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Cognitive load impacts of assistive technology devices used by sighted teachers in training during literary Braille instruction

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THE COGNITIVE LOAD IMPACTS OF ASSISTIVE TECHNOLOGY DEVICES USED BY SIGHTED TEACHERS IN TRAINING DURING LITERARY BRAILLE INSTRUCTION

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ABSTRACT

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The purpose of this study was to explore differences in perceived cognitive load experienced by sighted teachers-in-training using manual or electronic braille assistive technology devices to learn literary braille. Ninety-four participants from 18 personnel preparation programs across the United States and Canada participated in this study. Data were collected between August 2008 and June 2009 using the NASA-Task Load Index, the National Literary Braille Competency Test, and semi-structured interviews.

There were no statistically significant differences found between the technology groups in the quantitative measures of cognitive load or in literary braille proficiency according to the National Literary Braille Competency Test standard. However, interview data did indicate qualitative differences in perceived mental demand, frustration, and temporal demand between the technology groups. Statistically significant differences were found to exist within the sample with regard to previous braille experience and college term on three quantitative measures. MANOVA effect sizes (partial eta squared) ranged from 0 .01 to 0.15.

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I am grateful to Dr. Edward Bell of the National Blindness Professional Certification Board who made it possible for me to have access to the National Literary Braille Competency Test. Dr. Bell also introduced me to Ms. Amber Holladay who facilitated the shipment of materials, grading, and reporting of results for each test administration during this study.

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collection webpage and assisted with the development of software components for efficient data entry by participants and its secure storage throughout the course of the study.

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CHAPTER I

INTRODUCTION

Proficiency in the literary braille code is an essential skill which must be mastered by teachers of students who are visually impaired or blind in order for them to teach young children to acquire the ability to tactually discriminate among various configurations of the six-dot braille cell. These correspond to individual print letters, short forms of words, prefixes, suffixes, conjunctions, punctuation symbols, numbers, and composition signs that indicate capitalization. For older students who have mastered the literary braille code, it is important for teachers to have a strong foundation and understanding of braille in order to assist them in learning how to use volumes of brailled textbooks which correspond to print textbooks used by sighted peers and teachers in the classroom. This ability is necessary to provide access to all content vocabularies of curriculum areas presented in a general education setting.

Since 1946 the primary technology available for classroom preparation of braille materials has been the Perkins Braillewriter. This device superseded the slate and stylus which consists of a slate that clamps onto a sheet of braille paper. A person writing braille takes a stylus (a wooden handle with a metal point) to produce individual braille cells by using the slate as a guide. An ordinary slate contains three or four rows of spaces for the writer to prepare the six-celled braille symbols, keeping them neatly positioned at the proper distance for tactual reading. For a person who is blind, this was the earliest method of manually creating text and is somewhat comparable to writing print or cursive letters on paper for a person who is sighted. The advantage of using the slate and stylus for generating literary braille is that this device is small enough to be carried in a purse or pocket for embossing short notes such as telephone numbers, names, or shopping lists.

The Perkins Braillewriter is more sophisticated than the slate and stylus as a full sheet of paper can be inserted into the device and wound down inside the machine. The paper is then locked into position so that the cursor head impacts the paper to create braille cells moving horizontally in 40 cell lines. Margins can be set manually by moving margin sliders to the right or left on the back of the machine. Knobs on either side of the steel case enable the writer to adjust the writing position on the paper vertically and space and backspace buttons enable the writer to move the cursor head back and forth horizontally on a sheet of paper. A carriage return lever enables the writer to move the cursor head back to the beginning of a new line on the left-hand side of the page. There are six keys on the front of the device which when depressed correspond to each of the six dots of the literary braille cell. These keys enable the writer to create the appropriate dots necessary for each cell. Persons familiar with the use of all of these manual controls are able to generate hard-copy braille in a very similar manner compared to generating print using a manual typewriter.

The BrailleNote BT-32 notetaker has several similarities to the Perkins Braillewriter in that it incorporates the same keyboard arrangement of six keys for the braille cells and a backspace key. This device enables the user to generate literary braille electronic documents using word processing software similar to that found on personal computers. This device, first made available in an educational setting in 2000 (Kelly, 2001), was one of the first of its kind to give braille readers access to the Internet. The BrailleNote enables a person who is skilled in the use of the literary braille code to translate electronic braille documents into ordinary Microsoft Word documents which can be forwarded to sighted users of ordinary personal computers via email attachments. Print readers can then read these documents in print on computer monitor screens or can print them out on ordinary printers. The greatest advantage of this access technology device is that there can be instantaneous communication between braille users and print users without the need for a sighted person trained in both braille and print to translate back and forth. (The word "translate" is used instead of the term "transcribe" because it pertains to the electronic translation from print to braille or braille to print. The concept of translation in this context is not being used in the linguistic sense.)

There are several options to choose from when the BrailleNote user who is blind decides to proofread his/her work including a row of 32 refreshable braille cells (an 18 cell display is also available), auditory feedback, or hardcopy production of the braille document using a braille embosser. A braille embosser may use a tractor-feed mechanism to run a continuous series of sheets of braille paper attached by perforations. Once the embosser has completed the job, the user simply tears off the hard-copy document at the bottom of the last perforation and reads the document tactually line-by-line and page-by-page to proofread for errors. If hard-copy braille is not desired, the user can read the document line-by-line or word-by-word by depressing appropriate thumb keys located on the front edge of the BrailleNote. It is possible to use specially designed cursor-marker buttons for easy "tracking" over desired letters, words, punctuation, etc, to monitor the use of accurate formatting conventions in the electronic document. Additionally, the

BrailleNote user may choose to use auditory feedback alone or in combination with the refreshable braille display tactual feedback for scanning through documents or to use both auditory and tactual monitoring of document generation.

In an educational setting, it is possible for sighted teachers and peers to have direct electronic interaction with a BrailleNote-using student via visual observation of print text translated instantaneously from the BrailleNote's onboard braille translation software which is viewable on a computer monitor using the "Visual Display" software that accompanies the device. This transfer of information can be enabled via a standard nine-pin, null-modem serial cable attachment or wireless connection between the devices. Instead of having to contend with the long wait-time intervals for transcription of braille documents into print by a teacher of the visually impaired or a paraprofessional trained in the literary braille code, a general education teacher or sighted peers not trained in braille can interact instantaneously with a BrailleNote-using student which contributes to more meaningful learning experiences in the general education classroom for all parties involved (Farnsworth, 2006).

