

What's New with C-Print®?

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*Abstract:* The C-Print® speech-to-text support service refers to a family of computer-assisted, speech-to-print technologies. Since 1995, approximately 1000 deaf and hard of hearing students have been supported in educational environments through use of C-Print and over 500 individuals from approximately 350 educational programs in at least 46 states and 4 foreign countries have completed the month-long training to become a C-Print captionist. For the past six years C-Print has been widely disseminated beyond NTID and is now frequently requested by deaf and hard-of-hearing students around the world. In this session, we will review recent findings and forthcoming enhancements to the system. We will describe innovations in C-Print technology including the new server-client software and demonstrate C-Print with automatic speech recognition technology. We will also report on recent demonstration trials in local high schools with the new C-Print Pro® software.

C-Print® is a computer-aided speech-to-text service that is a support service option for communication access and learning for deaf or hard of hearing (hh) students in mainstream educational environments. It was developed at the National Technical Institute for the Deaf (NTID), Rochester Institute of Technology, to improve the classroom experiences for students at the elementary, secondary, and college levels. The C-Print system includes the dual capacity to transcribe speech into text with automatic speech recognition (ASR) and with a keyboard-based computerized word abbreviation system. An intermediary operator (captionist) in the classroom with the deaf/hh student(s) dictates into a microphone connected to a laptop computer containing the ASR software. The captionist also can type the spoken message using a computerized abbreviation system. Afterward, the text is available to students to use in printed or electronic format. The name “C-Print” reflects the real-time provision of text that can be seen-- the sound of the “C” is the same as the word “see;” “C” is also the first letter for “computer” and reflects the system’s computer-based operation. C-Print is being used successfully in many programs around the country (Stinson, Elliot, McKee, & Francis, 2001). Training for C-Print became available in 1996 and at this writing more than 500 C-Print captionists have been trained. An extensive program of research has provided evidence that the C-Print program works effectively in secondary and postsecondary educational settings (Elliot, Foster, & Stinson, 2002; Elliot, Stinson, McKee, Everhart, & Francis, 2001).

*Limitations of the Previous Version of the C-Print System*

Although many deaf/hh students have benefited from C-Print, we, the C-Print research and development team at NTID, have for several years been aware of limitations in the C-Print abbreviation system and in the computer software used by the captionist and students. One limitation of the abbreviation system is that the captionist cannot do the intense typing required to produce the detailed text necessary for good communication access for longer than one hour without fatigue. Prolonged typing may lead to pain and injury. This limitation has restricted flexibility in scheduling C-Print services, and it can increase cost when educational programs pay for the time when the

captionist is recovering from this fatigue. In addition, the pool of potential C-Print captionists has been restricted by the requirement that captionists have high-speed typing skills. An additional limitation has been that learning the rules for the computerized word-abbreviations has required about 5 weeks and additional time is necessary to learn to use these abbreviations effectively in classes.

Turning to the software, in the past, the C-Print captionists used three commercially available software applications that ran simultaneously—a word processing program, the word abbreviation system, and a communications program that allows captionist and student computers to “talk” to one another. The time that was required to start the three applications sometimes made it difficult for captionists to get the C-Print computers ready by the beginning of class. Also, technical difficulties with the software, while rarely interfering with provision of services, have occurred more frequently than was desired. Most important, the three applications were designed for other purposes, such as medical records transcription, rather than for the real-time provision of a speech-to-text service, and lacked needed features that would be helpful in providing services.

We wanted to improve student interaction with the software applications during C-Print services. The only interaction the previous version permitted was if the student wanted to ask a question or make a comment in class. To do this, the student needed to get the captionist’s attention, the captionist needed to stop typing, and then the student could send a message to the captionist by typing. Furthermore, although students could watch the real-time display of text for communication access, they could not interact with the display by highlighting text or adding their own notes. In addition, the applications could not adapt to many of the needs of students that received C-Print services. For example, these applications did not allow the captionist and student to individually adjust the font and background of their displays. This would significantly enhance services, such as those to deaf-blind students.

