StoryStation: Agent-based scaffolding of metacognitive processes for writing

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Abstract. This paper describes a research program aimed at improving students' metacognitive processes for writing. The project is based on the StoryStation system which gives students feedback on stories they've written. Each different type of feedback is delivered by a different animated pedagogical agent. We will assess to what extent interacting with these agents helps the students to think about their writing processes.

1 Introduction

Learning to write well is one of the most important tasks that students undertake in their school lives. It is fundamental to success in school and is a means by which content knowledge in many curriculum areas is developed and assessed. Yet, many students report that writing is one of the most difficult tasks they encounter in school [5] and teachers acknowledge that the teaching of writing is often frought with difficulties in terms of instructional sequence and focus [6]. Teachers' and students' concerns are mirrored in those held by other major stakeholders in education. Test results indicate that a high percentage of students leave the educational system with literacy skills below that which parents, employers and politicians would find an acceptable level.

Writing is most effectively taught by providing feedback to students on their compositions in a way that helps the students to treat writing as a problem solving process. Yet many teachers report that they simply do not have enough time to give each child the type of feedback that will best help them develop their writing skills. Advances in natural language processing techniques have made it feasible to provide many types of feedback automatically. The goal of this project is to develop and evaluate a system which supports the students' writing and their development of the metacognitive processes needed to write well. This paper presents the related research in composition, and the computational framework that we will extend to support the students' metacognitive processes. Finally, we present the methodology that we will use to evaluate our approach.

2 Metacognitive processes in writing

The composition literature includes a complex array of competing descriptions of what writing is, what it takes to learn to write, and what it means to teach writing well. Pedagogies

differ depending on the views of language espoused by their proponents. Whole language and process writing advocates develop supportive classroom environments, which encourage discovery and mirror the authentic purposes and audiences of natural language acquisition (see [3]). On the other hand, genre-based and critical pedagogy advocates insist that it is necessary to provide explicit teaching of skills and knowledge in classroom environments that recognize language as a social and cultural practice; especially since in many of our schools cultural, social and linguistic diversity is common. In such views, facility with writing requires a thorough knowledge of, and ability to apply the rules and conventions of the "discourses of power" [4].

Competing pedagogies aside, all participants in the debate would agree that our goal for education should be that students leave the system as "skilled" rather than novice writers. Seminal research conducted in the eighties by Bereiter and Scardamalia (1987) points to differences in the attitudes and processes of novice and skilled writers. They proposed that novice writers employed what they called "knowledge-telling" approach to writing while expert adult writers used a much more strategic approach. This "knowledge transforming" approach saw expert writers vary their engagement with writing tasks in order to make use of different strategies for writing. Expert writers were aware of their own thinking processes — their actions were guided by metacognitive and metalinguistic functioning. Similar findings are reported by Flower (1994). In describing the functioning of writers working with texts, Flower suggests that a number of "voices" constrain the writing process, often pushing the writer in conflicting directions. These voices ask questions like, "Who is your reader and what does he/she know?" and "How does what you know relate to the assignment?" Initially, the student does not even know what these voices are saying. Expert writers, Flower says, must recognize the constraints and reflect on how they can best be met.