In addition to braille notetakers, computerized emulators of the Perkins Braillewriter are available that can be uploaded to ordinary computers. Perky Duck is such an emulator available free of charge from Duxbury Systems. As many university and college programs offer braille training via distance delivery, Perky Duck or other electronic emulators of the Perkins Braillewriter are used to facilitate timely and efficient exchange of electronic simulated braille documents between students and their instructors (Farnsworth, 2007).

Statement of the Problem

Braille notetakers and electronic brailler emulators represent a considerable advance over the Perkins Braillewriter in that they enable the user to produce electronic documents that can be saved for later proofreading and upgrading compared to single sheet hard-copy output from the Perkins Braillewriter that is permanent only in the sense that it exists on a sheet of paper. Documents created using the BrailleNote can be translated into Microsoft Word format which makes these accessible for readers of print. This greatly reduces the need for a teacher of the visually impaired trained in braille to facilitate interaction between users who are blind and who are sighted. Because of these advantages afforded by braille notetakers, it is surprising that sighted teachers in training to become teachers of students who are visually impaired or blind in the United States are trained and required to demonstrate proficiency in generating hardcopy braille using a Perkins Braillewriter as opposed to a braille notetaker such as the BrailleNote. The National Literary Braille Competency Test, an assessment designed to measure braille competency in teachers of braille reading students, requires demonstration of braille proficiency using the slate and stylus and the Perkins Braillewriter (International Braille Research Center, n.d.). A comprehensive assessment of the test-taker's knowledge of braille is part of the test, but all demonstrations of proficiency must be produced using a slate and stylus and the Perkins Braillewriter. No allowance is currently made for persons proficient in the generation of hard-copy braille using electronic devices such as the BrailleNote notetaker as a component of this assessment. Many state education departments also have braille proficiency competency test requirements such as the Colorado Department of Education and prospective teachers must generate literary braille on the Perkins Braillewriter. Braille generation using electronic devices such as the BrailleNote is generally prohibited in the process of generating the hard-copy braille component of the Colorado Braille Proficiency Test (T. Anthony, personal communication, November 13, 2005). Reinforcing the notion that braille can or should only be generated on a Perkins Braillewriter is "The Braille Challenge," a national braille proficiency competition program for school-aged braille-reading students sponsored by the Braille Institute (2008). To participate in this competition, contestants must generate drafts of hard-copy braille documents using a Perkins Braillewriter as one component of braille literacy proficiency measurement. Teachers sponsoring participation in the Braille Challenge must ensure that their students are proficient in the use of the Perkins Braillewriter in order for them to do so. Students who have become proficient in the use of braille notetakers may be somewhat disadvantaged in this competition because of the tendency to become heavily dependent upon these devices as opposed to the Perkins Braillewriter for literary braille generation.

These national efforts to promote braille literacy using the Perkins Braillewriter in regard to state and national teacher proficiency tests and student braille competitions seem to run contrary to conventional wisdom with regard to known teaching strategies which are successful with sighted learners. In this case, we are concerned primarily with how sighted teachers in training can most efficiently learn the braille code. It is important to focus on the sighted teacher in training because the majority of teachers trained to work with students who are visually impaired or blind in the United States are sighted (Farnsworth, 2007).

Purpose of the Study, Research Questions and Hypotheses

It is the purpose of this study to compare perceived cognitive load effects of the Perkins Braillewriter and electronic emulators of the Perkins Braillewriter such as Perky Duck in the acquisition of the literary braille code in long-term memory by sighted teachers in training. I acknowledge that I understand the trappings of media comparison. This study looked at levels of achievement in both technology environments; however, in doing so, it combines the perspectives of the three cognate areas of an interdisciplinary doctoral degree which include special education, educational technology, and applied statistics and research methods. The following research questions and hypotheses guided this study:

RQ1 To what extent are mental demand and frustration levels impacted in sighted teachers in training in the Manual Perkins Brailler (MPB) group or the Hybrid (HYB) group during the learning of literary braille code?

H1 Teachers in the MPB group will experience higher levels of mental demand and frustration than their counterparts in the HYB group.

RQ2 How do temporal (time) demand and effort levels differ in impact upon sighted teachers in training in the MPB and HYB groups during the learning of the literary braille code?

H2 The MPB group will experience higher levels of temporal demand and effort than the HYB group.

RQ3 How do physical demand and own performance differ in the MPB and HYB groups?

H3: Participants in the HYB group will experience lower levels of physical demand and higher levels of own performance than their counterparts in the MPB group.

RQ4 How do literary braille code proficiency levels differ between the MPB and HYB groups according to the National Literary Braille Competency Test (NLBCT) practice test protocol standard?

H4 Participants in the HYB group will experience higher levels of literary braille proficiency according to the NLBCT practice test protocol standard than their counterparts in the MPB group.

RQ5 How do literary braille code proficiency levels differ between the MPB and HYB groups according to the National Certification in Literary Braille (NCLB) test standard?

H5 Participants in the HYB group will experience higher levels of literary braille proficiency according to the NCLB standard than their counterparts in the MPB group.

RQ6 How do attrition/non-completion rates differ between the MPB and HYB groups?

H6 Attrition rates will be higher in the MPB group than in the HYB group.

CHAPTER II

REVIEW OF LITERATURE

In a position paper comparing the rate of acquisition of Morse code in comparison to acquisition of the braille code, Farnsworth (2003) proposed that a computerized braille training program might be as effective in helping teachers learn braille as has been demonstrated by the use of such programs in training Morse code telegraph operators. Farnsworth further proposed that the use of such a computer program might have the effect of increasing braille literacy among students who are blind and who are sighted because of the ease of the learning process as delivered by an interactive computer program that provides immediate feedback. According to Sue Larson (personal communication, February 11, 2006), Louis Braille's purpose in developing the braille code was not to create a writing system intended for use at great speed, rather Braille envisioned that blind persons would have access to a tactual literary code capable of representing in comprehensive detail all of the conventions of print texts that are alphabetically based. Farnsworth (2006) and Farnsworth and Luckner (2007) determined that students who are blind and are proficient in the literary braille code transition quickly from the Perkins Braillewriter to the BrailleNote notetaker and are relatively eager to take advantage of the ease of communication possible between sighted teachers and peers via the transmission of Microsoft Word print documents sent as email attachments.