### *Developing a Better C-Print System*

To address these limitations, we applied for and received funding from the U.S. Department of Education to improve the C-Print system. Goals of this work were:

1. To adapt automatic speech recognition (ASR) to support students in mainstream classes to in order provide a second option for producing text in real-time .
2. To develop an educational software application that was designed to specifically support provision of real-time speech-to-text services.
3. To develop procedures and materials to train support personnel to use ASR and the educational software.
4. To conduct formative evaluations of the ASR approach to producing text in real-time and the software application by testing the system in the field.

We have now developed a system that includes ASR and educational software, we have developed training materials, and we are wrapping up a formative evaluation of the new features of C-Print system. The system now includes the capacity to transcribe speech into text with automatic speech recognition (ASR) in addition to transcription with a keyboard-based computerized word abbreviation system. A text display of the message appears on the monitor of a student laptop approximately 3 seconds after the words have been spoken by the teacher. Students can read the display to understand what is going on in class. Given the current ASR and keyboard technology, it is desirable to have both the ASR and abbreviation approaches, because this provides greater

flexibility than a single approach. The addition of ASR makes it possible for captionists to provide services for longer than an hour without the physical fatigue from typing. In addition, the system can now accommodate to differences in providers, such as in their typing skills. It is important to continue the use of typing because it is more accurate, and students may prefer the “flow” of its text display.

The new software developed at NTID by the C-Print team, C-Print *Pro*®, a graphical user interface application, increases students’ opportunities to learn. This application provides communication between computers via a network and provides displays for the captionist (server) and student (client) computers. It enhances deaf/hh students’ ability to participate in class discussion because student and captionist may exchange messages in an Instant Messenger format independently of the real-time display of text. The application also enables students to highlight the text produced by the captionist and to take occasional notes. The application enables students to actively work with the text while the teacher and others are speaking because it requires minimal diversion from attending to the text display or others in the class. Thus, the design addresses the critical issue for deaf/hh students of multiple visual demands. Students and teachers can view the text with the software after class as well.

### *Description of the New C-Print System*

We describe in further detail below the features of the new C-Print system.

*Equipment.* The C-Print system uses laptop computers compatible with Windows 2000 or greater as server computers that captionists may dictate or type into. The client or student computers are compatible with Windows 2000, or greater, and will soon be available with Mac OS9 or greater. A variety of local area network (LAN) cards that fit into computer slots are used for radio-frequency based wireless communication among computers. The system uses IBM’s ViaVoice (Version 10 or greater) as the ASR software.

*ASR.* In producing text with ASR, as the instructor (or student) speaks, the captionist dictates continuously into the dictation mask, saying each word distinctly, at a pace that keeps up with the instructor. The captionist adds punctuation and formatting. An example of formatting is moving to a new line and indicating whether the instructor or a student is speaking, as needed. Since it is not possible for the captionist to capture lectures verbatim, s/he must summarize or “condense” information. The goal of condensing is to capture the important points while using fewer words than the original speaker. The captionist occasionally switches from dictation to typing, such as when a word is not in the dictionary or when a mistranslated word needs to be corrected. In addition, the captionist performs preparation and editing activities. Before the first session of a class the captionist creates a voice file specifically for that class, and enters specialized vocabulary as well as available information that will help ViaVoice construct a model of how language may be used in that class. After class, the captionist corrects errors in the text for distribution of the text to students. In addition, words that ViaVoice mistranslated during class are trained so that it will translate them correctly in later classes. The procedures for using ASR to produce text as a support service have just been developed and are being further refined.

*Word abbreviations.* With the keyboard-based computerized word abbreviation system, as the instructor talks, the captionist types a series of abbreviations. The interface software includes a dictionary and word-expansion component. The software searches the dictionary for the equivalent full word and displays it on the screen. (e.g. Captionist types the abbreviation “slvg” and this expands

to full word “solving” on the computer screen.) The captionist does not memorize all the abbreviations in the system, but rather uses a set of phonetic rules which are then applied to any English word that has been added to the software’s dictionary. The general dictionary contains approximately 20,000 abbreviation-word pairs. The captionist also condenses information in a manner similar to that for ASR. In addition, the captionist performs preparation and editing activities. These include addition of new abbreviations for words that are not in the dictionary that will be used in class and correction of errors in the transcript before distributing it.