For teachers of writing, these studies raise important questions about how students might best learn to write well. A synthesis of research to date would highlight the need for teachers to work with students in ways that in addition to promoting the development of knowledge about texts and linguistic structures, also help students to become aware of their own thinking processes as writers [1]. Approaches that develop students' metacognitive functioning, equipping students with the ability to be reflective and strategic when completing writing tasks are likely to be more successful than those that rely on learning and applying rules for producing certain types of texts [6]. In everyday classroom practice, effective teachers of writing support students' development of metacognitive skills by providing feedback on their compositions in a way that focuses on writing as a problem solving process. Most of this feedback takes place in the activity known as the "writing conference" [1, 3]. In conferences, the joint interaction around students' texts helps teachers provide one-to-one needs-based teaching to developing writers. Teachers have been documented deploying a range of strategies designed to promote student reflection on writing and literate thinking [8]. They move students towards independence in writing by providing scaffolding in the teaching and learning interaction, and by gradually transferring responsibility for the thinking about writing from teacher to student [16]. Such tutorial activity makes good sense in terms of recent research and theorizing on the co-construction of literacy development [12]. It is proposed in such views that the modelling of feedback by an expert interlocutor via talk (external dialogue), will provide opportunities for the knowledge to be integrated and reconstructed in the students' internal plane of consciousness. In this way through talk with an expert other, novice writers come to take as their own, the metacognitive functioning they engaged in jointly [15]. Furthermore, learner writers then use the information gained in socially organized joint activity to form the basis of

personal functioning in independent activity [11]. The claim here is that it is through this and through continued engagement with others that they come to fully develop the metacognitive functioning associated with expert writers.

The activities and processes of transfer described here are no doubt rare in real classrooms. Many teachers say that they simply do not have time to give each child the type of feedback that will best help them make this transition [5]. This means that feedback on students' writing often happens in asynchronous ways. Students, more often than not, receive written feedback on their compositions rather than being engaged in conversations about their problem solving and decision making processes as writers. Such feedback, we would argue, is of questionable value in developing the kind of collaborative discourse that will come to form the basis of the internal dialogue that Bereiter and Scardamalia [2] suggest skilled writers engage in as they write. Providing feedback via peer- and self-conferencing strategies has been investigated in a number of studies [7]. More recently, technological advances utilizing computer-generated instructional environments have made it feasible to use computer programs to give a range of feedback on students' writing. This research program is focused on evaluating and extending one such program named StoryStation.

3 StoryStation current and future

StoryStation was designed to support students while they write and to help them learn how to meet the demands of writing tasks more effectively [14]. Making use of natural language processing techniques, support for developing writers is provided through feedback on writing and by offering the use of resources such as a dictionary and thesaurus. Animated agents in the form of virtual characters present the feedback and perform many social and cognitive functions. First, the agents act as a responsive audience for the writer. They also help to focus the student's attention on the feedback and on developing strategies for solving problems highlighted by the feedback. Figure 1 shows StoryStation's main screen where students enter their stories, access the system's resources, and ask for feedback.

3.1 Agents in education

A key feature of the StoryStation program is that it makes use of a variety of animated agents to deliver the feedback. Each agent gives only one type of advice associated with a particular dimension of writing.[1] Underpinning this approach is the notion that the association between the agent and the particular dimension may make it easier for the student to make use of feedback dialogue for metacognition. Initial evaluations of the program have focused on the students' attitudes towards the agents, comparing agent-based feedback to text-only on-screen feedback. These evaluations have shown that students enjoy writing with StoryStation, and find it to be useful. For the most part (more about this below), they think that the agents provide useful advice. These evaluations have also raised many more questions about the usefulness of agents in an educational setting.

In order to address the question of whether or not agents help students learn metacognitive processes for writing, we must first understand what effects agents will have on the students

[1] The agents are implemented using the Microsoft Agents technology and present their feedback with synthesized speech. The current agents were designed and animated by some of the students involved in initial pilot testing of the system.

