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Development and Implementation of the C-Print Speech-to-Text Support Service

Michael Stinson
Barbara McKee
Lisa Elliot

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Kommunikation und Kreativität

Festschrift für Klaus Schulte zum 70. Geburtstag

Herausgegeben von

John Albertini
Elsbeth Ehrhardt
Hans Christoph Strauß
Development and Implementation of the C-Print Speech-to-Text Support Service

In the past 25 years, the number of deaf and hard of hearing students being educated in classes with hearing students in the United States has increased significantly at both secondary and postsecondary levels (Lewis, Ferris, & Greene, 1994; Moores, 1992; Rawlings, Karchmer, & DeCaro, 1988; Schildroth & Hotto, 1996; Walter, 1992). In the United States, more than 20,000 deaf and hard of hearing students are enrolled in colleges and universities nationwide, with these students also predominantly mainstreamed. Also, less than 15 years ago, 30 percent of our nation’s deaf students were in mainstream secondary educational environments; currently 80 percent of these more than 60,000 deaf students are in mainstream environments in public school systems (Ficke, 1992; Lewis, et al., 1994; Schildroth & Hotto, 1994; Schildroth & Hotto, 1996; Walter, 1992).

Providing for adequate communication for the students in mainstream classes is a complex and challenging task. A reasonable approach is to provide the support services best tailored to the individual student’s needs, within constraints such as cost and availability. The traditional support services of interpreting and notetaking benefit some students. FM systems are also helpful to many students. However, other forms of support may provide the best access to communication for many students. One of these that has been recently developed is a computer-aided system for transcribing speech-to-text. In the past 10 years at the National Technical Institute for the Deaf (NTID) we have developed a speech-to-text support system that we have called C-Print (The sound of the “C” is the same as the word “see” and indicates the system’s real-time provision of print that can be seen; “C” is also the first letter for “computer” and reflects the system’s computer-based operation.)

In this chapter we provide an overview of the growth of this system from an idea to a system that hundreds of deaf and hard of hearing students depend on everyday for communication access and learning. This chapter addresses the following questions regarding the development and implementation of C-Print. Why is there a need for the system? How does C-Print work? What have been the phases in creating the current system? What is the research evidence regarding its effectiveness and limitations? How might the system change in the future as new technologies emerge?
1. Rationale for C-Print

1.1 Communication Difficulties in the Mainstream Classroom

A major concern for students in mainstream classes is the adequacy of classroom communication, and there is good documentation of the communication difficulties faced by these students (Foster, Long, & Snell, 1999; Jacobs, 1977; Osguthorpe, Long, & Ellsworth, 1980; Stinson, Liu, Saur, and Long, 1996). For example, Foster and Elliot (1986) interviewed 20 students who transferred to the National Technical Institute for the Deaf (NTID) from other postsecondary institutions. The researchers noted that these students had been particularly hampered by communication difficulties even when an interpreter and additional support services were provided. The transfer students complained that teachers frequently moved through the material too quickly, were impatient, and treated deaf students as though they could hear. As one student commented:

*Some of the teachers (at mainstream college), they had no experience with deaf.....they talk real fast. If I had a question, I'd have to raise my hand and stop the interpreter, stop the teacher. Then they'd explain and I'd have to turn over here (look back and forth) and it was really a pain (p. 12).*

The difficulties faced by students in mainstream settings at the secondary level in understanding the teacher and participating in class discussions have been as well documented as the difficulties faced by students at the postsecondary level (Kluwin & Stinson, 1993; Libbey & Pronovost, 1980; Stinson & Antia, 1999). One example of these difficulties is being able to understand hearing classmates. Many hard of hearing and some deaf students use Frequency Modulation (FM) system to supplement their lip-reading of the teacher. Usually, the FM microphone is worn by the teacher. When the student’s hearing aids are switched to receive the FM input, they generally cannot hear their classmates’ discussion. An interpreter could convey the students’ discussion, but students who use FM systems often have poor receptive sign skills.

