

# ASSISTIVE NOTETAKING USING SPEECH RECOGNITION TECHNOLOGY

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## INTRODUCTION

Innovative speech recognition (SR) technology was utilized to assist students in acquiring more complete and accurate lecture notes. SR-assisted notetaking can be accomplished in different ways to allow students to devote more attention to understanding course material than manually recording the instructor's lecture content. This technique has far-reaching benefits for students with mobility, sensory, or learning disabilities, students who are non-native speakers with regard to the language of instruction, and visual and aural learners.

Lecture notetaking is physically challenging for many students with disabilities who cannot take the bulk of lecture notes themselves. Many students with physical impairments must rely upon hired notetakers for classnotes, which may not readily available or feasible. They are also dependent on the skills and knowledge of the notetaker for the quality of their notes [1].

Difficulties in learning or communication, such as dyslexia, deafness, or underdeveloped English skills, can also hinder students from digesting lecture information and taking complete notes [2-4]. For example, it has been reported that students without disabilities record up to 70% more lecture information than students with learning disabilities [5].

Pilot studies at Purdue University evaluated different approaches of SR-assisted notetaking during typical lecture-based postsecondary and graduate courses with special emphasis on science, technology, engineering and mathematics (STEM) courses. Extensive notetaking is especially required in STEM courses due to the considerable course-specific jargon used and the density and rapid delivery of class information during lectures [6,7].

We propose SR-assisted notetaking as a viable alternative to traditional methods of using a notetaker, allowing students to acquire comprehensive and precise lecture notes for themselves.

## BACKGROUND

Notetaking is one of the most fundamental educational practices that students perform daily during lecture courses [8]. Notetaking is a practiced skill that serves as an important self-regulated learning technique to help students recall, clarify, organize, and comprehend lecture information better than relying on one's memory [8-10]. The more extensive the notetaking, the greater the understanding and stronger the connection to academic performance is reported [10-12].



Figure 1: Instructor recording a lecture via a wireless microphone headset which was synchronized with class Powerpoint™ slides.

## METHODS

### Classroom Recording

Instructors' audio was recorded during lectures with an Audio-Technica (Ohio, USA) 700 Series Freeway™ 8-channel UHF wireless microphone system, which was connected to the instructor's Windows® PC. For highest quality recording and efficient SR a hypercardioid dynamic microphone headset with wireless transmitter was worn (fig. 1). The instructor's audio was recorded within PowerPoint™ for lecture transcription and ViaScribe for real-time captioning.

### Lecture Transcription

A SR engine provided through IBM® Hosted Transcription Service (HTS) was used for lecture transcription. The HTS system performed speaker-independent, offline transcription of audio or video files. For more accurate processing, a double pass decoding technique is utilized. No speaker training is required, which represented a substantial improvement over conventional SR systems. Once transcription was completed, word error correction was performed to enhance accuracy and readability.

### Real-Time Lecture Captioning

IBM's ViaScribe™ SR engine was used to automatically display the instructor's speech to text in real-time on a projection screen or on students' laptop PCs through wireless internet connection during class. To increase word recognition accuracy initial instructor training was performed using the commercial IBM ViaVoice™ application to create a personal user profile. The user profile was imported into ViaScribe and consistently updated with corrected words or phrases during usage for improved SR.

## RESULTS

Both the technical and learning benefits SR-assisted notetaking were evaluated. Investigators worked closely other Liberated Learning Consortium (LLC) members in partnership with IBM, Inc. to employ innovative SR engines and functionalities for assessment of a) lecture transcription for the development

of online multimedia classnotes and b) real-time captioning of oral lectures during class.

### Lecture Transcription

During class the instructor's voice was automatically saved with each Powerpoint™ slide. The audio recording was then transcribed to text through HTS. The transcribed lectures were corrected for errors. The time required for error correction varied among instructors. A generated XML file contained the slide images, audio file, and timings for synchronization. With the addition of the lecture transcripts, complete multimedia files were produced. These synchronized classnotes were uploaded to Synote ([www.synote.org](http://www.synote.org)) for students to view once registered.

Instructors' and students' experiences with SR-mediated notetaking were overall positive – more so with lecture transcription than real-time lecture captioning. Student usage of the multimedia classnotes varied among the class and what aspects they found most beneficial. However, during the half of the course that students had access to the mixed media classnotes, they scored 10.2% higher on exams and 15% higher on non-compulsory online quizzes. In addition, when students had access to the multimedia classnotes they were 17% more likely to voluntarily take the online quizzes than during the course when they did not have these notes.

### Real-Time Lecture Captioning

This technology based on ViaScribe required greater accommodation to be effective than lecture transcription. Dual projection screens in the classroom were needed to display the instructor's caption in real-time in addition to showing class Powerpoint™ slides. The resident Boilercasting system (Purdue's in-classroom lecture room podcasting system) had inadequate audio quality for high word recognition. ViaScribe only worked on Windows XP, which limited its use especially by students who were interested in running the real-time captioning software as a client of the instructor's server on their own laptop Windows® PC during class.