Cognitive Load Theory

According to Paas, Renkl, and Sweller (2003), the underlying premise for cognitive load theory involves a fundamental model of human cognitive architecture central to which is the functioning of "working memory" (p. 2). Miller (1956) made the earliest observations about "immediate memory" consisting of about seven units of "unidimensional judgements" (p. 90). Theoretically, working memory is responsible for all conscious cognitive activities, but may be limited to simultaneously handling only two or three interacting elements from a source of new information. Similar to random access memory in a computer, this type of memory is temporary and short-lived. Based upon this premise, there are few human cognitive activities that could be carried on efficiently. Hence, Paas et al. (2003) posit further the existence of "schemas" (p. 2) which are constructs of long-term memory which when formulated appear to be permanent in duration. There appears to be an unlimited storage capacity in the long-term memory construct and one schema may represent all of the combined skills of a single activity such as those needed for driving a car. A single schema can be retrieved from long-term memory and brought into short-term memory as a single cognitive element, thereby minimizing overload of elements in short-term memory. This construct can be compared to files of information which may be permanently stored in the hard drive of a personal computer. The process of receiving conventional instructions for a learning task is deemed to create an extraneous cognitive load on short-term memory. When the task is learned to proficiency, however, there has been a transition from extraneous to germane cognitive load because the learner has engaged existing short-term memory resources to accomplish a task (Kirschner, 2002).

Cognitive load is defined by Paas et al. (2003) as aspects of a learning activity or environment that may unnecessarily interfere with the learning process and, thereby negatively impact the acquisition of information central to a learning task. According to Sweller (1994), the “redundancy effect” (p. 303) impacts cognitive load when working memory is taxed unnecessarily by multiple sources of information that convey the same meaning. This type of effect may occur when learners attend to both an auditory and a textual presentation of information. The “split-attention effect” (p. 303) may occur when learners must refer to two sources of information to transact meaning in a learning situation. An example of this would be a textbook with a labeled mathematics diagram on one page with an accompanying list explaining each component of the diagram on a separate location on the page or pages of the text. To avoid the spit-attention effect, it is best to integrate written information within the diagrammatic components and so reduce working memory demands.

Van Merrienboer and Ayres (2005) present an overview of cognitive load theory (CLT) and its impact on instructional design for electronic distance instruction delivery. They describe the shift in CLT research from an exploration of how effects of intrinsic, extraneous, and germane cognitive load may improve learning processes in general to a larger focus to minimize these cognitive load impacts by exploring methods to decrease extraneous cognitive load with regard to influences not directly related to learning. Chandler and Sweller (1996) explored element interactivity as it impacted intrinsic and extraneous cognitive load in two groups of participants using manual (textbook) or computerized instructional designs. They recommended that cognitive load should be a major consideration in the development of instructional designs.

Gerjets, Scheiter, and Catrambone (2004) used the NASA-TLX (Task Load Index) instrument to compare "molar" (p. 33) or overall solution sequences for problem-solving to "modular" (p. 33) or separately conveyed components of solution sequences to determine if a modular approach would reduce intrinsic cognitive load. They found that modular examples appeared to reduce levels of intrinsic cognitive load based upon measurements of ratings obtained from participants on the *Frustration, Stress and Task Demands* scales of the NASA-TLX.

With regard to element interactivity, Sweller (1994) suggests that cognitive load consists of both extraneous and intrinsic cognitive load. In his view, extraneous cognitive load is artificially imposed by methods of instruction and that instructors have no control over intrinsic cognitive load components. Furthermore, element interactivity within the content area being learned is primarily responsible for levels of intrinsic cognitive load. Also, Sweller (1994) makes a distinction between which types of learning materials may be elements in this context depending upon the difficulty of the task being learned. Specifically, the process of second-language learning is associated with tasks that involve high levels of interactivity and, hence this type of learning involves the acquisition of schemas. Although the literary braille code is not considered to be a language unto itself, there are components of learning braille that are unique to the code and, hence on a cognitive basis may be compared to the process of acquiring a second language for an adult learner (S. Larson, personal communication, April 3, 2008). Van Gerven, Paas, and Tabbers (2006) recommend in regard to creating optimal educational settings for elderly learners that computers have the capability to reduce levels of extraneous cognitive load by providing control of the training program. Also, they are able to positively impact levels of germane cognitive load by controlling the "sequencing and goal specificity" (p. 154) of problems used in the training process.

Plass, Chun, Mayer, and Leutner (2003) studied the impacts of multimedia aids on cognitive load in adult participants with varying levels of verbal and spatial abilities. They found that when adult participants are learning a second language that visual and verbal modes should be available, but that learners should have the option to select which information mode is most effective for their individual abilities. They noted further that multi-modal presentations of information may create high levels of cognitive load and hinder the learning process.

Visual and Verbal Processes, Acquisition, and Long-Term Memory Retention

Klimesch (1981) explored the connections that exist between verbal and visual systems that affect long-term memory and found that the retention of visual aspects of targets is more likely if these aspects of a visual target have been verbalized. Jenkins and Hoyer (2000) studied age-related differences in the acquisition of enumeration skills in experiments with young and old adults and found no differences due to age in the acquisition of these skills during initial learning of the skills, but did find that reacquisition speeds were slower for older adults after an interval of 18 months. Kendall and Koehler (1925) recognized that rates of transmission and receiving speeds for entire words in Morse code are positively impacted when telegraph operators focus upon learning whole letters instead of mentally counting the dits and dahs that make up each alphabetic character. Miller (1956) explained that the learning of Morse code by telegraph operators occurs as learners gradually make the transition from perceiving only individual components of letters to perceiving larger components such as words and sentences as individual units. Farnsworth (2003) suggested that computerized braille teaching programs may make it possible to produce similar effects in learners of the braille code as have been observed in learners of Morse code.

Access Technology

Luxton (1990) stipulated that adaptive computer training should be a foundational component of literacy training for persons with visual impairments. Benefits that persons with visual impairments can derive from this training include the learning of basic skills and concepts necessary for the use of computer hardware and software and increased knowledge of how to interact with the world by having the ability to manage large quantities of information. Brunken (1984) and Ashcroft (1984) urged that pre-service teachers have training in the appropriate adaptation and modification of computer hardware and software for the purpose of teaching their future students with visual impairments to maximize their levels of independence and, thereby, enable them to choose from an increased range of career options as adults. Mack, Koenig, and Ashcroft (1990) recommended that skills in the use of microcomputers and access technology devices become competencies required of in-service and pre-service teachers of students with visual impairments. They also stressed the need for teachers to have positive attitudes toward technology, in general. Edwards and Lewis (1998) encouraged the development of guidelines for access technology training in teacher training programs for students with visual impairments based upon the finding that teacher-respondents had very little familiarity with these devices as well as minimal opportunity to acquire sufficient training to master their usage of these devices. Cahill and Linehan (1996) and Rapp and Rapp (1992) found that, in comparison to their sighted peers, very small numbers of students with visual impairments opt to take higher level mathematics courses. The authors suggest that this tendency is very likely due to limitations in access to repetitive mathematical tasks rather than to difficulties with conceptualization or cognitive skills. They also cited the difficulty of acquiring appropriate materials and equipment as having a negative impact upon the progress made by their students with visual impairments in advanced mathematics courses.