1.2 C-Print and Other Speech-to-Text Systems as a Support Service

C-Print is a computer-assisted notetaking system that uses a standard keyboard. In the past 17 years in the United States and in some other countries, such as Canada, speech-to-text transcription services have become recognized as a support service that increases access to information and provides an effective study tool for many deaf and hard of hearing students (Levitt, 1994;
Robison & Jensema, 1996; Stuckless & Carroll, 1994). Currently, two general systems are used -- standard keyboard systems and steno-based systems. Steno-based systems, also called CART (Computer Assisted Real-Time), use a 24 key steno-machine that has been traditionally used by court reporters and that permits recording rates well over normal speaking rates (Stuckless, 1994). Transcripts produced by steno systems are almost always verbatim; those produced with standard keyboard systems can be either similar to notes prepared by notetakers or ones of a more detailed nature (Cuddihy, Fisher, Gordon, & Shumaker, 1994; James & Hammersly, 1993; Preminger & Levitt, 1998; Stinson & Stuckless, 1998; Stinson, Eisenberg, Horn, Larson, Levitt, & Stuckless, 1999; Virvan, 1991; Youdelman & Messerly, 1996).

2. Description of C-Print

The system uses a laptop computer and specialized software for transcribing speech into text. The captionist, using a computerized abbreviation system, types the words of the teacher and students as they are being spoken. The system provides a real-time display that the student can read on a laptop computer or television monitor. The text display of the message appears approximately 3 seconds after the words are spoken. In addition, the text files are saved after class and may be edited. These edited notes can be used by students, tutors, and instructors after class by reading them on a monitor or from a printed copy. The system cannot provide word-for-word transcription since it cannot keep up with the speed of speech (approximately 150 words per minute). However, the system does provide for capturing information meaning-for-meaning.

2.1 Equipment

The C-Print system uses laptop personal computers (compatible with DOS, or Windows95, 98, or NT) and a regular keyboard. For display purposes, a second laptop computer or a special adapter (to connect to a regular TV monitor) is used. When there are two laptops, the captionist and student can conduct two-way communication.

2.2 Abbreviation System for English

The operator of the C-Print system, the captionist, types a series of English abbreviations as the lecturer (or class participant) talks. An abbreviation software program (either Productivity Plus, or Instant Text) searches the C-Print
dictionary for the equivalent full word and displays it on the screen. Examples of C-Print abbreviations and their full expansions are the following:

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Full expansions</th>
</tr>
</thead>
<tbody>
<tr>
<td>t kfe drqr</td>
<td>the coffee drinker</td>
</tr>
<tr>
<td>slvg t pblm</td>
<td>solving the problem</td>
</tr>
</tbody>
</table>

Captionists do not have to memorize all the abbreviations in the system; rather, they learn a set of phonetic rules developed by the C-Print project, which are then applied to any English word that has been added to the system's general dictionary. The general dictionary developed by the C-Print staff currently contains approximately 10,000 words. Specialized entries can also easily be added to the dictionary by each captionist to allow for the abbreviation of terms unique to a course.

2.3 Condensing

Because the rates at which college and high school lectures are normally spoken can vary from 120 word per minute (wpm) to greater than 160 wpm, it is not possible for the C-Print captionist to capture lectures verbatim. Therefore, C-Print captionists learn to summarize or "condense" information, with the goal being to capture the most important points while using fewer words than the original speaker.

3. Phases in Development and Implementation of C-Print

Work with the C-Print system has occurred in four phases in which activity has moved from (a) development of the system, to (b) research that has evaluated the system and yielded knowledge about best practices, to (c) national and international training that is facilitating widespread use in educational programs.

3.1 Phase 1: 1989-1993

The project developed the abbreviation dictionary which initially had 2,500 words. We also developed the initial set of rules and materials for training captionists to use the abbreviation system. Major tasks during this phase were to determine whether the abbreviation system could be taught and to conduct a limited trial with the system in the classroom. Klaus Schulte observed the initial version of the system in 1990 at the International Conference on Education of the Deaf in Rochester, New York, U.S.A., and has been a supporter ever since.
This work was described at the 1991 Heidelberg conference on development of structures to support hearing-impaired students in postsecondary programs and was published in the report of the conference (Stiftung zur Förderung körperbehinderter Hochbegabter & Schulte, 1991).

3.2 Phase 2: 1993-1996

In this phase the dictionary was expanded to approximately 5,500 root words and 4,500 associated suffixes for a total of 10,000 abbreviations. The abbreviation rules and the training materials were substantially revised so that individuals becoming C-Print captionists could more easily learn them. The system was used as a support service extensively in secondary and postsecondary classrooms and the effectiveness of the system was evaluated with respect to accuracy, amount of information captured, and student perceptions. The first workshop was provided to train captionists to use C-Print as a support in programs other than NTID.