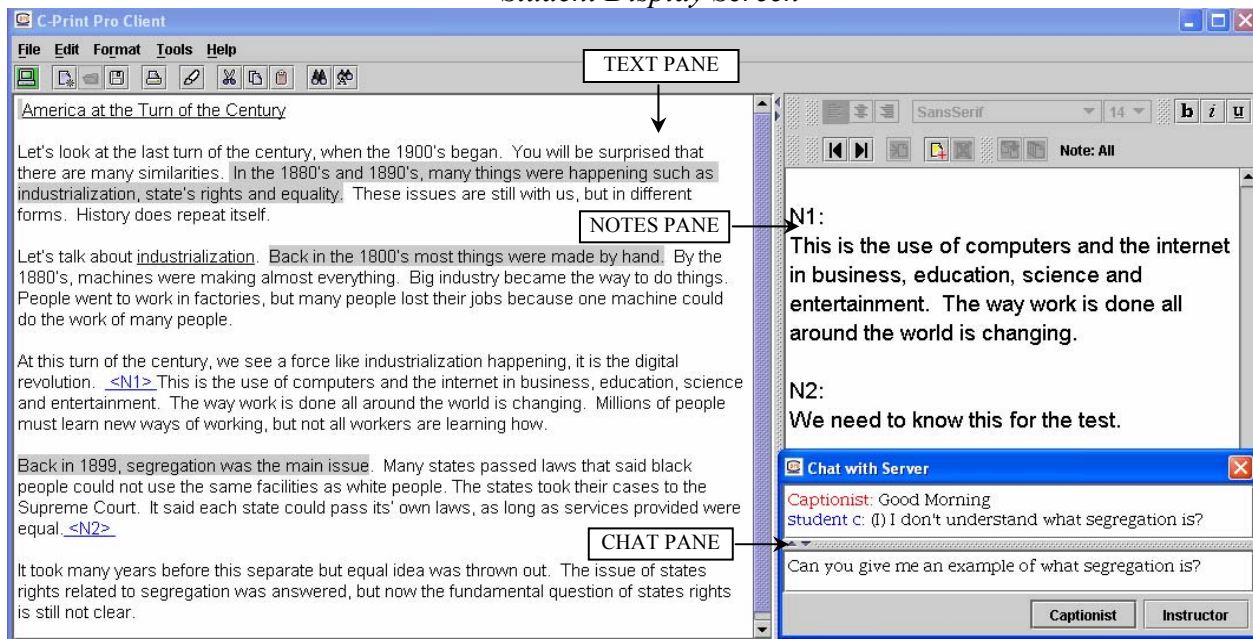
The C-Print captionist can use *both* the ASR and the abbreviation approaches *simultaneously*. For example if the ASR mistranslates the word “welcome” as “well come,” the captionist can type the abbreviation “wlkm” to produce “welcome.”

*User interface software application.* This application, C-Print Pro, includes separate text displays for captionist and student, allows keyboard and ASR input, provides networking capabilities, and has educational tools. The separate text displays permit the captionist and student to adapt their computer screens to individual needs such as different font size or type. For example, deaf-blind students may enlarge the font size on their computer. The software provides general formatting capabilities similar to word processing software; e.g. "open," "close," "cut," and "copy." With ASR input, the interface software accepts and displays text that is produced with the IBM ViaVoice engine. With keyboard input, the software provides automatic expansion of word abbreviations, and it supports standard typing as well. The networking component supports the communication between the captionist (server) and student (client) computers. In addition to sending text from the captionist to students, it includes a chat feature that enables student and captionist to communicate with each other separate from the stream of text. The software provides for identification of students registered on the network and ability of the captionist to disconnect students on the network. The educational tools include an optional split screen for the student to take their own notes. A “tag” feature connects these notes to specific lines in the text section of the screen. Students can also highlight important points in the text section. The file can be saved with this highlighting so that the student can note information that is important to remember later for assignments, tests, etc.

