MEN AND WOMEN



The students were also asked what advice they would give if anyone asked them how to learn GIS. Again five different learning strategies were identified, four of them similar to the above strategies and one of 'Others'. A comparison of these new types A, B, C, D (Figure 3) to the ones that describe the students' own learning strategy reveals some differences.

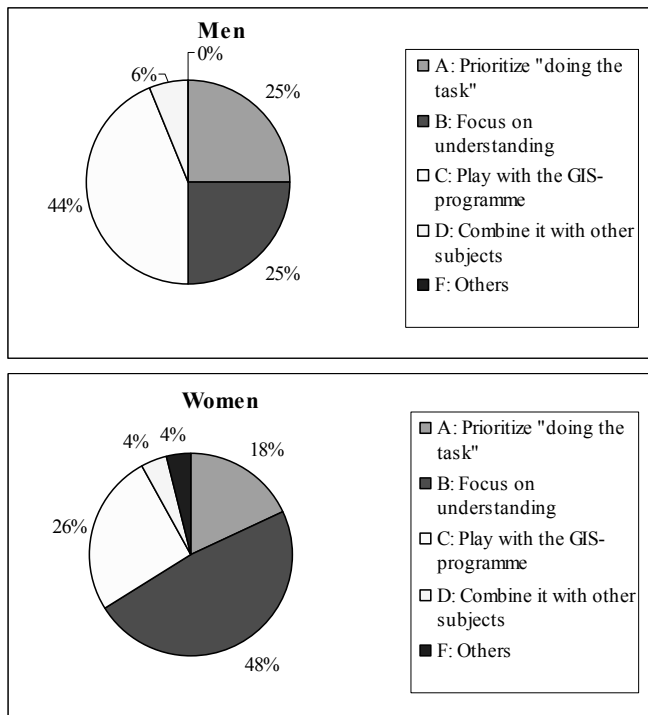
FIGURE 3
THE STUDENTS' ADVICE ON GIS-LEARNING STRATEGIES



More students recommend a type C learning strategy when they are giving advice on how to learn GIS and fewer students prioritize a type A strategy. The other two types (type B and D) have not changed significantly in total numbers. It seems that playing with the program are favoured when the students reflect on their learning processes in relation to GIS despite that some of them have not themselves used that strategy.

When we look at the gender differences when the students are asked their advice on how to learn GIS the picture within each type of learning strategies is the same as when describing their own strategy. Slightly more men than women tend to advise type A learning strategy, and distinctly more women than men recommend to focus on understanding (type B) whereas more men than women recommend playing with the program (type C). But something has changed when we look at the distribution of the total numbers on the students' advice (Figure 4) compared to those of their own learning strategy. Many more students tend to recommend a learning strategy of playing with the computer program (type C) than when they describe their own learning strategy. For both men and women there is a move from type A to type C strategies.

FIGURE 4
ADVICE ON GIS-LEARNING STRATEGIES – MEN AND WOMEN



5. INFORMING TEACHING PRACTICE

A discussion of how the knowledge of learning strategies can be used to inform and qualify the teaching practice follows. The discussion avoids trying to fit teaching practice into the existing learning strategies of the students, and instead supports some learning strategies in preference to others, with the aim of educating balanced learners with a full range of learning capacities.

Focus is on how learning strategies are linked to concrete practice during the course and how this can contribute to our understanding of changes in teaching practice.

5.1 ACTIVATING KNOWLEDGE IN COMPUTER BASED EDUCATION

The following is a typical quote from the exercise manual:

Choose **Spatial Analyst** → **Reclassify**, put Input-raster = `dist_water`, press **Classify**, press the Method-arrow and choose **Equal Interval**, press the Classes-arrow and enter **8** and press **OK**. Press the first **New Values record** in the Reclassify-window and replace the value 1 by 8, the value 2 by 7 and so on. Leave the field **No Data** untouched. Press **OK** and see the result which is placed in a new grid file with the name *Reclass of dist_water*.

This kind of cookbook recipe does not encourage the students to explore the software in whatever way they might see fit, as also argued by Meitner et al. (2005). Further, it restricts them in their practical experiences with the computer and thereby hinders construction of knowledge. An alternative approach would be to create a manual that goes from a high level of details of instruction in the beginning of the course to a much lower level of details in the end of the course. This would allow the students to gradually become comfortable with exploring the software. However, based on knowledge of the students' learning strategies, this seems to be more complex than all that, as argued in the following.

Students were asked to what extent they agree with the two quotes 'It is important for me that I am forced to think when I do the GIS-exercises' and: 'I often stop during the GIS-exercise and think through what I just did on the computer screen'. When the answers to these questions are linked with the students' learning strategies, it appears that students with different learning strategies also tend to react differently to these two quotes.

Most students think it is important that they are forced to think themselves when they work with the GIS-exercises. This tendency is strongest among the type A students (prioritize 'doing the task') where 65 percent of the students agree with the quote. For type B students (prioritize understanding) 42 percent agree that it is important for them, while 25 percent of Type C students (prefer playing with the GIS) agree. This tells us that the students who focus on finishing the exercise (type A) have an awareness of the benefits of reflecting through the exercise. But they do not themselves practice it, as revealed by their answers to the second quote. Here, only 12 percent of type A students agree that they often stop during the GIS-exercise and think through what they just did on the computer. 37 percent of type B students agree and 13 percent type C students agree on this quote. This tells us that the learning strategy with focus on understanding (type B) also has a practice that is related to this, namely to stop during the GIS-exercise and reflect.