3.3 Phase 3: 1996-1999

This phase is now ending. Implementation of the C-Print service was evaluated at eight sites: one secondary program in New York, two secondary programs in California, three postsecondary programs in New York, one postsecondary program in Connecticut, and one postsecondary program in Louisiana. Considerable data have been collected regarding the effectiveness of C-Print in different settings which is still being analyzed. Work in this phase has focused considerably on development of policies and procedures for effective practice as implementation, including the writing of an implementation manual which has been published (McKee, Stinson, Giles, Colwell, Hager, Nelson-Nasca, & MacDonald, 1999). Training expanded to include C-Print training at other sites in addition to NTID and trained 116 captionists who are working in approximately 60 educational programs in the United States, Canada, and Puerto Rico.

3.4 Phase 4: 1999

Phase 4 has just begun and it has two major emphases. The first focus is to provide extensive training and to increase use of the C-Print service in educational programs. In order to increase the availability of training we have begun to establish a national network of training sites, all of which include a local trainer throughout the United States. Seven of these sites have already provided a C-Print workshop, with many of these supported by the Northeast
Technical Assistance Center based at NTID. A new project funded by a federal grant supports nine additional sites that will participate in the National Network and provide training. The second focus is to develop a system of certification levels for C-Print captionists. The goal of this certification is to promote an appropriate level of professionalism and to help ensure quality service. This system will be partly based on the certification systems of the National Association of Court Reporters for stenotypists working in educational settings and that of the Registry of Interpreters of the Deaf.

4. C-Print Training

The development of instructional materials to train C-Print captionists has been a continuous iterative process that began shortly after the project was initiated. During the summer of 1990, the first study evaluating the partially developed system was conducted with six typists participating in a six-week training session. Results of that pilot project demonstrated that typists could increase their typing speed substantially using the system, averaging a 50 percent gain in speed from pre to post-test. At that time the abbreviation system reduced keystrokes by about one-third. Therefore, the typists increased their speed as much as the system allowed. A formal instructional manual was developed just prior to the 1990 pilot and those initial materials were structured to cover a six-week part-time training schedule (approximately 3 hours each day). The phonetic rules were organized sequentially, with an average of two new rules presented in each lesson. Those early materials have been revised several times over the past years and major modifications have been made to the content and format. What has remained consistent however, is the fact that training and the accompanying training materials is part of an iterative process. After each set of groups goes through training, project staff reevaluate the training materials and procedures are reevaluated and make further improvements.

4.1 Initial Development of Training Materials

Our first three captionists were hired and trained individually under what could best be described as an "apprenticeship model" with the primary instructor being the linguist who developed the original abbreviation rules. Information gathered from these early captionists convinced us that our original goal of "verbatim" capturing of lectures was simply not realistic given the other constraints that we had placed upon the system. In order to capture verbatim a lecture given at 120 words per minute (slow normal), the abbreviation rules would have to enable the captionist to drop fifty percent of his/her keystrokes.
We originally anticipated that there would be a large number of repeated phrases or sentences in most lectures that could be recreated with a few keystrokes. Such turned out not to be the case. College faculty are not as repetitious in their lectures as we had anticipated. This was a major turning point for the training portion of the project. We realized we would need to add a text condensing/summarization component to the training and simplify the abbreviation rules because of the additional cognitive load placed on the captionists by the need to summarize the information presented in the classroom. Major modifications were made to the training materials, the original twenty abbreviation rules were reorganized into five principles and some of the more difficult rules were dropped. A section on condensing/summarizing was added and the amount of audio tape practice was more than doubled. We also structured the materials to cover a two-week, full time, training schedule. Although there are some advantages to training a few hours a day for six weeks, such a time period is not feasible for captionists living in distant locations, such as California, and traveling to Rochester, New York for training.

A completely revised set of training materials was developed prior to a workshop held in the summer of 1996 at which eight people were trained to become C-Print captionists. Those first workshop trainees were from across the country (California, New Mexico, Ohio, Pennsylvania, Oklahoma and Arkansas) and they became a nucleus for the dissemination of the system. Later the "on-site" training time was further reduced by restructuring part of the materials so they could be mastered independently by the captionists prior to traveling to a training site for a one-week workshop. As of this writing over 120 captionists have been trained and the C-Print staff has recently been awarded a federal grant to establish a network of training centers across the country. The staff and monetary support of the Northeast Educational Technical Center and the Department of Educational Outreach at NTID has been crucial to making the training widely available.