To illustrate some of these features, Figure 1 shows the screen for a student computer in a high school class with three panes open. The top of the screen provides the menus and tool bar for various functions, such as to highlight text. The text pane shows the text produced by the captionist in real-time. In this section, the student highlighted the text that is marked with gray background. The student also tagged the text, as indicated by the <N2>, connecting it with the corresponding note that she typed in the notes pane. The chat pane shows the separate exchange of messages between the student and captionist.

When a class session is completed, students have the option of saving and printing C-Print text in three different ways: (a) they may save the material in the text and notes panes, and then print the content with the notes merged as indented text throughout the document; (b) they may save only the material in the text pane; or (c) they may save only the material in the notes pane.

Figure 1  
Student Display Screen



### Research Findings

#### ASR Accuracy

Transcripts from real time speech-to-text transcription using automatic speech recognition with ViaVoice© software from IBM were analyzed for the percentage of idea units captured and the accuracy of words transcribed by the system. The following paragraphs describe the procedures used in determining these data.

*Procedure.* The classroom discourse from two high school classes and one college class, were audio taped and a verbatim transcript was produced from the recording. In addition, the voice captionists (1 novice, 1 with slightly more experience) gave us printouts of the real time transcripts that they produced for the students in those classes.

*Idea units captured.* The audio taped transcripts were then divided into idea units using the technique described in Stinson & McKee (2000). In each transcript, the first 10 idea units were selected, and then the next 10 were skipped, and then the following 10 were selected and so on. The number of idea units sampled depended on the length of the audio taped transcript. One hundred and sixteen idea units were sampled in the college transcript, and the high school transcripts had 97 idea units and 50 idea units respectively.

For each idea unit in the original lecture, two experienced coders compared the audio transcript with the ASR transcript and determined whether or not the captionist's text included the same idea in terms of meaning equivalence (see Stinson & McKee, 2000). The two coders had 98% agreement in their coding. The median percent of idea units captured by the captionists was 82.66%.

*Word accuracy.* One difficulty of ASR software is that word mistranslations can be frequent when the software has not been sufficiently "trained" by the user. With this in mind, we also looked at word accuracy of the dictation produced by the captionist with ASR relative to the number of mistranslations. One of the experienced coders compared the audio transcript with the ASR transcript. We used the same transcript samples as described above. Mistranslations were interpreted as words that did not match up with the audio transcript. For example the sentence, "One client's Dad works right near the trade center" was translated by the ASR software as "One *glance* Dad works right near the trade center." This would count as 1 mistranslation ("glance" instead of "client's"). Another example was "He cannot get in touch with his father." ASR mistranslated this sentence, "He cannot get in touch with *this fall there*." Since the original words should have been "his father," this excerpt would have 2 mistranslations. For these same three lectures, captionists have produced text with a mean word accuracy of 97%.

### *Trials in Middle and High Schools*

In 2002, we began testing the ASR version of C-Print in local middle and high schools. To date, 9 deaf or hard of hearing students have received a 3 or 4-day trial of C-Print in their mainstreamed classrooms. The students were nominated to participate in the trials by their teachers of the deaf. We have tested one sixth grader, two 7<sup>th</sup> graders, one eighth grader, two 10<sup>th</sup> graders, one 11<sup>th</sup> grader, and two 12<sup>th</sup> graders. All but one of the students was male (an 8<sup>th</sup> grader). The students ranged in age from 13-19, and their grade level reading ability ranged from 6<sup>th</sup> grade-post-college level as determined by their scores on the Woodcock-McGrew-Werder Mini-Battery of Achievement (1994). Due to the very short duration of the trial, students retained their usual support services (e.g. interpreters, notetakers, FM systems) and used C-Print in addition to those other supports. In 2002, four of the students used the ASR version of C-Print with older (non-interactive) software, while the remaining 5 students in 2003 used the ASR with the new C-Print Pro software.

