MAP INTERPRETING SKILLS – A CLASSROOM EXPERIMENT WITH AND WITHOUT ICT AMONG LOWER SECONDARY SCHOOL PUPILS IN NORWAY

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Abstract

This study focuses on 8th- 9th grade pupils' skills in interpreting biological map information. The teaching was done as a project-based cross-subject work, aiming to test map interpreting skills through pre- and post tests. Data was collected from 100 pupils coming from one lower secondary school in a rural area in Mid-Norway. The pupils were divided into two test groups, a "GPS-group/digital map group" and a "Compass/paper map group". Teaching was carried out in the framework of sociocultural theory, pupils worked in pair-groups, and the learning was seen as a social authentic inquiry based activity. The results indicate that the pupils increased their map interpreting skills, but no difference was found between the two groups using different tools. The conclusion from this study is that the tools, digital or not, did not influence the subject learning if taking into account the importance of making interesting, challenging, authentic, and inquiry based tasks based on sociocultural thinking. The study will be followed up by analysis of a follow-up test 5 months after ending the project, by deeper analysis of the presented tasks; and of analysis of other tasks involving the understanding of map scale and the map coordinate system.
Keywords: *GPS, ICT, learning, maps, science.*

Introduction

A statement often used in Norwegian school policy documents (i.e. in Utdannings- og Forskningsdepartementet, 2003) is "Use of ICT gives higher knowledge", often with reference to results of the BECTA projects in England. (i.e. Comber et.al., 2002). Among others, this statement has made me interested in: Do the use of ICT increase subject knowledge (short- and long-term)?

Human tools or artefacts have from early human history been an important part of human beings way of learning (Säljö, 2006), and by changing artefacts the way of learning will, or can be changed. ICT as a learning tool is quite new, but tools (e.g.: Abacus, calculation machines) have been the part of teaching and learning for years. A lot of tools (radio, television, tape recorder, and video) were once thought to make changes in school, like computers have done (Cuban 1986). But the frequency of use of most of these tools decreased after a short period of time. Because of this, ICT can be looked upon

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 16, 2009

as very similar to earlier technology's entry into school. One important point here is that ICT originally was not developed to increase learning or push the development of schools, the school link is a sort of after hand construction (Erstad in: Säljö, 2002). It is still an open question which role the ICT will play in tomorrow's schools.

Global Positioning System (GPS) is a navigation tool based on satellite communication, and is used together with digital map systems, GIS (Geographical Information System) for handling spatial data. Its potential for pedagogical use is great, in school subjects like mathematics, technology, science (MTS), and geography.

GPS is an ICT tool that could be used inquiry-based in situated science teaching and learning situations, and with great potential as a cross-subject tool. Several researchers have concentrated on the use of GPS and GIS in (and outside) the classroom (Baker, 2002; Baker, 2003; West. 2003; Andersland, 2004; Nielsen & Horn, 2006; Cyvin et. al., 2006; Carlson, 2007; McClurg & Buss, 2007). I am especially interested in the learning benefit (knowledge) of alternative teaching tools, given the same subject tasks, and the same teacher. Arntzen et. al. (2003, p. 28), with reference to the internet program about radioactivity (available from www.viten.no) asks just for studies like the one presented in this paper when they say "There is need for research that among other things compares pupils subject benefit when using the radioactivity program, compared to the benefit in control groups not using the program." [1]

The teaching done as part of this classroom experiment was carried out in the framework of sociocultural theory (according to Vygotsky, 1986); focusing on social interaction among the pupils through work in pair-groups and inquiry-based activities done in authentic settings. The term *Inquiry* is imprecise, but according to Anderson (2006) Inquiry Learning can be described as a learning process involving: An active process, individual constructs depending on prior conceptions, context based individual understandings and socially constructed meanings. *Authentic* is here used in the meaning of activities involving: Real-world problems, inquiry activities, discourse among a community of learners' and pupils' empowerment through choice (Rule, 2006).

Research questions

Will the introduction of GPS and simple GIS-system as pedagogical tools give different learning outcome in selected topics in MTS and geography compared to the use of compass and paper maps, and which differences can be identified?

This research question was separated in different sub questions and in this paper the results from the following sub questions will be presented:

- Did the pupils improve their skills in interpreting map information after the project period?
- Were there differences in map interpretation skills between the GPS and Compass group after the project period?

Methodology of Research

The study reported on here was carried out in 2005-2006 and involved 100 pupils. They came from grade 8 & 9 at one lower secondary school in a rural county in the Mid-Norway. The school was chosen because the headmaster and the teachers showed a positive attitude to the research project. The study was designed as a comparison study with two groups. The separation in two groups mainly followed the school's established class structure, with approx. the same number of pupils from each grade level (Table 1).