Distance Delivery of Pre-Service Teacher Training Programs

Arter and Mason (1996) compared the advantages and disadvantages of a distance delivery program in the United Kingdom and found that distance learning may be the only option in some cases when the traveling distances to institutions is extreme. Disadvantages include students' lack of access to library facilities and the pressures of coping with a full-time job simultaneously. Koenig and Robinson (2001) evaluated an on-line braille code training course for pre-service teachers and found that this instructional mode offers a challenging and high-quality program if students are persistent and have confidence in their ability to use computer technology to interact with instructors and peers. Parsons (1990) and Huebner and Wiener (2001) described the shortages of teachers in the field of visual impairment and blindness and suggested that this situation might be alleviated somewhat by distance delivery teacher training programs.

DeMario and Heinze (2001) reported that over 50% of university preparation programs designed to prepare personnel for the various fields that serve students who are visually impaired or blind include a component that involves distance education delivery. Rosenblum (2001) described the process of modification necessary for delivery of university distance programs for pre-service teachers of students with visual impairments. Arter, McLinden, and McCall (2001) describe the progress made in the United Kingdom in the use of distance delivery methods for preparing teachers of children with visual impairments. They predicted that distance delivery methods would remain the primary teaching mode and that the greatest challenge for the future will be to assure instruction of high quality for these pre-service teachers.

Bruce and Hwang (2001) report that web-based preparation of teachers in visual impairment programs requires 5-23 hours of preparation per lecture hour as compared to 2-10 hours of preparation per lecture hour for on-campus courses. Trief, Decker, and Ryan (2004) recommended the use of programs which involve a combination of distance learning via the Internet with weekend visits to the university or college campus for direct instruction for pre-service teachers.

Teacher's Attitudes Toward Braille-Training Preparation

Wittenstein (1993) found that a relationship exists between types of pre-service braille training received and teacher feelings and attitudes about braille as a learning mode and their competence about teaching braille. More positive attitudes and feelings appear to be attributed to teachers whose programs placed emphasis upon teaching methodologies and upon the sequences involved in the development of tactual awareness. The author also emphasized that training teachers of students who are visually impaired to simply become efficient braillists falls far short of the actual needs of these students. DeMario, Lang, and Lian (1998) and DeMario (2000) investigated the attitudes of teachers in perceived competence in braille systems and, specifically, the Nemeth braille code for mathematics and science. They found that most teachers had more positive attitudes toward teaching literary braille than Nemeth braille. They recommended that pre-service training in the Nemeth code should perhaps be expanded beyond the single standard overview course to include specific emphasis upon the unique content areas of mathematics curricula such as geometry, algebra and the adaptation of graphics.

Perceived Decline in Braille Literacy

Mullen (1990) identified that the absence of national standards, inadequate preparation, and a lack of commitment on the parts of pre-service teachers to develop high levels of proficiency in braille skills contribute to the perceived decline in braille literacy. Wittenstein (1994) investigated the causes for the perceived decline in braille literacy and found that a large sample of teachers from a national study reported strong support among teachers of visually impaired students for the use of braille as a learning medium and who felt confident with regard to their abilities to teach braille to their students. The author suggested that the cause of the perceived decline in braille literacy is not lack of commitment or lack of braille skills on the part of teaching professionals.

Certification of Braille Competency for Pre-Service and In-Service Teachers

Spungin (1976) and Huebner and Strumwasser (1987) conducted national studies of state departments of education with regard to certification requirements for teachers of students who are visually impaired. They found that, although most states have vision-specific requirements for certification, there was considerable variation between states. The authors recommended the re-evaluation of certification requirements, on-going support for teacher preparation programs, and the development of national standards for preparation and certification of teachers of students with visual impairments. Allman (1987) emphasized that preparation programs for teachers of visually impaired students should be consistent with teacher preparation programs in general education areas including high program entry standards, increased field experience requirements, and the development of in-service programs to maintain high levels of competence among teachers in the field. Tait (1987) observed minimal teacher preparation requirements for general education teachers across several states despite the inclusion of students with disabilities in these classrooms.

Amato (2002) surveyed teachers' competencies in literary and Nemeth braille and found that 96% of teacher training programs provide training in the literary braille code in the first semester and that in almost 50% of these programs the Nemeth code for math and science was not included as a course requirement. The author made a recommendation in support of nationally standardized levels of competence in braille skills. Knowlton and Berger (1999) endeavored to identify the most important braille competencies needed by teachers in elementary and secondary school settings. They found that teachers of braille should have in-depth knowledge regarding the teaching of reading skills in addition to contracted braille proficiency, that teachers should embrace computer technologies to give their students electronic access to large quantities of braille information, and that teacher preparation programs should endeavor to offer instruction related to braille skills that are directly related to employment.

Allman and Lewis (1996) examined the content validity of the National Literary Braille Competency Test. They found that transcribing braille with a Perkins Braillewriter without the use of reference materials is a valid and appropriate skill to assess as a requirement for certification of teachers of students who are visually impaired or blind. However, they determined that the use of a slate and stylus for the same purpose should not be considered a valid competency. Of the 181 participants in the study, 64% of teachers used computer software to transcribe braille. The researchers concluded that the National Literary Braille Competency Test should not be used for the purpose of certifying teachers of students with visual impairments. Waugh (2008) found that the slate and stylus, braillewriter, and proofreading sections of the National Literary Braille Competency test have reasonably good construct validity and reliability. He recommended that the multiple choice section of the test be administered without reference materials to increase the reliability of this section.

