Examining Naturally Occurring Tutorial Dialogues within Ill-Structured Classroom Activities

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Abstract. This paper outlines an integration of computing technology and instructional practices that allows teachers to use tutorial practices with their students on academic tasks that are initially ill-structured. Important conditions for the emergence of tutoring interactions include the use of a cooperative learning approach, and the fostering of student expertise and responsibility with respect to use of technology, both of which free the teacher's time from traditional classroom routine. The tutorial interactions involve substantial evaluation activities which inform the teacher of the progress of the student(s) on open-ended tasks. These tutorial interactions allow for on-demand instruction, and also address motivational needs of students and help to model and set classroom standards for learning.

1 Introduction

This paper presents an initial examination of tutoring practices implemented by teachers in regular classrooms (student/teacher ratio of about 25/1) where there is an integration of computing technologies and instructional practices. The computing technologies consist of networked personal computers (8 to 10 per classroom) running standard applications such as word processors, databases, and drawing programs. The instructional practices consist of cooperative learning approaches, distribution of expertise across students in upper elementary grade classrooms, and ongoing evaluation procedures by both teachers and students that are both formative and summative in character. The classroom activities to which tutoring is applied are projects in the sciences and social sciences which require the collection of information from multiple sources, followed by integration and synthesis of the information. Typically in such activities an important part of the work is defining the nature of the task itself; hence, the activity is initially ill-structured. The combination of technology and instruction provides teachers with the time and opportunity to give individualized and ongoing feedback to students.

1.1 Problem Overview

Derry and Lajoie [6] articulated a dimension along which one can place most efforts to use information technologies in tutorial types of instruction. One end of this dimension is characterized by the fullest possible use of computing technology in order to model the knowledge that the student is to learn, and, in particular, to track individual student's performance and develop a model of what the student has learned in order to provide appropriate feedback, correction, and guidance for further learning. The other end of the dimension is characterized by the use of information technologies to support and enhance student performance and learning (as 'cognitive tools' in Lajoie and Derry's apt phrase [12]), with the tasks of evaluation and feedback being left to the users of the technology—primarily the teacher, but also the students as they master reflection and self-monitoring skills. Along the dimension can be placed efforts that use information technologies in an intermediate way, especially to model domain knowledge and to provide students with assistance in planning and reflecting as they learn the domain knowledge. Examination of the use of technology along this dimension reveals a concurrent variable that characterizes these efforts—namely, that the tutorial systems which make the most use of student modeling capabilities are also those systems for which the domain knowledge to be learned is highly structured and in principle limited in extent (e.g., the Geometry Tutor [2]). This concurrent variable arises simply because, as domain knowledge becomes less structured and more extensive, modeling the student learner becomes increasingly more complex and computationally difficult.

This does not imply that information technologies cannot support learning in such domains. Reusser [15] presented eight principles for the design and use of information technologies in any instructional domain:

1. Design and use computer-based tools pedagogically, that is, as cognitive instructional tools for mindful teachers and learners in a culture of problem solving.
2. Extend and empower the minds of intentional learners.
3. Provide learners with some guidance according to the "principle of minimal help".
4. Have students construct and externalize their mental models.
5. Provide students with intelligible and effective representational tools of thought and communication.
6. Promote the use of comprehension-related strategies.
7. Encourage reflective and self-directed learning.
8. Extend the use of computer-based instructional tools into a supportive classroom culture of collaborative learning

In applying these principles for the design of HERON, his system for supporting mastery of mathematical word problems, Reusser emphasized the importance of having a model of the task or domain knowledge presented by the system. This can be seen to be especially important for the application of principles 3, 5, 6, and 7, all of which imply that there is a standard, at some level of detail, to which guidance, representations, comprehension and reflection can refer.

Project activities in the classroom that are ill-structured, in that it is not clear initially what domain knowledge will be relevant, present an interesting case for Reusser's principles. The principles are certainly valuable, but require some modification for their application. In particular, representational means provided by information technologies have to be general in nature, but also must have enough design features that the learners themselves can shape their representations to the demands of their evolving task. Also, the individualized guidance and monitoring of comprehension that comes with good tutoring must be provided by the teacher and the students themselves in an ongoing manner as the project is developed by the students. There is a challenge in employing realistic ill-structured problems in that they are more demanding cognitively than conventional tasks [10]. They are more open-ended, complex, and they require sustained periods of investigation [9], [17] and engagement [11]. At issue is how to foster meaningful learning while also preserving the integrity of complex problems; i.e., not reducing the complexity to routine procedures and rote learning. One way to accomplish this objective is to scaffold learning and support cognitive activities through effective tutoring strategies. The remainder of this paper is concerned with documenting the kinds of tutorial-type interaction that can be achieved on project work in classrooms where technology and pedagogy are used effectively.