[1] Translated from this Norwegian text by the author: "Det er behov for forskning som blant annet sammenligner elevenes faglige utbytte ved bruken av radioaktivitetsprogrammet med utbyttet i kontrollgrupper som ikke bruker programmet."

Table 1. Number of pupils in each test group, GPS-group and Compass-group coming from different grades (n=100).

	GPS-group	Compass-group	Total
Pupils 8th grade	24	25	49
Pupils 9th grade	25	26	51
Total	49	51	100

The first group (hereafter: the GPS-group) was offered ICT tools like a Garmin handheld GPS receiver for field use, and a laptop computer with topographic maps for use in the classroom. The other group (hereafter: the Compass-group) was offered traditional, classic tools as magnetic compass, paper maps, pencils and plastic sheets for the production of overlay maps.

All the pupils received a similar set of problem based, open ended tasks, and the main differing factor was the tool (GPS or Compass/paper map). Both of the groups used tools or artefacts that in some way would affect the pupils learning processes and the learning outcome (following Säljö's [2006, p. 157-168] discussion of how learning is changed as a result of development of artefacts).

Teaching was done by the author in both groups, with the ordinary teachers as assistants. Figure 1 shows important factors that could influence on the learning, and consequently the pupils' scores on the different test tasks.

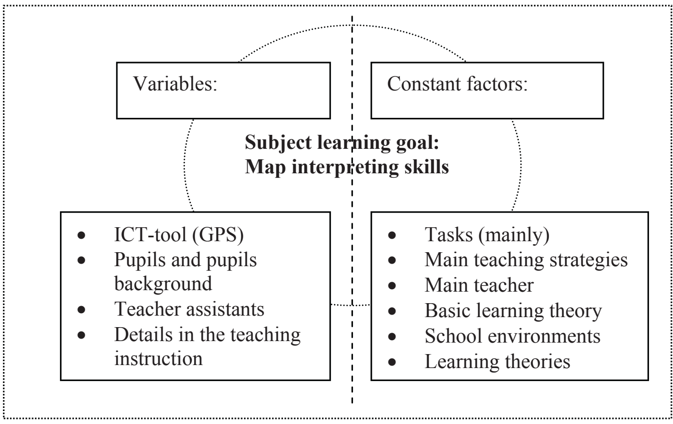

Figure 1. The figure shows how the main goal of the project is related to important constant and variable factors that possible could influence on the learning and thereby on the score of the knowledge tests.

All the tasks were carried out by the pupils in groups by two (or a few cases with 3 persons in the group), focusing on building competence through social interaction learning processes as discussed by Vygotsky (1986) and inquiry based science teaching, among others discussed by Andersson (2006). The given tasks were thought to be situated in the meaning of being "authentic and relevant" to the learner as pointed out by Hennesey (1993). This implicated that the students had to work against authentic learning (as defined by Rule, 2006), which in the next step implied that also the group working with digital tools had to do field work, not only simulations inside the classroom walls. The project went on for 5 days, 3 hours each day.

The first two days were used for pre-tests and exercises in tool use and the third day the pupils did fieldwork for a mini-project with the title "Sample water from different locations in a local lake, and register possible pollution spots along the lake shore, using the GPS/Compass and maps to register the coordinates of the investigated spots.". The forth day were used for production of maps from the field-work, and the fifth day for post-tests and project close-down.

The pupils' map interpretation competences were tested through a pre- and post-test. They were told that a new flower species had been found in the area, and through a map showing roads, waterways and "flower-spots" they were asked to interpret possible causes for the plant immigration. The post-test had a similar map with roads and waterways, but now the task was to interpret possible causes of bird death. The pupils were given three transparent topographic maps to put on top of the map with flowers/dead birds. Map1 had only very few details, Map2 a bit more details, and Map3 a lot of details about waterways, roads and houses. All the maps had a small legend explaining the used map symbols. The pupils were asked to write in their own words (open-ended questions) the reasons they could think of when they saw the topographic maps together with the thematic maps with locations of new flowers (pre-test) and dead birds (post-test) in the area. Both the GPS and Compass group received identical pre- and post-test questions. The same procedure was followed for all the 3 maps.

Before analyzing the free-text answers, these were coded based on a hierarchical code system that was made after reading through all the answers to be able to cover all alternatives. First it was decided whether the answers were connected to impact from nature (code number starting with 1), or from humans (code number starting with 2). Then the statements were, if possible, coded with sub codes. An example of a part of the code system is shown in Table 2. All the statements in the text were coded, which implied the need for up to 5 different codes per answer.