Training of In-Service Teachers

Swallow (1990) observed several problems impacting university teacher preparation programs. These included the need for alternate training options due to changes in program funding and variations in the populations of students with special needs, development of combined training in areas other than visual impairment, and supervision for these teachers in their first 3 to 4 years of teaching. Jones and Wolfe (1996) studied the Texas Commission for the Blind's initiative with regard to its ability to enhance the braille skills of teaching staff. They concluded that the Texas initiative has produced very good results in standardized braille training for rehabilitation teachers in teaching reading and writing skills. Wormsley (2001) reported positive reactions from teachers that participated in a 6-week braille refresher course focused upon helping teachers become acquainted with and prepared for the National Literary Braille Competency Test. Ratings from participants were particularly high for components of the course dealing with proficiency using the Perkins Braillewriter and low for components dealing with development of proficiency using the slate and stylus.

Allman and Holbrook (1999) reported positive reactions from teachers who participated in a braille refresher course. The authors noted that teachers within the sample had wide ranges of types of instructional demands placed upon their caseloads, had for the most part been teaching for an average of 10 years, and had an average of 5.85 braille students in their entire careers. This observation provided the rationale for recommending that states having braille certification requirements should make regular in-service training available to their teachers so that they can maintain high levels of braille competency. Barraga (1981) and Sowell, Correa, and Wardell (1987) observed that outreach programs in which university professors leave campuses to train teachers already in the field in rural areas is a valid and economical approach because these teacher-trainees already have close ties to their local communities and are likely to remain in these geographical locations after graduation from a program. Walker (1979) urged the development of comprehensive, on-going local programs for in-service training of teachers of students with visual impairments in local school systems.

Current Status of Pre-Service Teacher Preparation Programs

The *Instruction Manual for Braille Transcribing* (4th edition) is currently used as the primary textbook for pre-service teachers in learning the literary braille code in some universities and colleges (John Wilkinson, personal communication, March 22, 2006). This manual progresses through the 189 contractions and 450 rules that govern contracted literary braille over the course of 20 lessons (Risjord, Wilkinson, & Stark, 2000). According to Wilkinson (personal communication, March 22, 2006), this manual was developed for the purpose of training persons to become transcribers of braille from print and there is no research basis in existence to support its development or usage for training pre-service teachers to become teachers of students who are visually impaired or blind. The braille transcribing course for which the *Instructional Manual for Braille Transcribing* was designed is typically completed in 7 to 8 months and includes a 35-page manuscript to be submitted at the end of the course (National Braille Association, 2006). Receipt of the National Library Service transcriber certificate upon completion of the lessons and manuscript requirements of the *Instructional Manual for Braille* does not prepare a person to start transcribing textbooks immediately. Usually, it is recommended that prospective textbook transcribers complete 12 months of braille assignments using the literary braille code before starting to prepare literary textbooks. Becoming proficient in the use of the Nemeth and music braille codes may require an additional 2 to 5 years of training (National Braille Association, 2006).

The National Professional Blindness Certification Board awards the *National Certification in Literary Braille* (NCLB) credential to persons who successfully demonstrate competence in the use of literary braille upon completion of the National Literary Braille Competency Test designed primarily for teachers of students with visual impairments (E. Bell, personal communication, March 4, 2008). Erin (1992) described the persistence necessary for sighted, adult pre-service teachers to complete initial college courses in literary braille. She states that the most important factor needed to complete this process successfully is a positive attitude.

Head (1989) and Silberman, Corn, and Sowell (1989) pointed out the grave shortage of pre-service teachers in preparation compared to the numbers of students with visual impairments in need of qualified teachers and recommended that university preparation programs broaden their focus to cope with this need on a national basis. Head

(1989) warned of the danger of many of these students being serviced by “generic special education teachers” (p. 151) as a substitute for service delivery by certified teachers of students who are visually impaired or blind.

Corn and Silberman (1999) examined teacher preparation programs offered at 39 universities concentrating on types of program delivery, practicum supervision, sources of external funding, and the status, rank, and salaries of faculty delivering these programs. They urged that research be on-going in regard to monitoring the ability of these programs to recruit and train qualified faculty suited to run university teacher training programs. Corn and Ferrell (2000) noted that the current lack of university researchers and faculty is negatively impacted by minimal funding available to support doctoral learners in the fields of education and rehabilitation of students who are blind or visually impaired. Silberman and Corn (1996) urged collaboration between state departments of education, the federal government, and local education agencies to ensure that “high-cost, low enrollment” (p. 7) graduate and undergraduate pre-service teacher training programs remain economically feasible to maintain. Amato (2000) found considerable variation within teacher preparation programs in Canada and the United States with regard to braille instruction. She recommended that teacher training programs incorporate two semesters of braille training into their curriculums in order to assure that pre-service teachers reach high levels of proficiency in braille skills.

CHAPTER III

METHODOLOGY

The purpose of this study was to compare the perceived cognitive load impacts encountered by the manual Perkins Braillewriter (MPB) group and hybrid technology (HYB) group on the learning of the literary braille code in sighted teachers in training. This study employed a quasi-experimental design involving the use of both quantitative and qualitative measures. A password protected webpage (see Appendix A) facilitated the bulk of data collection. By logging on to this webpage, participants could download the UNC IRB consent form (see Appendix B) to indicate consent by means of an electronic signature and return the completed form to the researcher as an email attachment. Upon returning the consent form, it was possible to download the Participant's Personal Information Sheet (see Appendix C), fill in the requested information for the independent variables to be analyzed, then return this as an email attachment to the researcher. Once both the IRB consent form and Personal Information Sheet were submitted, the researcher assigned the participant a unique alpha-numeric identifier for confidentiality purposes when submitting data using the NASA-TLX instrument. The NASA-TLX (task load index) instrument (see Appendix D) was self-administered by participants on a weekly or bi-weekly basis depending upon the frequency of lesson completion in each institution's approximately 15-week literary braille training program. In some cases, programs presented literary braille over the course of 2 semesters in which case participants submitted NASA-TLX ratings over the course of approximately 30 weeks.

The National Literary Braille Competency Test NLBCT – practice test protocol was administered as a measurement of competency in braille transcription and proofreading of literary braille according to the NLBCT standard using the braille assistive technology device (Perkins Braillewriter or Perky Duck – electronic brailler emulator) available during the course, upon completion of each literary braille training program. Some program coordinators elected to use the NLBCT practice test protocol as their course final exam for their students and supervised its administration following the criteria of provision of 3 hours for completion of both sections of the protocol with access to the *English Braille, American Edition (EBAE) 1994* with 2002 revision as the only reference. Some differences in formatting in braille drafts were encountered between hard-copy braille passages created on the Perkins brailler and electronic passages created using Perky Duck. At the request of the researcher, NBPCB graders made adjustments in their grading process so that there would be no scoring differential between the electronic and hard-copy braille drafts.