2 Method

For the past four years we have been studying the changes in teachers' instructional practice that accompany their use of the new information and communication technologies as an integral part of their instruction in the classroom.

2.1 The setting

The teachers and students come from six different classrooms, with grade levels covering grades 5, 6, and 7. The teachers are all experienced, with an average of 15 years in the profession, and with some prior experience with the use of computers in the classroom. They also volunteered for the project, agreeing to participate after consultation with board administrators and ourselves. The schools are situated in middle- to lower-class, urban or suburban neighborhoods.[1] Each classroom is equipped with 8 to 10 networked, multimedia computers and customary peripherals

[1] The selection of schools and teachers was made in cooperation with our participating boards of education, the Protestant School Board of Greater Montreal (now the English Montreal School Board) and the Khanawake Education Centre. The choice of schools in less than advantaged communities was a deliberate one, in that we all were interested in examining the impact and use of information technologies in such learning circumstances. As one of the principals characterized his students in a grant application to obtain funding for teacher professional development, "Many of these students can be considered to be at risk in their upcoming studies in secondary school."

such as printers, CD-ROMs, scanners, and cameras. As well, each classroom has at least one computer with access to the internet. The number of students in each class has varied from 25 to 30; thus there are usually three students per computer in the class.

2.2 Sources of data

Data sources consist of: a) audio-taped interviews of participating teachers that follow a structured interview format to insure coverage of relevant topics (e.g.,. the importance of knowing software features, differences in learning associated with computer use, etc.), b) journal logs recorded by research assistants who where observing classroom interaction and also helping with technical problems, and c) videotape both of classroom activities using the computers and of interviews of teachers and students on specific topics such as grading practices.

3 Results

In order to appreciate the nature of the tutorial dialogues within project-based investigations it is important to understand how both teacher and student interactions evolve into a community of learners type of environment. Teachers who introduce computers into their everyday practice may go through changes to their beliefs about how to teach as well as how students' learn [1], [3].

3.1 Pedagogical approaches

The pedagogical approach implemented by our teachers was informed by findings from the Apple Classrooms of Tomorrow project in which it was found that teachers frequently experienced difficulty getting past an initial concern with student discipline and using computing resources for more than drill and practice (summaries of this research can be found in [7] and [16]). It was clear from this research and from our own prior observations of classrooms that the mere presence of computers in the classroom constituted significant competition for teachers who wished to instruct and manage students using didactic techniques (in the apt phrase used by our French-speaking colleagues, 'la pédagogie frontale'). Accordingly, coinciding with the introduction of the technology into the classroom, the teachers instituted a cooperative learning approach [4] that gave the students the skills to work both independently of the teacher and also together in small groups.

As well, the teachers rapidly adopted the practice of fostering student expertise in the use of the technology, and nurtured the expectation that teacher and student would work cooperatively in acquiring and consulting about expertise. As one teacher said in an interview early in the project,

> As long as we have a little head start and basically know what we're doing then we can learn as we go along. I find that preferable to waiting because otherwise you don't start anything. If you're afraid and say, "I really have to know this software inside out just in case somebody asks me a question", you never try anything. The children know we've tried it, this is interesting, this is what we can do with it. They share because we usually have a little post mortem. We try to stop a few minutes early and they tell the class what they've discovered.

This sharing of responsibility allowed the teachers to make the well-documented change in roles from a didactic instructor to a coach who facilitates student academic inquiry [14] (see also references in [8] Observation 11). This sharing also almost immediately carried over into the teachers' perspective on learning in the classroom. As another teacher put it in one of our early interviews,

> I find that they're learning from each other a little more than I used to think. I used to think it all came from the teacher. I'd stand up there at the front and entertain them. That's fading out a bit.