As Indicator A of the pupil's interpreter skills the number of relevant suggestions that the pupil had to the questions about the new flowers and the dead birds was used. Here all biological relevant answers were included, even those that were not possible to read from the maps, or figure out by mixing information about flowers/birds and the map information. Example: "The new flower could be spread by birds." This is a highly relevant answer but from the text information given plus the map information, you actually have no evidence to say so.

As a second indicator (Indicator B), a score based on specific statements that are supposed to be a sort of "correct" answer was calculated. For the pre-test "correct" answer included all statements like: Impacts of water and waterways (rivers, lakes, ponds), all kind of human impacts in general, more specific human impacts as i.e. roads, and water pollination[2]. For the post-test "correct" answer included all statements connected to: Water and water pollution, human impact in general, impacts of houses, roads and cars including air-pollution.

It was very interesting to read all the diverse answers that in a lot of cases involved advanced thinking even if the answers were not among the "correct" answers. Because of this Indicator A was established and tested, in order to collect the creativeness that was demonstrated by some pupils, even if the answers could not directly be read out from the map information.

Table 2. Part of the code system for the dead birds map. All the sub codes to code 22 – Car/Road/Vehicle is shown.

Code number	Code text
221	Tractor
222	Roads
223	Cars
224	Exhaust
225	"Nutrion" from roads
226	New matter from traffic
227	Vehicles

The statistics in this study were chosen to be non-parametric, because the sample is not random, and when splitting the population into smaller groups (GPS against Compass, Pre against Post) the sample size and the underlying distribution of the population was not ideal for parametric tests.

Results of Research

First the pre-test results from the whole group (n = 100) were tested against the post-test results by Wilcoxon Signed Rank Test, or also referred to as Wilcoxon Matched Pairs Signed Rank Test (Pallant, 2006), through the computer statistical package SPSS Statistics 17.0.

[2] Here one can suggest that some of the pupils mix the concepts *seed dispersal* and *pollinate.*

When Indicator A (number of relevant answers) was tested a significantly (p<0.005) higher score in the Post-test than the Pre-test group was found (Table 3).

Table 3. The significance levels and the Z value from the sign rank test of the Indicator A (number of relevant answers) for the pre- and the post-test. (n=100).

Indicator A	Map1 (simple information)	Map2 (medium information)	Map3 (most information)
Z (based on neg. ranks)	- 4.113	-4.842	-4.696
Asymp. Sign. (2-tailed)	p < 0.001	p < 0.0001	p < 0.0001

In Table 4 all the ranks are shown. The total number of students were 100 all the time, but because some of them did not answer one or more of the map questions the pairs of pupils involved in the actual analysis at a time differed somewhat. The total numbers of pairs of pupils involved in the different analyses are given as *total* in Tables 4 and 5.

Table 4. Ranks from the sign rank test of Indicator A (number of relevant answers), showing differences between the post- and the pre-test. (n=100).

	Ranks	N Map1 (simple information)	N Map2 (medium information)	N Map3 (most information)
Negative ranks	Number of pupils with: POST-number-of-answers < PRE-number-of-answers	17	12	5
Postive ranks	Number of pupils with: POST-number-of-answers > PRE-number-of-answers	44	49	37
Equal ranks (ties)	Number of pupils with: POST-number-of-answers = PRE-number-of-answers	23	24	13
Total		84	85	55

When testing Indicator B ("correct" answers), the result was the same as with the Indicator A, the post-test score was significantly better ($p < 0.05$) than the pre-test score (n = 100, Z-value based on neg. ranks = -2.517, Asymp. Sign.: p = 0.012 [2-tailed]). Correct pre-test scores were based on answers coded as water, water pollination and all kind of human impacts. For the post-test correct scores were based on codes for water, water pollution and human impacts in general, and roads/cars and houses more specific. All this according to the information possible to read from the maps, or figured out through information given together with the maps.

Pupils with statements coded with codes that *did not* match codes for water and roads were given score 1, likewise for all pupils with no answer. This was done to be able to test the group of pupils having correct score (score 2) against all the rest of the pupils as one group. In Table 5 all the ranks are given.

Table 5. The ranks from the sign rank test of the Indicator B ("correct" answers to the map interpretation), comparing the pupils' scores on the pre- and post-test. (n=100).

Ranks		N
Negative ranks	Number of pupils with worse score on the POST than the PRE test	3
Postive ranks	Number of pupils with better score on the POST than the PRE test	14
Equeal ranks (ties)	Number of pupils with equal score on the POST and the PRE test	59
Total		76

If the group with no answers was looked upon as a separate category (assigned a score = 0), and tested (with Wilcoxon) against the two categories for right (score = 2) and wrong (score = 1) answers, the

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 16, 2009

tendency of improved skills among the post-test-group was the same, but not significant on a 95% level (p = 0.096). This may be due to small numbers in each category.