The actual National Literary Braille Competency Test (NCLB) was administered to participants upon completion of their courses. In most cases, participants were given several weeks following the completion of their coursework to prepare for the NCLB test. Participants who elected to take the NCLB did so either at an administration of the test in their geographical region supervised by the researcher or at test centers facilitated by the National Professional Blindness Certification Board. The NCLB test consists of four parts: Section 1 – braille transcription using a Perkins Braillewriter, section 2 – braille transcription using a slate and stylus, section 3 – proofreading for errors embedded in a passage of embossed Braille, and section 4 – multiple choice questions on background knowledge of contracted literary braille. This test was administered only to participants who successfully completed their institution's literary braille training programs. Twenty-one participants took part in semi-structured interviews with the researcher at the conclusion of the training period. Interviews were administered by telephone or, in most cases, to participants at the sites where they completed the NLBCT test. The 10 most informative interviews were purposefully selected by the researcher, manually transcribed from electronic recordings, and were subjected to thematic analysis. A cross-section of all participants including those that experienced successful completion of their programs and those who were not successful were included in this component of the study.

Selection and Description of the Participants

In July 2008, program coordinators at 30 personnel preparation programs in the United States and Canada were contacted by the researcher. Contact information was acquired from the Association for Education and Rehabilitation of the Blind and Visually Impaired (AER) personnel preparation webpage and by college level braille instructors and professors in the field who were colleagues of the researcher. Between August 2008 and June 2009, students enrolled in 23 universities or college literary braille training programs were contacted by their instructors on behalf of the researcher and invited to participate in this study using two different assistive technology environments to learn the literary braille code and thus partially fulfill the requirements of their courses. Criteria for selection of participants were that they were sighted and were enrolled in the participating institutions' teacher-training program with the ultimate goal of becoming practitioners in the field of education of students who are visually impaired or blind. Ninety-four participants were recruited from 18 personnel preparation programs from the United States and Canada. The researcher employed a purposive sampling procedure of a fairly small population. Forty-three participants were placed in the Manual Perkins Brailler (MPB) group due to their sole usage of the Perkins Braillewriter and/or the slate and stylus during instruction. Fifty-one participants were placed in the Hybrid technology (HYB) group because their programs were designed to develop proficiency on a combination of both manual and electronic braille assistive devices. These devices would have included Perky Duck, the Perkins Braillewriter, and/or the slate and stylus.

Literary braille courses were offered during different semesters/quarters of the year. Also, there was considerable variability with regard to semester/quarter beginning and ending dates across institutions. Data collection was on-going from mid-July 2008 through the end of June 2009 to enable potential participation by as large a subgroup as possible of pre-service teachers from institutions across the United States and Canada. Data were acquired from the participants as they took part in usual academic settings as designed by their institutions. By taking this approach, participants encountered minimal interference or extra time pressures and ecological validity of the study was preserved to a large degree.

Variables

Dependent variable #1 is the measurement of perceived mental demand and frustration levels as encountered by teachers in each assistive technology learning environment. The researcher anticipated that high levels of perceived mental demand and frustration would be evident as participants progressed through literary braille lessons. Making the transition to a six-key braille keyboard was a new skill for most participants in each assistive technology environment. Levels of perceived mental demand and frustration were expected to vary in each assistive technology environment as participants acquired expertise in the use of assistive technology devices and the literary braille code.

Dependent variable #2 was the measurement of perceived temporal (time) demand and effort levels encountered by teachers in training in each assistive technology environments. The researcher anticipated that the quantity and sources of perceived temporal demand and effort would vary between each assistive technology environment.

Dependent variable #3 was the measurement of perceived physical demand and perceptions of own performance as experienced by teachers in training in each assistive technology environment.

Dependent variable #4 was the measurement of the proficiency of learning of the literary braille code and is defined as the assessment of the degree of proficiency attained in literary braille according to the NLBCT practice test protocol standard by participants after completion of their institution’s literary braille course.

Dependent variable #5 was the measurement of the proficiency of learning the literary braille code and was defined as the assessment of proficiency attained in literary braille according to the NLBCT test standard by participants upon completion of their institution’s literary braille course.

Dependent variable #6 was the measurement of attrition/non-completion rates in the HYB and MPB groups.

Instrumentation

NASA-Task Load Index

The National Aeronautics and Space Administration – Task Load Index instrument (NASA-TLX) was designed to monitor various aspects of perceived cognitive load as experienced primarily by pilots in aircraft cockpit environments and not on the population of sighted teachers in training learning the literary braille code. In its current form, this instrument may be used to measure and monitor the effects of perceived cognitive load in a variety of settings in which humans interact with technology. Within the context of this study, the NASA-TLX instrument was self-administered to participants on a weekly or bi-weekly basis for the duration of their literary braille training cycles. The NASA-TLX instrument was accessible to participants via the Internet on a password protected webpage maintained by the researcher. Participants were given instructions including participant codes for logging onto a website dedicated to hosting the NASA-TLX (computerized version). A computer based audio-visual tutorial was available for participants to use for guidance on how to register responses on the instrument from the data collection webpage as well as similar print instructions that could be downloaded if desired (see Appendix E). The researcher was available by email and cellular phone to answer questions related to use of the instrument as needed and closely monitored this process providing reminders as necessary.

The NASA-TLX scales measure consciously perceived mental demand, physical demand, temporal demand, performance, effort, and frustration level. Although each scale is configured in a manner similar to a Likert scale, Hart and Staveland (1988) elected not to use numeric markers on this instrument. Instead, each rating scale consists of a 12-centimeter line with “low” on the left side anchor and “high” on the right. Participants were simply requested to place a mark on each rating scale which “represents the magnitude of each factor in the task you just performed” (p. 177). On the computerized version of the TLX, participants used a computer mouse to orient the mark placement for each scale.

With regard to using the NASA-TLX ratings to measure specific components of perceived cognitive load, the instrument does not have clear boundaries for making distinctions among intrinsic, extraneous, and germane components of perceived cognitive load. Rather, the instrument measures perceived cognitive load as a single construct. According to Paas, Tuovinen, Tabbers, and Van Gerven (2003), this practice is usual in CLT research. In order to answer RQ1 [To what extent are mental demand and frustration levels impacted in the Manual Perkins Braillewriter (MPB) group or the Hybrid Technology (HYB) group during learning of the literary braille code?], the amounts of perceived mental effort and frustration being experienced by participants in the task of learning the literary braille code were assessed. The researcher anticipated that differential ratings would result between the two assistive technology environments on the mental demand and frustration level scales.