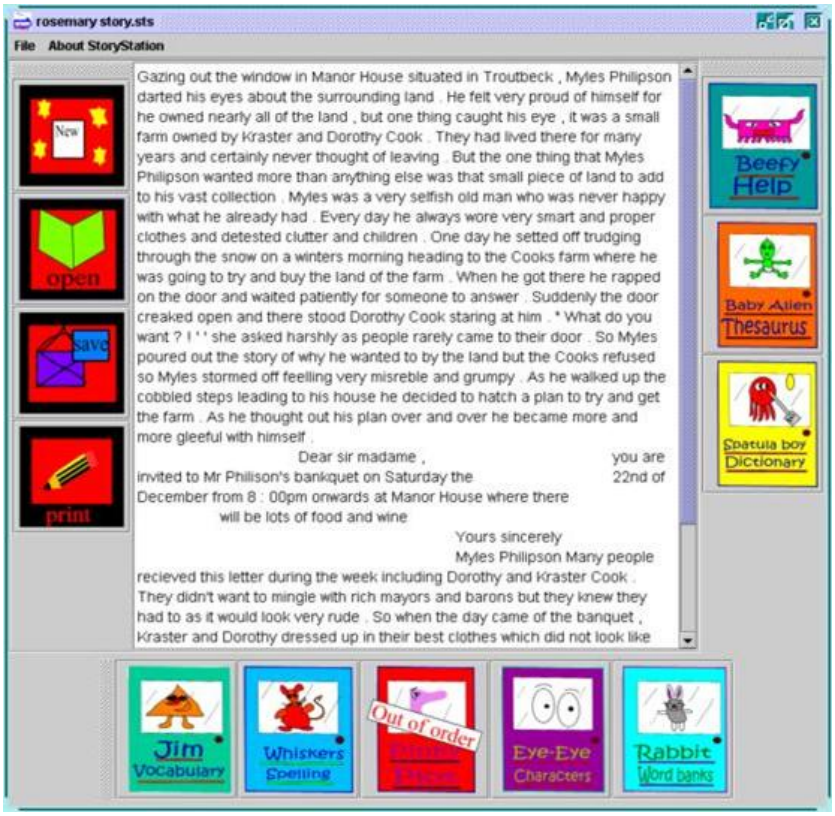

Figure 1: The StoryStation main screen

in general. In particular, the technology that enables us to provide animated agents has raced ahead of the research which examines the effects which those agents have on the students. What little research there is ambiguous in its findings. While we know that agents often help motivate students to use a piece of software [10], they do not always lead to improved student learning. In our previous research, we have compared automatically generated feedback on student's stories that was either presented textually or from animated agents. Female students found the agents to be both interesting and helpful. Significantly fewer boys agreed. One hypothesis for this difference is that boys at this age (10 – 12) are more hesitant to expose their weaknesses to others — even if those others are computer-generated agents [9]. In a recent pilot test of the system with struggling and advanced writers, we found that although all of the students worked longer with StoryStation than with a general-purpose word processor, the quality of the stories written by the good students improved, and the quality of the stories written by the struggling students went down [13]. A significant focus of this project is to further analyze the situations in which agents are or are not helpful in education. This will start to fill a large gap in our understanding of the appropriateness of animated agents for education.

3.2 Story re-telling

StoryStation was designed to be used by 10 to 12 year-old students in a task called story re-telling. In this task, students view a video of a storyteller presenting a story. Then they are instructed to write their own version of the story. This task scaffolds the writing process

by providing a general plot that the students can follow, while still allowing for creativity. It also makes the language analysis techniques more powerful, because the computer "knows" which words and event descriptions are likely to appear in the stories. The narrative genre is not especially challenging for students of the target age range (and it may change in the future), but this allows us to focus on the development of reflective processes in the context of a known rather than unfamiliar task.

The system provides basic word processing functionality plus a set of valuable resources: a dictionary, thesaurus, and lists of "recommended" words (modifiable by both student and teacher). The system provides feedback via the animated agents. The student can choose to get feedback from a particular agent by clicking on a button with that agent's image. The feedback is then presented by the agent, which moves and speaks with a synthesized voice. The current types of feedback focus on the mechanics of writing like spelling, the use of emotion words, and the use of unusual words. The agents may provide suggestions that the text needs to be corrected, or they may congratulate the student for good performance highlighting the noteworthy aspects. The system's initial feedback was based on the Scottish National Curriculum for writing (it was funded by a grant from the UK Engineering and Physical Sciences Research Council when the first author was teaching at the University of Edinburgh). StoryStation can make a determination (with optional input from the teacher) about the curriculum level at which the writer is functioning. This helps it to provide feedback that is within the student's zone of proximal development.