Due in part by the rapid processing required to perform real-time captioning of the lecturer, word recognition accuracy was not as great as lecture transcription through HTS (table 1).

Table 1: Word Error Rate and Accuracy for ViaScribe and HTS

	ViaScribe	HTS
Error rate before training	45%	N/A
Error rate after training	26.6%	12.5%
Word recognition accuracy	73.4%	87.5%

## DISCUSSION

Technical implementation of both lecture transcription and real-time captioning was possible in conjunction with existing classroom audio-visual equipment and high-quality microphone recording during single instructor and team-taught undergraduate and graduate courses at Purdue. These SR-assisted notetaking technologies did not interfere with usual classroom or teaching activities, only requiring the instructor to wear a wireless microphone, which is commonly performed during large lecture classes for voice amplification.

Compared to real-time captioning, the lecture transcription system was more robust to implement and had greater word recognition accuracy (87.5% versus 73.4%). For real-time captioning, instructor training was very important to increase word accuracy. This may not be practical for busy instructors. During lecture transcription word error correction to also enhance word accuracy can be performed by someone else. Still, because of the different SR engines utilized by ViaScribe and HTS, we believe that HTS provides superior SR no matter how much training is involved.

Another advantage of lecture transcription is the generation of comprehensive, multimedia classnotes, synchronizing lecture transcripts with audio and PowerPoint slides. Multimedia classnotes could be utilized flexibly according to the different needs and study habits of students at their own leisure. Greater class performance was evident during lectures where multimedia classnotes were available.

We believe the advantages of real-time captioning are realized in its ability to assist students in extemporaneous notetaking and to engage in greater active learning during class

through real-time annotation of lecture captions.

We believe both forms of SR-assisted notetaking can benefit all students, especially students with special needs. This technology allows these students to be more independent and less reliant upon notetakers. Students can pay greater attention to the lecture content instead of exerting undue effort in recording complete classnotes.

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## REFERENCES

- [1] L. Elliot, S. Foster, M. Stinson, "Student Study Habits Using Notes from a Speech-to-Text Support Service." *Exceptional Children*, vol. 69(1), pp.25-40, 2002.
- [2] J. Huang, "English Abilities for Academic Listening: How Confident Are Chinese Students?" *College Student Journal*, vol. 40(1), pp. 218-226, 2006.
- [3] T. Mortimore, and W.R. Crozier, "Dyslexia and Difficulties with Study Skills in Higher Education," *Studies in Higher Education*, vol. 31(2), pp. 235-251, 2006.
- [4] J.R. Boyle, "The Process of Note Taking: Implications for Students with Mild Disabilities." *Clearing House: A Journal of Educational Strategies, Issues and Ideas*, vol. 80(5), pp. 227-230, 2007.
- [5] C.A. Hughes and S.K. Suritsky, "Notetaking skills and strategies for students with learning disabilities", *Preventing School Failure*, vol. 38(1), pp. 7-11, 1993.
- [6] K.E. Brobst, "The process of integrating information from two sources: lecture and text." Doctoral dissertation, Columbia University, Teachers College. *Dissertation Abstracts International*, vol. 57, pp. 217, 1996.
- [7] H. Lyles, B. Robertson, M. Mangino, J.R. Cox, "Audio Podcasting in a Tablet PC-Enhanced Biochemistry Course." *Biochemistry and Molecular Biology Education*, vol. 35(6), pp. 456-461, 2007.
- [8] J.M. Bonner, and W.G. Holliday, "How college science students engage in note-taking strategies". *J Res Sci Teach*, vol. 43(8), pp. 786-818, 2006.

- [9] B.S, Titsworth and K.A. Kiewra, "Spoken Organizational Lecture Cues and Student Notetaking as Facilitators of Student Learning". *Contemporary Educational Psychology*, vol. 29(4), pp. 447-461, 2004.
- [10] S.T, Pevery, V. Ramaswamy, C. Brown, J. Sumowski, M. Alidoost, J. Garner, "What Predicts Skill in Lecture Note Taking?" *Journal of Educational Psychology*, vol. 99(1), pp.167-180, 2007.
- [11] K.A. Kiewra, "Investigating notetaking and review: A depth of processing alternative". *Educational Psychologist*, vol. 20, pp. 23-32, 1985.
- [12] D. Leitch, and T. MacMillan, "How Students With Disabilities Respond to Speech Recognition Technology in the University Classroom", Year III Final Research Report on the Liberated Learning Project July 2002. [http://www.liberatedlearning.com/resources/pdf/RC\\_2002\\_Year\\_III\\_Research\\_Report.pdf](http://www.liberatedlearning.com/resources/pdf/RC_2002_Year_III_Research_Report.pdf)