3.2 Three types of tutoring activities

One of the principal outcomes of the use of cooperative learning practices and the sharing of responsibility for both learning and the use of the technology is that the teachers' time is freed up, allowing the teacher to be more responsive to student academic needs, consulting with individuals and groups, helping them to set priorities, guiding student learning, and assessing student performance and learning in new ways. In other words, different opportunities for tutoring arise throughout the entire sequence of instruction. We have observed three types of tutoring events when students are engaged in project work: a) guiding student learning, b) providing information on demand as students request it, and c) evaluating student learning. The type and quality of the tutoring that is provided varies according to the instructional opportunity afforded by these events and is based on the individual differences in student background as evidenced in their student-generated projects. The type and quality of tutoring also highlight the the importance of evaluation practices that fill the teacher in on what the students have accomplished and are doing in their evolving project tasks. Such evaluations of where the students are 'at' are necessary if the teacher is to provide timely and appropriate direction to the students. In this sense, the tutorial dialogues represent an extension of just-in-time instruction from well-defined domains such as arithmetic to less structured domains such as natural science projects. The three situations are illustrated by the following protocols taken from videotapes of classroom activity.

Guiding student learning. In the first illustration, students were working in groups at the computers on projects in science and social science. The teacher moved from group to group, assessing progress and offering suggestions on what resources to access. One of the students was working on a project on the physical geography of Europe and the teacher suggested that he prepare a map showing the major mountain ranges. The true flavor of the interaction can be seen in the transcription of the teacher and student conversation:

Student: Where can I get a picture of that?
Teacher: Well, start with your atlas, and we d-, we do have an atlas on-on disk but um, it may not show what you want it to show.
Student: C- can we add the mountains, like put the mountains like (on it?).
Teacher: There's a good idea. I bet there's a way to do that.
Student: Does anybody know here in class?
Teacher: Well why don't you start working on the problem, and if I find anyone who can help you with it I'll send them to you. OK?

There are a number of noteworthy aspects of this interaction. First, the student was thinking of a computer-based presentation from the beginning, and in response to the teacher's doubt about whether what is needed exists in soft copy of the information, asked if the mountains can be put in over an existing map. Second, the teacher immediately acknowledged this request as an innovative and worthwhile goal. Third, the teacher also acknowledged indirectly that he did have the procedure readily at hand (I bet there's a way to do that). Fourth, the student invoked potential help with this goal from other students who might know how to do it, reflecting an awareness of the distributed knowledge in the class. Fifth, the teacher acknowledged the distributed knowledge and undertook to try to bring it to the student. Over the course of the next half hour the teacher checked with the student at about ten minute intervals to ascertain the progress that he was making.

Providing information on demand. In the second illustration, a group of students was also working in groups at the computers, in this instance on a social science project. The teacher again was moving from group to group when one of the groups accosted him for help with the meaning of a word in a reference text which the students were using as a source, engaged in transferring the content to their own presentation. The interaction was the following:

Student 1: Mr. T., do you have another word for abolish?
Teacher: OK, give me the sentence (looking at the monitor screen)
Student 1: OK. (reading) "By 1966 the religious courts had abolished..." But we want to put it in…
Teacher: Abolished what?
Student 1: "…abolished their duties, assumed(?) by civil courts"
Student 2: Because what if anybody doesn't understand the word. We want them to understand it.
Teacher: OK. It means that it, its, they uh closed down…
Student 1: The religious courts closed down.
Teacher: Right, or stopped working.
Student 1: OK. The religious courts closed down (reaching for the keyboard).

The noteworthy aspect about this interaction is that the students were aware that they, and perhaps others, would have problems with the word abolish in this context and sought the teacher's help. It may have been that they did not understand the word, and it may have been that the syntax of the source material was problematic--'abolish' is a transitive verb which takes a direct object, but in this context the object noun phrase was partially reflexive on the subject of the verb, that is, 'their duties' referred to the duties of the religious courts themselves. This reflexivity was not well-signaled by the syntax ('their own duties' would have been better). The teacher's suggested translation may have been a little broad, but it did capture the essence of the situation. Of course, finding out the meaning of words can be done by consulting the dictionary; but this little interaction highlights the importance of the teacher as a knowledgeable source for making sense of particular contexts.

Evaluating student learning. In the third illustration, a group of students was working on a natural science project on snakes. Again the teacher was moving from group to group assessing progress on the projects. He examined the content of the screen for this group's work, and then initiated a conversation with the group, asking:

Teacher: What are vipers?
Student 1: Uh, vipers are a kind of snake. Uh, some of the vipers have horns on their side.
Student 2: Two horns like this.
Student 1: Well, not horns, but horns like this.
Teacher: OK.
Student 1: Some, some of them are called tr-, true vipers.
Teacher: And are they poisonous, or are some-?
Student 2: They're poisonous.
Student 1: They're poisonous.
Teacher: (reading from the screen) True vipers live in Africa, Asia, Europe, and East Indies.