Since the post-test seemed to indicate improved skills to interpret maps (based on the indicators), the material was split in two groups, the GPS-group, and the Compass group. These two groups were tested with Wilcoxon Signed Rank Test to see if the same tendency could be found in both groups as in the total material. The result of this analysis did not show any difference in the significance levels according to Indicator A, both groups had significantly (p < 0.001) better scores during the post-test than the pre-test, independent of group (GPS/Compass), and independent of map information given (Map 1, 2, 3).

In Table 3 and 4 are shown the test results in detail. As mentioned in the methodology the pupils map interpretation skills (Indicator A) was derived from the number of relevant suggestions that the pupil had to the questions about the new flowers (pre-test) and the dead birds (post-test).

A test between the two groups (GPS and Compass) by Mann-Whitney U-test showed no significant difference (p = 0.735). The indicator B had a small tendency towards better post-test score in both groups, but not significantly so (p = 0.059 in the GPS-group, and p = .096 in the Compass group). A Mann-Whitney U Test did not show any significant differences between the groups, neither on the pre- or post-test connected to Indicator B.

Conclusions and Discussion

The research questions rises two questions: Did the pupils improve their skills in interpreting map information after the project period, and ware there any differences in map interpretation skills between the GPS and Compass group after the project period?

The conclusions from the analyses so far is quite clear about the effect of the project on the map interpreter skills, based on the two Indicators A and B, but there are no significant differences between the GPS-group and the Compass-group. Even if one may question whether the indicators are good enough, such an effect is not unexpected. The pupils did an intensive inquiry-based project for 2 days with a lot of authentic work, discussing and interacting all the time in small groups. They had to construct their own maps, and got well trained in making thematic maps as the sum of topographic information and thematic information, putting symbols on maps, making legends, and all what follows map production. This was a process that all of them went through independent of the tools used.

When looking at the results from the two test groups (GPS/Compass), the result is less clear. There are no significant differences between the two groups, but according to Figure 1, more than the tools were different between the two groups; pupils were different, the assistant teachers were different, and the author's teaching was different with different pupils even if the intention was to make the teaching as similar as possible between the groups. And of course the tools were different.

According to Säljö's (2006) discussion about how aspects of learning are changed when you develop artefacts, it is very difficult to do measuring that could answer the second part of the research question in this paper. Even if the main goal of the teaching project is unchanged in the two test groups, many of the sub goals are changed. The learner has to approach the subject teaching goals through different (and sometimes new) mental processes, and thereby with the possibility to learn different skills or to learn in different ways. But, on the other hand if one looks at the overall questions about what to learn of basic subject matter (in this study interpretation of maps), how to handle the concepts and the logical way of analysis, one could suggest that this could be independent of new ICT tools or even disturbed by the introduction of complicated new technology. Many of the studies referred to in the introduction report interesting findings related to learning outcome of projects introducing digital map tools (i.e. Andersland, 2004; Baker, 2002; Baker, 2003; West, 2003), but few of them makes good comparison studies or establish comparison groups at all (as asked for by Arntzen et. al., 2003, p 28). This means that only groups using ICT is studied or the groups without ICT functions as control groups only. In these cases one will (of course) often get good or better results from the ICT-groups because one may inadvertently change the way of teaching in these groups; from instructional to constructivist, from demonstration to inquiry, from typical school tasks to authentic learning.

Through a test design based on constructivist learning (according to Vygotsky, 1986) and with authentic, inquiry based tasks (according to Rules' [2006] definition of authentic, and Anderson's [2006] description of inquiry learning) this study has tried to establish optimal learning culture in both groups. Results similar to the findings in this study, where large differences between the two groups in subject learning is not found, is consequently as expected. Säljö (2006, p. 23) recommends that the focus should rather be put on the possibilities or the difficulties that come with new technology.

The analyses presented in this paper will be followed up by analyses of other questions asked in the pre- and post test, involving the understanding of map scale and the map coordinate system. Analyses from a follow-up test done with the same pupils 5 months after the end of the current project will also be performed in order to look for possible long term learning-effects of the teaching of map interpreting, map scaling and the map coordinate system. A deeper analysis of certain aspects of the results presented her, e.g. according to gender and with focus on the possibility to explain pupil's results according to different out-of school skills (surveyed through a questionnaire) is planned. A discussion of the possibilities and difficulties following science projects involving modern digital map technology will be meaningful at the end.

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