For each student who participated in the trial, we also interviewed the students' classroom teachers and the students' teachers of the deaf (TOD). TODs in Monroe County, New York are itinerant teachers. Their level of interaction varies with each student, ranging from a consultant-type role where the TOD sees the student only infrequently, to situations in which the TOD meets with the student outside of class a few times a week or even attends class with the student on a daily basis. In this trial, all such TOD situations were represented.

We interviewed the students, their classroom teachers, and their TODs individually. Interviews were audio tape recorded and transcribed verbatim. Interview data has been content analyzed for recurrent themes according to the procedure described in Bogdan and Biklen (1998). What follows are some preliminary findings from the interviews.

### *Student Perceptions of C-Print with ASR*

Students commented on a variety of topics related to their C-Print experience. In this preliminary look at the data, students have discussed topics such as errors, amount of lecture understood using C-Print, lag time, new software features and social acceptance.

*Errors.* One difficulty with the ASR system is that the computer sometimes mistranslates words. In the section above, we documented that captionists have achieved 97% word accuracy with ASR. In the interviews, we pursued what this actually meant for students using the system in real-time. How did students react to mistranslations? For the majority of students, mistranslations did not impede student comprehension. When asked how they dealt with discrepancies in the text, most students relied on the context of the lecture to help them determine what the proper word (or words) should be. For example, one student described the experience this way:

**Interviewer:** *Sometimes there were mistakes because the computer does not hear the words properly. Did any of those mistakes bother you?*

**Student:** *Not really, no. I could pretty much figure out what she was trying to say.*

**Interviewer:** *How do you figure that out?*

**Student:** *Ummm, first I would hear the teacher say it and I could figure out what she was trying to write. I had no problem with that. It works out well.*

**Interviewer:** *Okay. Were there any mistakes that interfered with your ability to understand the lecture?*

**Student:** *No.*

*Amount of information understood with C-Print.* Another issue related to errors is how much of the course material students actually understood with C-Print. Students were pleased, overall, with the amount of material understood with C-Print. Most of the students said that they understood all of the material presented in class as it was displayed by C-Print, including, and especially, comments from other students. Consider the experiences of these students, a 7<sup>th</sup> grader, an 8<sup>th</sup> grader, and an 11<sup>th</sup> grader:

**7<sup>th</sup> grader:** *I don't know. Sometimes I would miss something and I would have to use the screen to go back and see what I missed...that was the other thing that was useful. When I miss something I get a little embarrassed of asking for the repeated information. So it was kind of useful for me by going back and looking at the information I missed.*

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**Interviewer:** *So, when you get to read that extra stuff on the screen, how does that help you?*

**8<sup>th</sup> grader:** *I know what other kids are thinking and their opinions about certain things which is nice because I want to hear it anyways and I am more alert I think.*

**Interviewer:** *You are more alert?*

**8<sup>th</sup> grader:** *Yeah. My head is up more and I am sitting up, moving more and I am not so much slouched like all the rest of them. Yeah, I am not tense or anything I am just more alert which is always very, very good, especially at the end of the day.*

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**11<sup>th</sup> grader:** *It made it a lot easier for me a lot of conversations and words and stuff. A lot of times, students would not speak up loud and it is hard to hear. It really helped me out a lot.*

Only one student, a 12<sup>th</sup> grader with both excellent English and ASL skills, was dissatisfied with the quality of information in the C-Print display. This student's expectation was that the display, because it was presented in English, would resemble written English text as it appears in published books. He was disappointed to realize that the C-Print text did not read more like a book.

*Lag time.* Another issue that sometimes comes up with students who use C-Print is the issue of lag time. During these trials, the issue of lag time was raised a few times, but did not heavily influence most of the students' appreciation for C-Print. However, for at least two students who relied heavily on interpreters, the lag time produced by C-Print was troublesome. It appears that how one relies on the C-Print display may influence one's tolerance for lag time. For example, one middle school student said that the lag time did not bother him because he usually listened to the teacher first, and then followed up by looking at the computer screen. He did not notice the lag time because he attended to the teacher first. The students who were most troubled by lag time were those who also were using an interpreter at the same time.