4.2 Current Training Materials

The current training materials consist of a manual and 40 hours of audiotapes. The manual is divided into two sections. The first section, meant to be mastered independently, consists of 9 lessons that cover the abbreviation systems and brief forms (abbreviations that do not follow the linguistic rules but need to be memorized such as the names of the 50 states).
Following is an example of the type of material that participants in the training program learn independently: Principle 2: Type only the sound you hear in a word. Do not type letters that are silent.

<table>
<thead>
<tr>
<th>Type letter/symbol</th>
<th>for sound</th>
<th>example</th>
<th>abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>k</td>
<td>clean, kitchen</td>
<td>klen, kcn</td>
</tr>
<tr>
<td>j</td>
<td>j</td>
<td>general, justice</td>
<td>jnrl, jsts</td>
</tr>
<tr>
<td>f</td>
<td>f</td>
<td>phone</td>
<td>fon</td>
</tr>
</tbody>
</table>

Do not type silent letters - write, knife rit, nif

The rules are followed by paper and pencil and audio tapes practice with the principles. The audio tapes become increasingly realistic as the training progresses with longer and longer passages spoken at increasing speeds.

The second section of the manual is designed to be taught in a small group (workshop) setting and includes rules and practice in condensing information, information on preparing C-Print Notes, tips on actually offering the system as a service in the classroom, and technical information related to customizing the system. The workshop portion of the training also includes discussion of ethical issues related to C-Print and other associated issues such as American Deaf culture.

Research on the transcripts produced by the C-Print captionists has demonstrated that captionists with a year's experience in the classroom are able to capture approximately two-thirds of all the information provided in a classroom and three-fourths of the important information (Everhart, Stinson, McKee, Henderson, & Giles, 1996). We also have learned much about the skills necessary to become a C-Print captionist and have developed several screening tests for potential captionists. We have also learned that after the formal training, approximately 10 weeks of in-class supervised experience is required before a captionists is ready to function without this assistance.

5. Research on the Use of C-Print in Secondary and Post-secondary Settings

In addition to this work on training, much research has been conducted with the C-Print system that has employed both quantitative and qualitative methodology. This work has yielded knowledge regarding the benefits of C-Print in supporting students, suggested strategies that enable students to use the system as effectively as possible, identified practices of teachers and
captionists that contribute toward providing optimal support to students, and noted limitations of the system.

Data looking at the effectiveness and impact of C-Print comes from a number of different studies (Elliot, Foster, Stinson, & Colwell, 1997; Elliot, Foster, & Stinson, 1999; Everhart, Stinson, McKee, & Giles, 1996; Stinson & McKee, 1998). A quantitative questionnaire study of C-Print was conducted with 36 deaf or hard of hearing college students who received the C-Print support service in one of their mainstream courses in the RIT College of Business or Liberal Arts between the spring quarter of 1994 and the fall quarter of 1996. In-depth interviews were conducted with 22 college students in order to understand their perceptions of C-Print and how they used it to aid classroom learning. Twenty-one of the students also answered the questionnaire described above. Additional interview data comes from 12 college professors, 25 high school students and 14 of their teachers and 3 captionists. Students were interviewed using certified ASL interpreters. All of the interviews were audio taped and transcribed verbatim, except for one college professor interview which was conducted via e-mail.

5.1 Benefits of C-Print

One of the benefits of C-Print is that the real time display remains on the screen for approximately one minute. This allows students time to check back and fill in information they might have missed from either the interpreter or teacher. As one student described the experience:

...I go back and forth between the teacher and the (C-Print). But if I understand with the (C-Print), it is clear. It doesn't mean the interpreter doesn't do a good job, but sometimes it is a lot, overwhelming all that information, trying to memorize everything. But if I can look at it on C-Print, then I can understand it. Looking back and forth I miss what is happening sometimes actually what is going on with the interpreter. But the information is wonderful on (C-Print).

