A TOOL FOR COLLABORATIVE KNOWLEDGE-BUILDING IN STATISTICS EDUCATION

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Learning to understand statistical concepts, necessary to become a knowledgeable scientist is difficult. From learning and educational points of view it may help if students work together in groups on learning tasks. If they are stimulated to write about their understanding of relevant concepts they become active learners. The writing can be seen as a process of developing understanding. This process could be stimulated by using a computer tool. Such a tool, called POLARIS was used in our study. In this paper we describe the developmental process of POLARIS. The statistical learning environment in which we used it and how we used it is described.

WHY COLLABORATIVE LEARNING?

Modern views of learning and powerful learning environments agree that effective learning can be described as: constructive, cumulative, self regulative, intentional, situational, collaborative and individual (De Corte, 1995). Of course learning is individual. Nevertheless, interactions with other learners are expected to stimulate and deepen this individual process (Van der Linden, Erkens, Schmidt, and Renshaw, 2000). Individual knowledge develops through interactions with others. Collaborative learning situations elicit discussion, argumentation and explanation and stimulate verbalization and explicit formulation of concepts and processes under discussion.

Bereiter and Scardamalia are strong advocates of student communities working together to become proficient in fields of knowledge (Bereiter, 2002; Scardamalia and Bereiter, 1994). They introduced the concept of knowledge-building communities, where students learn to work with theoretical and practical concepts as objects (Bereiter, 2002). They advocate strongly that students become knowledge-builders and participate in the knowledge-building discourse. The focus is on: 1. problems and depth of understanding; 2. decentralized, open knowledge environments for collective understanding; 3. productive interaction within broadly conceived knowledge-building communities. (Bereiter and Scardamalia, 2003). The program POLARIS, described below, is developed to be a tool in a knowledge-building community.

NEW TECHNOLOGY: POLARIS

The Development of POLARIS

The acronym POLARIS is derived from Problem Oriented Learning And Retrieval Information System. The program was developed in three iterative phases: a *principled approach* phase; a phase of *productive learning interactions* and finally a *knowledge building* phase (Ronteltap, 2006).

The principled approach as suggested by (Koschmann, Kelson, Feltovich, and Barrows, 1996) included a four step procedure: analysis of desired instructional system; analysis of current practices; specification of a new learning system and the production of the new system. Based on the key principles of problem-based learning a questionnaire was developed. It was concluded: that not all students discuss their work and get feedback on their work; one strives at a quick solution of the problems worked on; less time is spent on reflection and elaboration of knowledge; individual contributions are not compared and integrated; discussions do not lead to new learning issues; the way students learn is not a topic of discussion. This phase ended with four experiments with an early version of POLARIS. The same didactic scenario was used in different curricula and different classes giving students access to a group environment working together in a self-managed way. The displayed group interactions were studied, yielding two observations: asynchronous collaborative learning is a complex process; and dependency in the learning situations may stimulate the use of the communication tool.

In *The productive interactions* phase small group interactions and the design of the learning were explored (Ronteltap, 2006). In group communications studied by the project group the following problems were faced: unstructured patterns in communications; contacts between group participants were loosed; too much information was distributed; no clear discussion threads and the learning process was not visible in the communications between students. The new tool needed to overcome these problems and additional requirements for collaborative learning needed to be incorporated: 1.*Effective learning mechanisms as*: *conflict*; *explanation*; *searching for information*; *negotiation*; *comparison*; and *reflection*. 2. *Effective learning behaviours* as: *navigation* and *orientation*; *transparency of the learning process*; *reorganising*; *common features*; *decision making*; g*roup cohesion*; *reuse of the content*; and *structuring* (Dillenbourg, 1999). Based on these requirements and considerations the Polaris builders moved on to the next phase (Ronteltap, 2006).

That phase was called *learning as knowledge building*. Studying the content of the information exchange in the learning environment of the Maastricht University it could be concluded that a lot of the communications between students was limited to the distribution of information. No, or too little elaboration of the information was observed. No new understandings, critical comparison of different sources of information, no reflections and compilation of information were found in the learning groups (Ronteltap, 2006). During this phase the designers used the view of activity theory, in particular the concepts of knowledge building (M Scardamalia and Bereiter, 1994; M. Scardamalia and Bereiter, 1996) in order to overcome the mentioned difficulties. In knowledge building communities the goal of interactions is to develop, evaluate and modify conceptual artefacts collaboratively. Interactions are aimed at transforming and developing knowledge by means of questioning and criticising important concepts. To be used as a knowledge building environment a repository of shared knowledge is needed and supported by specific functions to enable participants to process the content.