Again, there are a number of noteworthy aspects about this interaction. First, the teacher examined the information that the students had input into their project files in order to determine the progress students were making. Second, he asked the direct question of the students, "What are vipers?" Thus he used this activity as an opportunity to evaluate the students' understanding of the information they had been inputting, and to insure that the project information was not simply a product of copying and pasting from other sources. The teacher then returned to examining the information on the screen. Third, the interaction demonstrated an increased integration of instructional and evaluative activities in these classes, in which the types of evaluation routines were not simply summative, but could be used formatively in guiding student learning.

One of the most interesting outcomes of this kind of evaluation activity by the teacher was that it came to serve as a model for student interaction around project matters. In the following interaction a group of students were conducting a peer evaluation of another group's science project on plant reproduction. One of the authors of the project was also present to provide information. The evaluation was carried out by means of a rubric that was jointly designed by the teacher and students, and consisted of criteria such as layout and functionality, content, and spelling and grammar. The evaluation team was working with the criterion of spelling and grammar at the time of the following interaction:

Evaluator 1: OK, now spelling and grammar. Let's look into your information.
Evaluator 2: We have to look at the information. Let's go to pollination.
Evaluator 1: Alright. (reads silently). What is an ather (sic)?
Author: An anther? It's the female part of the flower.
Evaluator 2: Is it ather or anther?

Author: Anther, anther.
Evaluator 2: But it says ather.
Evaluator 1: Spelling mistake. OK, well we won't take that much off so don't worry.

What is noteworthy about this interaction is that, in the midst of evaluating spelling and grammar, the evaluator asked a knowledge question of the author. That is, the students had adopted the same practice as the teacher in asking questions that assess the understanding and knowledge of the author concerning the information that has been entered in to the project. The interaction indicated the distribution across the class of standards of responsibility and accountability with respect to the knowledge that students were mastering and working with.

4 Discussion

The tutoring activity that was seen in these classrooms marks a different type of pedagogy from traditional didactic instruction and seatwork activities. It is achieved through support from a number of factors. One of these was the technology itself, which provided students with representational tools which allowed them to create explicit and public works that could be accessed by others, both students and teachers. In this way the technology realized principals 4 and 5 advocated by Reusser. Just as important was placing the use of the technology within a set of pedagogical practices that enabled its effective use. Especially important is the use of cooperative learning techniques and the distribution of responsibility and expertise across the members of the class. These practices helped the students engage in intentional and cooperative learning activities, and realized principles 1, 2, and 8 advocated by Reusser. Finally, a consequence of these factors being in place is that the teachers had time to engage tutoring types of instruction with individuals and groups, and in particular were able to institute ongoing support for and evaluation of student progress. This tutorial activity realized principles 3, 6, and 7 advocated by Reusser.

Further, it is clear from an examination of the pedagogy, that the teachers were not only addressing the cognitive demands of the students, they were also attending to their motivational and affective needs [5], [13]. This was achieved in large part through the distribution of responsibility across the classroom, which provided students with a sense of ownership of academic activities, as seen in the adoption of the teachers' evaluation practices (see third illustration above). It was also achieved through the tutorial interaction instituted by the teachers, as can be seen especially in the first illustration above, where the teacher both guided the student toward the information resources that could prove useful and also praised the student's initiative in undertaking the mapping task.

Although the analysis of the tutorial dialogues is preliminary, it is still possible to extract key instructional characteristics of situations where tutoring is salient and can lead to significant change in what is learned in these evolving, project-based investigations. First, the tutoring that is done by the teachers often occurs 'on demand' since it is initiated by the students. This is in keeping with, and is a consequence of, students assuming a more independent role in the classroom for their learning.

Second, in these situations, evaluation skills become a key component of tutoring. The teachers frequently begin an interaction with a series of questions to the student or group of students that serves to bring the teacher into the context of the student activity. This is a consequence of the evolving nature of the student projects, which requires the teachers to update themselves as to the characteristics of the projects and the students' plans for further development. In further research on this type of interaction, it would be worthwhile to gather information on how teachers respond to individual differences as seen in prior knowledge and interests of the students, on the depth and extent of scaffolding that is achieved in this way (e.g., in the first illustration above, what were the characteristics of the follow-up interaction with the student concerning the making of the map?), and on the effects of this type of interaction for what students learn and the practices that they adopt for furthering their learning.