A second benefit of the system is that a hard copy of the complete lecture transcript is available after class. While the lecture is not typed verbatim, students are generally very satisfied with the quality of the notes. From the questionnaire data, all students for whom data were (31 out of 32) available reported feeling that the summarization done by the C-Print operator was acceptable and that all the important information was captured (Stinson & McKee, 1998).
Several of the high school teachers remarked that their students were less anxious and more focused during class when they were using C-Print (Elliot et al., 1997). This teacher captures their shared sentiment:

...I think that it gives them a security that once again they know they're going to get all that information so they don't need to worry about missing something because it's all there.

A third benefit of the system is that exact technical information and specific vocabulary are captured more often. All of these benefits amount to significantly higher levels of comprehension by the students. The mean percentage of lecture information that students reported they understood with an interpreter was 69.9%, as compared to the mean percentage of lecture information understood with C-Print, 84.4% (p < .025).

5.2 Effective Strategies for Students in Using C-Print

One of the most useful aspects of the C-Print system are the hard copy notes that students receive after class. Survey respondents were asked to rate the helpfulness of the notes: “help little or none,” “help enough,” and, “help very much.” Thirty-three out of 36 students rated the notes as “helping enough” or “very much” (p < .01). Twenty-four out of 34 students responded that they used the C-Print notes more than the notes from the notetaker. This was also a significant difference (p < .02). Students used the notes in a variety of different ways. Twenty-nine said they skimmed, 16 noted unfamiliar vocabulary and ideas, 10 used notes to create their own outline, and 14 reported “other” uses, such as rereading (Stinson & McKee, 1998).

5.3 Best Practices of Teachers

While the C-Print service was presented to classroom teachers as a benefit to their hearing impaired students, a number of teachers began to appreciate the service for themselves and other students in the classroom as well. For example, teachers used the C-Print notes for themselves to review what happened in class and to prepare exams. Teachers also used the notes with hearing students who were having difficulty with course material or who had been absent (Elliot et al., 1997). Several of the teachers suggested that C-Print was good to have in the classroom because it was another way to generate awareness about disabilities. Teachers also found that C-Print helped them to become better teachers:
...It made me think more about my teaching and my presentation...and if anything, it made me try to be more organized...it made me think more about what the other students in the classroom see, how clear my directions are for them, and the explanation of the content...So, if anything I think it helped me be more conscientious.

For the majority of teachers, having an additional adult (the captionist) in the classroom did not pose any problems. In fact, many teachers preferred the service because it was “invisible” and it required little (if any) modification of their classroom behavior. College professors related the least to the captionist; the professors generally chose to ignore the captionists in class. In contrast, several of the high school teachers appreciated having additional adults in the room. Captionists served as resources, while other teachers just “appreciated the captionist’s company.” Captionists found that they were most satisfied in the classroom when they were acknowledged, received the handouts, and when the instructor spoke clearly and at a reasonable pace (Elliot et al., 1999).

5.4 Limitations of C-Print

While filling an important gap in services, C-Print is not perfect. Several limitations exist with the current C-Print configuration. First, the C-Print display has a lag time of about three seconds. Depending upon the nature of the classroom discussion, this may inhibit students from participating in class discussions, although lag time was not seen as a major irritant by most students. Second, captionists will occasionally make typing errors. Twenty-two out of 26 questionnaire respondents (p<.001) were untroubled by those typing errors (Stinson & McKee, 1998). Third, some students prefer the emotional tone conveyed by the interpreter’s “body language” as compared with the textual approach of the C-Print display. Fourth, at the current time, C-Print does not capture graphics, so visual material needs to be captured in another way. Therefore, C-Print works best with lecture-based classes and less well with classes that might require different representations of information.

In summary, although the C-Print service does have its limitations, students and teachers and captionists are generally pleased with the options that C-Print offers to the classroom.
6. Future Developments

These research findings, along with the positive informal feedback that C-Print staff regularly receive, and the high demand for the service from educational programs encourage efforts to further advance C-Print and other speech-to-text services. New developments in technology will enable C-Print and other speech-to-text systems to become more effective in the future. The success of the C-Print abbreviation system in English suggests that it might be adapted to other languages, such as German. For these languages, a specific set of abbreviations that reflect the manner in which words are used would need to be developed. Of particular significance is speech recognition, which now has capabilities that are dramatically better than a few years ago.