The next version of POLARIS contained two components: a group environment *Knowledge Builder* for the exchange of information, asking questions and feeding back information. And a personal environment *Knowledge Manager* for storing and manipulating products of collaboration for later access. The contemporary version of POLARIS contains the following functions (Ronteltap, 2006):

- Icons: Meta information of function of documents in the discourse. The functions are: question; answer; debate and supplemental information;
- Flag: personal marks for later use;
- Thumbs up: positive feedback during knowledge building processes;
- Number of agreements: indication for convergence in knowledge building;
- Overview entire thread: an aggregated document that contains a complete conversation. Facilitates learning mechanisms as reflection, negotiation, argumentation;
- Overview questions and answers: summary of conversation focussed on questions and answers to these questions;
- Overview references: summary of conversation on learning resources;
- Search: Free text search on concepts used in the discourse;
- Structured form for new posting: prompts students to explicate the role of their posting and references;
- Save link, save citation: possibility to store postings and part of postings in the knowledge manager;
- Import link, import citation: incorporate previous contributions in a new posting;

THE USE OF POLARIS IN A STATISTICS COURSE

Students of the School of Health Sciences are for each course on a regular base assigned to small collaborative learning groups. These groups are guided by a tutor. In the academic year 2002-2003 two of these groups out of 10 used the learning tool Polaris for studying and discussing statistical subjects: regression analysis, analysis of variance and chi square tests. For each of these topics a discussion forum was available. The number of students in the experimental groups was respectively 15 and 12. Group 1 was not actively stimulated by the tutor to use Polaris, group 2 was actively stimulated by the tutor to use Polaris.

The effects of the learning tool have been evaluated by means of 1) a questionnaire measuring student satisfaction, 2) discussions documented within Polaris; analysed and scored with respect to relevance and correctness from a statistical content point of view and 3) by means of normal test results on the end of term exam. Furthermore the different activities of the students in Polaris have been established; e.g., number of documents, number of discussion threads, number of times a document is read or approved, number of active students in each forum etc.

The two experimental groups are compared with each other regarding their activities in Polaris and with groups not using the learning tool regarding the test results.

RESULTS

The table below summarizes some of the activities in Polaris of the groups.

Table 1: Activities of Group 1 and 2

Forum	*# of documents*		*# of threads*		*Average thread length*	
	1	*2*	*1*	*2*	*1*	*2*
1 introduction to statistics	11	7	4	2	2.75	3.5
2 statistical testing	13	12	4	4	3.25	3
3 anova	3	17	3	2	1	8.5
4 linear regression analysis	1	17	1	3	1	5.67
5 anova for factorial designs	2	25	1	3	2	8.33
6 analysis of crosstables	0	33	0	5	0	6.6
7 miscellaneous	1	56	1	11	1	5.09
Total	*31*	*167*	*14*	*30*	*2.21*	*5.7*

These discussions between the students are in Dutch. We will summarize some of the most salient features during the presentation at ICOTS7. Suffice it to mention that the stimulated group 2 is more active than the other group. The students in group 2 have more discussions and the discussions have a greater length. Furthermore the discussions lasted for the time of the whole course. The more difficult subjects like ANOVA and factorial designs took more sentence lengths. The mean scores on the final test of group 2 was higher, although this difference is not significant: mean score of group 1 = 12.44 and of group 2 = 14.57, ($t(21) = -1.276$; $p = 0.108$). The mean score of the reference group who did not use POLARIS at all was 14.85, not significant compared to either of the two groups. The maximal test score was 20.00. The correlation between the number of student contributions to the POLARIS discussions and the final test score was slightly negative: -.20.

Evaluations using a questionnaire showed that the students who did use POLARIS were quite positive. They indicated that POLARIS is: easy to use; quite suitable for group discussions about the learning material and leading to better and deeper understanding. Group 2 asked for using POLARIS during statistics courses to come. This actually happened and again this group was able to study statistical subjects to a level of deep understanding.

DISCUSSION

POLARIS was developed to stimulate deep learning using small group discussions. In this article the use of POLARIS in a statistics course is described. When stimulated to write for learning using POLARIS discussion threads of students become available for students themselves as well as for the tutor. When not stimulated to use POLARIS its initial use fades away. But if students are stimulated they take responsibility for each others learning processes. The learning processes can be monitored by themselves and by the tutor. They help to explain their own understanding of relevant concepts. The discussion documents show the learning process. How students come to understand the subject matter can nicely be followed by the tutor. Arisen misconceptions can be corrected. Working together invites students to become knowledge workers and prepares them to really participate in the knowledge age we are living in. POLARIS appeared to be a very useful tool. Also in a statistics course.

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