3.3 Extensions

The research project we describe here has two main goals. One is to extend and evaluate our understanding of computer assisted learning environments deploying interactional supports for learners. This is an important area in which the technology and the hype have outpaced our understanding of how and when their use is appropriate. Research on the role and effectiveness of agents in educational software has been sparse. Few studies to date document and describe the uses agents are put to and even fewer examine the interactional effects of such learning tools. What makes this project innovative is that advanced natural language processing techniques will be used to analyze student writing to create feedback, and that multiple agents will be used to deliver that feedback. The second goal is to examine the role these agents can play in helping learner-writers develop metacognitive strategies used by expert writers. StoryStation's agents embody, in a sense, the constraint sets or problems faced by writers as they write. Each time (positive or negative) feedback is given on a particular aspect of writing, we propose that students will come to attend to the problem at hand and through interaction with the agent will come to do the necessary metacognitive processing associated with a more skilled writer.

We are extending the system to provide feedback to span seven dimensions of textual functioning: Audience/Purpose, Content, Structure, Language Resources, Sentences, Punctuation, and Spelling [6]. In order for writers to be seen as skilled writers, their metacognitive self-talk needs to take account of decision making at all levels of text. The current system merely provides feedback on the stories when the student requests it. The student is left to determine what (if anything) to do with that feedback. In order to strengthen metacognitive processes, the behavior of the agents will be extended in two ways. First, additional knowledge will be added to the system to provide the feedback more strategically, focusing on what

the student is likely to benefit from the most. This should also reduce the extent to which students can "play" with the system (for example, by having it give the spelling of their name in order to hear it with the synthesized voice). Second, the agents will be given the ability to have more in-depth dialogs with the students about the different dimensions of feedback. The conferencing between agents and students should help strengthen the students' own internal dialogs.

4 Evaluation

Our research methodology will be to design different versions of the system for use in schools. A pool of schools will be developed to represent the diversity found in the Chicago Public School system. Once identified, the target schools and teachers will be invited to take part in the program. After an initial information session, students will begin using the StoryStation system in normal classroom practice. The expected period of use will be ten to twelve weeks. Videotape recordings will be made of all the interactions with the system and copies of all texts produced will be obtained so that independent measures of writing performance may be made. After completing their interactions with the system, students will take part in semi-structured interviews to allow opportunities for them to record their impressions of the system. Recall and evaluation questionnaires will focus on students' remembered impressions of the agents, particularly whether or not they remembered which agents were associated with which types of feedback, and which they found most helpful.

To evaluate StoryStation's abilities to foster metacognitive processes, we will need to look for evidence of transfer of procedural and knowledge-based dialog from the agent to the student's talk. Using a think-aloud protocol technique, students who have used the system will be paired with those who have not. Each student will conduct a peer conference with her partner. Glasswell's conference analysis framework [5] will be used track the interactions taking place on a cognitive and interactional level. The tracking of talk in these conferences will help to determine whether the "talk" and/or the focus of improvements made by the agent are apparent in the collaborative discourse that takes place around the students' writing. Time sampling will allow for an analysis of the students' development in terms of independent functioning in writing (the goal of metacognitive instruction).

5 Conclusion

We hope that this project will provide valuable information about how technological solutions to problems associated with the teaching and learning of writing can be of benefit to developing writers. The particular genre of writing that we have chosen to study is narrative. It is the most widely undertaken type of writing in elementary and middle schools. The research design we employ focuses on the development of generic metacognitive processes that will be applicable to writing across all curriculum areas. Developing student's problem solving skills as writers through metacognitive strategy instruction will serve the students well throughout their education.

What we learn from this project can have a direct effect on development of future agent-based technologies for education. It should also help us learn more about the acquisition of metacognitive processes in children and to what extent they can be aided by technology.

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