6.1 Speech Recognition

The C-Print project is currently conducting a pilot project to adapt speech recognition technology for use as a support service in mainstream classes. Because current speech recognition systems are speaker-dependent, an intermediary captionist transcribes the discourse into a form that the computer can convert to understandable text. The captionist listens to the lecture or class discussion of the students and dictates the words into a microphone connected to the computer. A baffle which the sound of the dictation to a level that is not distracting in the classroom. Occasionally, the captionist types words or punctuation into the computer. This combination of spoken and typed input is then displayed on a monitor for the student. The captionist speaks at a controlled rate of about 100 words a minute. In current work we can achieve about 95 percent accuracy in real-time while listening to a lecture. The errors are frequently mistranslations of short words, such as “there” mistranslated as “their,” or mistranslations of places or technical words that are not yet in the speech recognition dictionary. The large dictionary of the speech recognition system does, however, permit correct translation of many technical words. The captionist needs to practice extensively with the speech recognition system to achieve this level of accuracy.

Current speech recognition technology does not permit one to walk into a classroom with a laptop computer and begin to successfully support a mainstream student. Much training is required in order to produce a display that is acceptably accurate, and the problem of the dictation causing distracting noise must be dealt with. If the speech recognition can be used successfully in the classroom, this means that a good typist or stenotypist would not be needed, as is currently required in speech-to-text support services. Sign
language and oral interpreters and notetakers could use the system in combination with interpreter and/or notetaking.

A development that should occur in the more distant future will be systems that automatically convert speech into text and that are speaker independent. Such a system would mean that the deaf individual would no longer need to rely on an intermediator or captionist. This development, however, would only address receptive communication; it would not touch on expressive communication by deaf and hard of hearing people, and the latter issue is important.

6.2 Advances in Computer Communications and Displays

Wireless communication between the captionist's host computer and the students' viewer computer, and improved ways of displaying information on these computers may further increase the benefit of C-Print and other speech to text systems. For C-Print, and other speech-to-text technologies, to be truly effective they must be able to adapt to variations in classrooms including the number of deaf students, the kinds of support services, and seating arrangements. The technologies also need to adapt to specific student needs, such as a visual impairment, and to preferences regarding use of text information and the integration of it into learning activities in the classroom.

Major advances are being made in radio-frequency based networking devices that can increase the portability and ease of use of C-Print in the classroom. Currently the captionist's and student computers are connected with a cable between the two laptops. One drawback of these cables is that the two laptop computers, ie. the one being used by the captionist and the one being used by the student, need to be relatively close to each other. Also cable connections require set-up time (often between classes) and are inconvenient when strung out in a classroom setting. With wireless communication it would not be necessary for the two computers to be in close proximity to each other, and time does not need to be devoted to connecting the computers.

New developments with Local Area Networks mean that it will be possible to support multiple users in the classroom and to support simultaneous two-way communication between computers. This means that it will be possible for students to add inexpensive hardware and software to their own computers and bring them to class. These students' computers will be able to receive the real-time text display produced by the captionist, and several students will be able to communicate synchronously with the captionist.
7. Conclusion

The C-Print speech-to-text support service has grown from what was only an idea 10 years ago to a system that is being used internationally by more and more educational programs. In the early years work focused primarily on research and development of the system, and work now focuses primarily on dissemination and training. The growing acceptance of C-Print reflects the system's educational benefit to students, as has been demonstrated by research. The continuous revision and improvement of training materials and procedures, the development of a national network of training sites, and the collection and dissemination of information on best practices with C-Print have also contributed importantly to C-Print's growth.

C-Print and other speech-to-text services are not a cure-all for the communication difficulties of deaf and hard of hearing students. C-Print does not support participation in class if a deaf student wishes to communicate by signing. In certain instructional situations such as small group discussions, laboratories, and one-to-one tutoring, C-Print may be less appropriate than it is in lecture situations (Haydu & Patterson, 1990). Furthermore, many deaf students prefer an interpreter to C-Print in most class situations (Stinson, Stuckless, Henderson, & Miller, 1988).

Even with these limitations, C-Print has been used repeatedly to effectively support accessibility to information in the classroom, and use is growing rapidly. The 5 years of experience in providing services with C-Print has clearly demonstrated that C-Print is a viable option for supporting the communication access of many mainstreamed students. In the future as speech-to-text and associated technologies improve, and as we learn more about supporting students who use these services, speech-to-text services should make even greater contributions to improving the education of students who are deaf or hard of hearing.
8. References