To answer RQ2 [How do temporal (time) demand and effort levels differ in impact upon sighted teachers in training in the MPB and HYB groups during the learning of the literary braille code?], ratings on each of these scales were assessed. The researcher anticipated that differential ratings would result on perceived temporal (time) demand and effort scales between the two assistive technology environments.

To answer RQ3 [How do physical demand and own performance differ in the MPB and HYB groups?], the researcher anticipated that decreasing rating trends in levels on the physical demand scale and increasing rating trends on the performance rating scale would occur over the course of the study. Also, the researcher anticipated that there would be differentials in these ratings between each assistive technology environment.

National Literary Braille Competency (Practice) Test

This version of the National Literary Braille Competency Test was made available via the Internet to persons who were interested in practicing before taking the actual test for certification. Participants in the HYB group took this test using the electronic braille emulator, Perky Duck. Participants in the MPB group took this test using the Perkins Braillewriter. This test instrument was administered to each group within a few weeks of completion of coursework and only the braille embossing and proofreading components were used.

Two options for taking the NLBCT practice test were available during the study. Some personnel preparation programs administered this test on campus. In many cases, participants self-administered the test under the supervision of a colleague, friend, or family member who signed a Proctor Affirmation Form (see Appendix F) indicating that specified testing conditions were maintained. Staff at The National Professional Blindness Certification Board (NBPCB) graded the tests and used pre-set criteria for passing and failing scores. These criteria were observed in determining the literary braille proficiency scores for participants in this study in each administration of the NLBCT practice test (see Appendix G) (E. Bell, personal communication, March 4, 2008).

National Certification in Literary Braille Test

The National Certification in Literary Braille (NCLB) test is a criterion referenced instrument developed jointly by the Braille Development section of the National Library Service of the Library of Congress and the National Federation of the Blind. It consists of a four-component assessment of general knowledge with regard to the literary braille code. The NCLB assesses the examinee's ability to transcribe one complete print page into literary braille using all of the rules and contractions that pertain to the contracted braille format and to identify errors in braille usage in four medium length braille paragraphs. Transcription of literary braille was demonstrated both by using the slate and stylus and the Perkins Braillewriter. The examinees were expected to complete these tasks successfully in approximately 5 hours (with interspersed breaks) and were able to use the *English Braille, American Edition (EBAE) 1994* with 2002 revision as the only reference for all but the multiple choice question section 4. Staff at The National Professional Blindness Certification Board (NBPCB) graded the tests using pre-set criteria for passing and failing scores. These criteria were observed in determining the level of literary braille proficiency for participants in this study in each administration of the NCLB (E. Bell, personal communication, March 4, 2008).

Semi-Structured Interview Schedule

Semi-structured interviews were administered by telephone or in person to 21 participants. As perceptions were expected to be somewhat unique to each participant, the semi-structured format was adopted for the purpose of capturing these experiences and perceptions as valuable qualitative data at the conclusion of literary braille coursework.

The following are the types of questions that were asked within the semi-structured interviews:

Perceptions of assistive technology environments

- Please tell me about your experiences in completing literary braille lessons. Could you explain some of these in detail?
- Please tell me about your opinions regarding the assistive technology device(s) you used to complete literary braille lessons. Could you describe these?
- What changes would you make with regard to use of assistive technology devices in literary braille training?

Cognitive load

- Do you feel that the assistive technology device(s) you used in completing literary braille assignments made this task easy? Could you explain why you feel this way?
- Are there any specific elements/components of the assistive technology device(s) that made completion of braille lessons easy? Could you describe how/why these components/elements helped you?
- Were there any specific elements of the assistive technology device(s) that hindered you in any way in completing braille lessons? Could you describe these?
- Did you feel rushed to complete braille lessons? If so, please explain.

- Could you describe how much mental effort you needed to expend to complete braille lessons? Did the amount of mental effort needed seem to vary from lesson to lesson?
- How did your braille assistive technology device(s) affect your mental effort? Could you elaborate on one or two of your experiences?
- How did the design of the braille assistive technology device affect your focus on learning the literary braille code? How did it affect your concentration?
- Please describe your stress level while completing braille lessons. Did you find that the stress level tended to vary from lesson to lesson?
- How did the design of the braille assistive technology device affect your stress level? Could you elaborate on this?
- How did the design of the braille assistive technology device affect your willingness to continue using it in future braille courses? Could you elaborate on this?

This instrument is a modified version of one used by Miller (2006).

Data Collection

Data were collected using the quantitative scales of the NASA-TLX as a formative measure. Ratings that were submitted via a dedicated website on a weekly basis were automatically stored and backed up at regular intervals and categorized according to assistive technology environment group and level of lesson progression for subsequent analysis.

Results from the NLBCT- practice test protocol were collected by university proctors at participating institutions or self-administered by participants under the supervision of a proctor. Upon completion of the test, all materials were forwarded to the NBPCB for grading. All test materials were labeled with alphanumeric indicators to maintain confidentiality.

Results from the NCLB tests were collected under the direct supervision of the researcher at participating institutions or at NCLB administrations facilitated by the NBPCB. Each set of test materials was labeled with an alpha-numeric indicator for the purpose of maintaining confidentiality. Staff at the NBPCB graded the tests, assimilated the results, and returned these data to the researcher for analysis categorized only by their alphanumeric indicators. Only participants that successfully completed their institution's literary braille programs were given the opportunity to take the NCLB test. Participants who successfully completed all components of the NCLB were notified by the researcher and received the *National Certification in Literary Braille* credential awarded by the National Professional Blindness Certification Board.

Semi-structured interviews were administered either by telephone or in person depending upon logistics and convenience at the conclusion of the study to 21 participants. The interviewees were split evenly between the two assistive technology environment groups. A representative sample of participants who did not complete their institution's literary braille programs was selected to gain their perceptions on this process and especially to gather background information on why they elected not to complete their training. Access to these individuals was entirely dependent upon attrition rates of participants in their institution's programs. At the beginning of the study, attrition rates in literary braille training programs were reportedly high at several institutions (S. Amato, personal communication, February 28, 2008). Interviews were recorded electronically for subsequent manual transcription and analysis.