Based on these results we can see that some students (type B) actually do stop and reflect on what they are doing, despite that the manual thoroughly specifies every task to be accomplished. By changing the manual we probably could get more type A students to reflect on their practice because many of them agree that it is important that they are forced to think. But what about type C students, what would their reaction be to such a change? They do not to the same extent as type A students agree that it is important for them to be forced to think themselves. And at the same time most of them do not by themselves stop and reflect during the GIS-exercise. However, classroom observations and interviews gave the impression that some of the type C students use the manual quite systematically just as the type A students but at the same time they perceive this as a kind of pre-understanding. Later on they go home and play with the computer program in order to gain a deeper understanding. From this viewpoint, the study has given more questions than answers, and in efforts to improve teaching in GIS we

need to address the possibility that if the manual is changed, it will support some learning strategies and not others.

5.2 CREATING LINKS BETWEEN THEORETICAL AND PRACTICAL KNOWLEDGE

Integration of lectures and laboratory classes is essential and often it is argued that only an overall coherence in terms of content is not sufficient, but also references back and forth are needed. For example to link the lecture content back to previous laboratory classes, start the laboratory classes with links to lecture content and so on (e.g., Meitner et al., 2005). However, providing references does not necessarily mean that links are perceived by the students.

Students were asked if they had finished an exercise without understanding its goals. Two students answered in this way:

Student 1. *'As it has been said several times: It is just so schematically and pedagogically put together that you are able to put yourself on autopilot – that's at least how we have experienced it – and we sit and are almost – not falling asleep, but you get very tired in your head because – and now it is very harshly said – but you just put yourself on autopilot and just do [press with the fingers in the table] what is said in the papers [exercise manual].'*

Student 2. *'And often, when a result appears on the screen, you look and then think: oh well!'*

Student 1. *'Oh well, that looks fine enough.'*

Student 2. *'That's probably right, one thinks. That's presumably as it is supposed to be and then you go on and you look at the other students' screens. Oh, ok – that looks the same. They just have other colours, so that's fine enough.'*

Student 1. *'But, on the other hand – I would not do without it [exercise manual].'*

The link between theory and practice is missing for these two students although there is topic overlap between themes in lectures and exercises, process-diagrams of the exercises are available, and the teacher's focus on telling about the connection. The point is that the link between the theoretical and practical GIS must be constructed by the students themselves.

In the questionnaire, students were asked how much they agreed with the following two quotes: 'I often finish an exercise without understanding its purpose' and 'It is a goal for me to finish the exercise within the allocated time'. Again a difference between the different learning strategies was found. Of the type A students, 71 percent agreed that it is a goal to finish on time, whereas that was only the case for 37 percent of type B students and 38 percent of type C students. The answers were more similar for the first quote. Here 29 percent type of A students, 21 percent of type B students, and 38 of type C students partly agreed that they had finished an exercise without understanding it.

These numbers show us that the link between the theoretical and practical knowledge does not appear by itself and that the different learning strategies in different degrees support the construction of a link. These relations are complex and beyond the scope of this study. However, it seems that type B students are better at creating the link themselves, whereas the learning strategies of both types A and C support a construction of the link to a lesser degree.

6. CONCLUDING REMARKS

When the goal is to help students create their knowledge, the need to address the issue of individual learning strategies arises. In a study of student learning strategies in relation to a hands-on course in GIS three main learning strategies were identified. The learning strategies are in different degrees based on doing the task (type A), understanding (type B), and playing

(type C) in relation to what has been taught. Further, there were differences related to gender. It seems that more men than women tend to play in their learning process whereas more women than men tend to focus on understanding. This reflects different approaches of the students to learning in relation to computer-based instruction.

The study also shows that students respond differently to what is being taught depending on their learning strategy. For instance students that base their strategy on understanding (type B) actively stop during the exercises and reflect upon what they are doing while this is not common for students with a strategy of 'doing the task' (type A). The study further shows that the same observed practice of students can correspond to quite different learning strategies. An example is that both type A and type C students tend to use the exercise manual thoroughly as a cookbook recipe. However, this is the only thing type A students do, whereas type C students seem to use it to obtain a pre-understanding of the issue and then play with the computer program outside the educational setting to get a deeper understanding.

Moreover the study raised new questions. As educators, we may ask ourselves if our role is to support some learning strategies rather than others, and if so, then how to do it? One could argue that it would be better to support Type B students who seek understanding instead of type A students who try to get through all the assignments. This could be done by forcing the students to reflect while doing the laboratory classes; for example, by being less detailed and putting more questions in the exercise manual. In such an approach, however, it is important not to try to teach according to the identified learning strategies, but to widen the students' possible learning strategies and in that respect educate learners by inspiring them to reflect upon their own learning strategy. In that respect the differences between genders also seem to raise important new questions on differences in learning strategies and how these are related to teaching practice.

This paper by pointing out that the educational field of GIS has moved from being seen as automating the tasks geographers have been doing for years to being seen as a subject in itself. This presents new challenges for the teaching of GIS as discussed in the paper. However, this also has at least two other important implications from a more general educational perspective. First of all, educators have to deal with a wide range of student skills, and not all students are particularly interested in GIS, as it often changes status from being a voluntary to a mandatory part of becoming a geographer. Secondly, as GIS is now seen as overarching the entire geographical curriculum and not just a technical tool supplementing geography, attention must be paid to how teaching GIS is linked to the other geographical courses in the curriculum.

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