References

1. Amundsen, C., Saroyan, A., Frankman, M.: Changing Methods and Metaphors: A Case Study of Growth in University Teaching. Journal on Excellence in College Teaching, 7 (1996) [Journal published in 1998] 3-42
2. Anderson, J. R., Boyle, C. F., Yost, G.: The Geometry Tutor. In Proceedings of the International Joint Conference on Artificial Intelligence-85. Los Angeles, IJCAI. (1985)
3. Bracewell, R. J., Breuleux, A., Le Maistre, C.: The Role of the teacher in Opening Worlds of Learning with Technology. In: B. M. Shore, M. W. Aulls, M. A. B. Delcourt, F. G. Rejskind (eds.): Inquiry: Where Ideas Come from and Where They Lead. Mahwah, NJ, Lawrence Erlbaum Associates (in press)
4. Brown, A. L., Campione, J. C.: Guided Discovery in a Community of Learners. In: K. McGilly (ed.): Classroom Lessons: Integrating Cognitive Theory and Classroom Practice. Cambridge, MA, MIT Press (1996) 229-270
5. Cordova, D. I., Lepper, M. R.: Intrinsic Motivation and the Process of Learning: Beneficial Effects of Contextualization, Personalization, and Choice. Journal of Educational Psychology 88 (1996) 715-730
6. Derry. S. J., Lajoie, S. P.: A Middle Camp for (un)intelligent Instructional Computing: An Introduction. In: S. P. Lajoie. S. J. Derry (eds.): Computers as Cognitive Tools. Hillsdale, NJ, Lawrence Erlbaum Associates (1993) 1-11
7. Fisher, C., Dwyer, D. C., Yocam, K. (eds.): Education and Technology: Reflections on Computing in Classrooms. San Francisco, Jossey-Bass Publishers (1996).
8. Grégoire, R., Bracewell, R. J., Laferrière, T.: The Contribution of New Technologies to Learning and Teaching in the Classroom: A Documentary Review. Report prepared for the Advisory Committee on Research, SchoolNet/Reschol, Canada (1996) Available: http://www.fse.ulaval.ca/fac/tact/fr/html/apport/impact96.html
9. Haury, D. L.: Teaching Science through Inquiry. Columbus, OH: Clearinghouse for Science, Mathematics, and Environmental Education (ERIC Reproduction Document No. ED 359 048) (1993)
10. Koschmann, T. D., Myers, A. C., Feltovich, P. J., Barrows, H. S.: Using Technology to Assist in Realizing Effective Learning and Instruction: A Principled Approach to the Use of Computers in Collaborative Learning. The Journal of the Learning Sciences 3 (1994) 227-264
11. Kuhn, D., Shaw, V., Felton, M.: Effects of Dyadic Interaction on Argumentative Reasoning. Cognition & Instruction 15 (1997) 287-315

12. Lajoie, S. P., Derry, S. J. (eds.): Computers as Cognitive Tools. Hillsdale, NJ, Lawrence Erlbaum Associates (1993)
13. Lepper, M. R., Woolverton, M., Mumme, D. L., Gurtner, J.: Motivational Techniques of Expert Human Tutors: Lessons for the Design of Computer-based Tutors. In: S. P. Lajoie, S. J. Derry (eds.): Computers as Cognitive Tools. Hillsdale, NJ, Lawrence Erlbaum Associates (1993) 75-106
14. Means, B., Olson, K.: Tomorrow's Schools: Technology and Reform in Partnership. In: B. Means, (ed.), Technology and Education Reform: The Reality Behind the Promise. San Francisco, CA, Jossey-Bass (1994) 191-222
15. Reusser, K.: Tutoring Systems and Pedagogical Theory: Representational Tools for Understanding, Planning, and Reflection in Problem Solving. In: S. P. Lajoie, S. J. Derry (eds.): Computers as Cognitive Tools. Hillsdale, NJ, Lawrence Erlbaum Associates (1993) 143-178
16. Sandholtz, J. H., Ringstaff, C., Dwyer, D. C.: Teaching with Technology: Creating Student-centred Classrooms. New York, Teachers College Press (1997)
17. Schauble, L., Glaser, R., Duschl, R. A., Schulze, S., John, J.: Students' Understanding of the Objectives and Procedures of Experimentation in the Science Classroom. The Journal of the Learning Sciences 4 (1995) 131-166