*User interface software application.* New C-Print software enables students to interact with the display during the real-time transmission. As described earlier in this paper, students may highlight notes, "tag" or extract notes, and type their own notes. Five of the students, including two 7<sup>th</sup> graders, and 8<sup>th</sup> grader, and two 12<sup>th</sup> graders had the opportunity to try out these new features. Among these 5 students highlighting seemed to be the most popular feature. One 12<sup>th</sup> grader explained his preference this way:

*It stands out more, it picked up more rather than just a plain white paper. You can read what you just highlighted rather than just going over the whole notes and highlight the important information...*

Students also appreciated the other note taking features. The 12<sup>th</sup> grader quoted above also described how he used the typing feature:

*...I can actually, if there is something that didn't make sense to me on the screen, if I had to make it easier for me to remember, I can go to my notes type it in under a different wording method for me to understand what it is talking about.*

*Social acceptance.* A concern of every adolescent is the degree to which she or he is accepted by peers. Students in our study were no different. One of students' main concerns was whether or not other students in the classroom would consider the C-Print service to be "cool." All of the students found that their peers were accepting of the service. Many classmates were curious and attended to our students in very positive ways. For example, consider the experience of this 7<sup>th</sup> grade boy.

**Interviewer:** When you first learned about C-Print, when we came to talk with you about it, what did you think was going to happen in class?

**Student:** I thought that the students would enjoy it.

**Interviewer:** You thought the students were going to enjoy it?

**Student:** Yes. I thought that they would like seeing the laptop as the words show up.

**Interviewer:** So you thought the other students in class were going to like this? What



happened?

**Student:** They did.

**Interviewer:** How do you know?

**Student:** Because a lot of people said, “cool” and like the people next to me would look at it.

**Interviewer:** Did any people like get out of their chair and come by?

**Student:** Well, at the beginning the first time that they had it, the first time that she talked into it and words came up.

### *Teacher Perceptions of C-Print*

While previous research on C-Print has demonstrated that teachers generally perceive the system positively (Elliot et al., 2002; Elliot, Foster, & Stinson, in press), there has been no published research to date on teachers’ perceptions of speech-to-text systems that incorporate ASR in the classroom setting or that use the new C-Print Pro® software. Thus, the trials we have conducted recently lay new groundwork for the exploration of such systems in educational settings. Three important issues emerged from our preliminary analysis of these interviews: distraction in the classroom, impact of C-Print on the student, and uses of notes.

*Distraction in classroom.* One item of interest to us was whether or not teachers or other students would be distracted by the sound of the captionist speaking into the steno mask. Only one of the teachers interviewed expressed a slight concern about the dictation. Here, two teachers share their experiences with ASR in the classroom:

**Teacher:** *If I had any concerns, it was mostly about having someone in class speaking while I was teaching, and the only way we were going to discover what that was like was to implement the system... Honestly, I have a small class and it is a big classroom, but (the captionist) was close to the students and I did not even notice. I was not even aware that she was speaking into the software. It was great.*

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**Teacher:** *I would say no more distracting than having someone sign. The first week or two when I came into school it was my first time ever having a deaf student who needed an interpreter so I would watch and try to gauge if I was going too fast for the interpreter and then I just forgot they were there. They told me, “Don't watch me, don't worry about me,” and it is the same thing with a notetaker. At first I heard all the mumbling and it distracted me a little bit but, by the second the day I did not even notice it, the kids did not even notice it. In fact after she had left some of the kids said, “Oh hey, where is that lady?” So it did not distract them.*

*Impact of C-Print on student.* Teachers mentioned a number of different ways in which they thought C-Print might impact their students. For example, a number of teachers commented on the importance of students’ ability to manipulate the information presented in class. This is the way one teacher described what happened for her student:

**Teacher:** *Yes, I was so pleased that he was pulling out the important things. I don't think he always could do that. This way, again, it is another reinforcement of what is important. He is not only hearing it from me, he is not only reading it in the book, he is seeing it as it is*

*printed and he is moving it to a place where he finds it's important. I think that is one thing that helped with his test score.*

Another observation made by several teachers was C-Print's influence on improving students' social standing in the classroom. Consider this teacher's observation:

**Teacher:** *I think it makes her an individual in the classroom, but not in a bad way. She likes, I think she likes that she got the attention and that kids are interested and this is how I think kids talk to her a little bit more to get past her disability.*

**Interviewer:** *Did you notice that happening?*

**Teacher:** *Yes, like boys. And it is the boys that are interested in the computer so I noticed that they would gravitate towards the computer and then they would peek and want to see what she was doing and yesterday they were sitting on either side of her watching what she was doing. When she came in the class late they were sitting by her computer almost guarding it, it was very interesting.*

*Uses for notes.* Teachers' comments on the utility of C-Print notes were, in large part, consistent with our findings from previous studies (Elliot et al., 2002). For example, teachers would use the notes to verify what they had covered in class or provide the notes to students who were absent. One way in which teachers' comments during this study differed is that some of the teachers, especially the middle school teachers, were pleased to see how their students had used the notetaking features of the software. It gave the teachers increased insight into their students' thinking about the material and how the teacher might reinforce the lessons.

### *Certification and Training*

#### *Captionist Certification*

*Description.* A captionist certification exam is currently undergoing pilot testing. We expect that the final version of the test will be ready by January, 2004. Captionists who have received C-Print training and who have logged at least 200 hours of documented service time (not including editing) are eligible to take the test. The exam is administered in two parts. The performance section tests the captionist's skills of real-time transcription. It is a 40 min timed test in which captionists practice for 10 min, build dictionaries for 10 min, and transcribe for 15 min. Captionists may complete the performance section for either form of C-Print, ASR or the abbreviation system. The second part of the test is an objective, 75-item multiple-choice exam that includes basic information in the areas of computer technology, implementation of captioning, deafness, relevant legislation, and captionist ethics. Captionists receive up to one hour to complete this section of the exam.

*Scoring.* The performance section is based on the captionists' ability to accurately transcribe portions of a pre-recorded videotaped classroom lecture. Captionists' transcripts will be scored for the amount of information captured in comparison to the actual amount of information presented in the lecture using the technique described by Stinson & McKee (2000). Captionists will receive a score on the written section based on the number of items that are answered correctly.

*Computer-based training for captionists.* We are currently developing on-line instructional materials for individuals to become captionists who provide real-time text in a classroom with ASR or with the word abbreviation system. The materials will be used as a self-study program. The sets of materials for learning to use ASR and the abbreviation system include instruction in text, screen

displays of various computer functions, digitalized audio and audio-visual material, and interactive features to immediately inform the trainee whether a response is correct. For example, for some sequences in the training for the abbreviation system, the trainee sees a practice sentence, types the abbreviations for that sentence, and then immediately sees whether s/he has typed the correct abbreviations. These materials are sequenced from basic to more complex skills, and trainees need to pass a particular criterion level in order to proceed to the next exercise. Mastery of the materials will provide the trainee the basic skills to produce text in real-time, and they are designed to be used in conjunction with one or two day workshops that will focus on issues regarding the use of the system in the classroom. Furthermore, after completion of this basic training, it is desirable for captionists to practice producing text in real-time for an additional 20 hrs before they are ready to provide support services for students. The C-Print team has already developed and field-tested printed versions of the ASR and word abbreviation training materials.

#### *Future Directions*

Now that these new features of C-Print have been developed, it is important that future work of the project address four areas:

1. To demonstrate in the field and thoroughly evaluate, qualitatively and quantitatively, the effectiveness of the new features at middle/high-school and postsecondary levels.
2. To complete and evaluate the on-line training materials.
3. Finish piloting the captionist certification test and make certification available on a national level.
4. To develop a student guide for effective use of the C-Print system located on a web-site.

This work will contribute to the project's long-term goal of producing a practical tool that enables many deaf/hh students to function more effectively in mainstream classes.

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