Data Analysis

In order to determine the impacts of perceived cognitive load effects on participants' formative assessments were implemented. These took the form of data accumulated by participants' weekly responses to assistive technology environment tasks throughout their literary braille training programs. In all cases and for each rating scale implemented using the NASA-TLX instrument, multivariate analysis of variance (MANOVA) was performed on each rating scale using SAS 9.1 statistical software to determine if differences existed between the mean scores of participants in each technology group (see Appendix H for SAS coding for Research Questions 1-3). Components of perceived intrinsic, extraneous, and germane cognitive load were assessed dependent upon the above described rating scales for each component. Descriptive statistics were used to describe trends in data from these scales ratings to assess the degree to which fluctuations in perceived cognitive load effects impacted participants in each assistive technology environment group.

Multivariate analysis of variance (MANOVA) was performed upon the means of the HYB and MPB group means from the NLBCT – practice test protocol to determine if significant differences existed in levels of braille proficiency (according to the NLBCT standard) attained by participants in each technology group (see Appendix H for SAS coding for Research Question 4). The purpose for employing this method was to determine if there is any advantage to using electronic brailler emulators over the Perkins Braillewriter in literary braille instruction for sighted pre-service teachers.

Multivariate analysis of variance (MANOVA) was performed upon the means of each assistive technology environment group's scores from the National Literary Braille Competency Test- National Certification in Literary Braille (NCLB) test (see Appendix H for SAS coding for Research Question 5). The purpose of employing this method was to determine if statistical differences existed between levels of proficiency in literary braille according to the NCLB standard attained by each group.

In order to answer Research Question 6 [How do attrition/completion rates differ in the MPB and HYB groups?], Chi-square tests of association were conducted on all participants dependent upon the availability of attrition/completion information provided by the participants and/or their instructors (see Appendix H for SAS coding for Research Question 6).

Effect sizes were calculated from MANOVA tests of group comparisons using partial eta-squared (η^2) with .02 being considered low, .05 considered moderate, and .08 being considered a high effect size (Tabachnick & Fidell, 2007).

Glaser and Strauss' (1967) constant comparison method was employed to analyze the semi-structured interviews to identify emerging themes. Emerging themes were sorted into categories (Bogdan & Biklen, 1992) and the frequency of each theme was tabulated across all transcripts (Miles & Huberman, 1984). Themes that occurred in the highest frequencies were taken to be the most meaningful results from the qualitative analysis (see Appendix I for data from participant interviews by emergent theme).

Interpretation of the results from both quantitative and qualitative data took place simultaneously for the purpose of triangulation of data (Kelle & Erzberger, 2004;

Tashakkori & Teddlie, 1998) from both types of measures. The researcher anticipated that data from both sources would have the effect of strengthening the overall validity of the findings.

CHAPTER IV

QUANTITATIVE ANALYSIS

The purpose of this study was to compare perceived cognitive load effects experienced by teachers in training using primarily manual braille assistive technology devices designated as the Manual Perkins Brailler group (MPB group) and their counterparts who used both electronic and manual assistive technology devices designated as the Hybrid technology group (HYB group) during their college or university courses in literary braille. The following six research questions and hypotheses guided this study:

RQ1 To what extent are mental demand and frustration levels impacted in sighted teachers in training in the Manual Perkins Brailler (MPB) group or the Hybrid (HYB) group during the learning of literary braille code?

H1 Teachers in the MPB group will experience higher levels of mental demand and frustration than their counterparts in the HYB group.

RQ2 How do temporal (time) demand and effort levels differ in impact upon sighted teachers in training in the MPB and HYB groups during the learning of the literary braille code?

H2 The MPB group will experience higher levels of temporal demand and effort than the HYB group.

RQ3 How do physical demand and own performance differ in the MPB and HYB groups?

H3 Participants in the HYB group will experience lower levels of physical demand and higher levels of own performance than their counterparts in the MPB group.

RQ4 How do literary braille code proficiency levels differ between the MPB and HYB groups according to the National Literary Braille Competency Test (NLBCT) practice test protocol standard?

H4 Participants in the HYB group will experience higher levels of literary braille proficiency according to the NLBCT practice test protocol standard than their counterparts in the MPB group.

RQ5 How do literary braille code proficiency levels differ between the MPB and HYB groups according to the National Certification in Literary Braille (NCLB) test standard?

H5 Participants in the HYB group will experience higher levels of literary braille proficiency according to the NCLB standard than their counterparts in the MPB group.

RQ6 How do attrition/non-completion rates differ between the MPB and HYB groups?

H6 Attrition rates will be higher in the MPB group than in the HYB group.

This chapter includes results for the data analyses used to answer the research questions listed above. For Research Questions 1-5, statistical tests in the model incorporated the independent variables technology group, age, delivery type, educational level, previous experience with literary braille, and college term. For Research Question 6, gender and school were also incorporated as independent variables.

Participant data from the MPB and HYB groups were used for the Multivariate Analysis of Variance (MANOVA) to answer Research Questions 1, 2, and 3 which deal with the dependent variables mental demand, frustration, temporal demand, effort, physical demand, and own performance as measured by the NASA-Task Load Index (NASA-TLX) instrument.

Participant data from the MPB and HYB groups were used for the Multivariate Analysis of Variance (MANOVA) to answer Research Question 4 with regard to participants who completed the National Literary Braille Competency Test – practice test

(NLBCT practice test). Non-standardized score data on a braillewriting task performed on the participant's usual or preferred assistive technology device and a braille proofreading task were the dependent variables used in this MANOVA. These scores were determined by the National Blindness Professional Certification Board (NBPCB).

Participant data from the MPB and HYB groups were used for the Multivariate Analysis of Variance (MANOVA) to answer Research Question 5 with regard to participants who completed the National Literary Braille Competency Test for the National Certification in Literary Braille (NCLB certification test). Non-standardized score data on a Perkins Brailler braillewriting task, a slate and stylus braillewriting task, a braille proofreading task and a multiple choice question task comprised the four dependent variables used in this MANOVA. These scores were determined by the National Blindness Professional Certification Board (NBPCB).

Data from all study participants in the MPB and HYB groups were used in a Chi-square test of association to assess the relationship between the single dichotomous variable of completion/non-completion rates and the independent variables to answer Research Question 6.

Question 1: Mental Demand and Frustration Level in the MPB and HYB Groups

Mental demand and frustration level mean scores from participants in the MPB and HYB groups who submitted data using the NASA-TLX instrument were analyzed using a MANOVA design. The independent variable technology group was not found to be relevant in the model at alpha = .05, Wilks' Lambda = .98, F (2, 60) = .47, p = .628, η = .01 (see Table 1). Therefore, the null hypothesis was not rejected for Research Question

1. There appears to be little if any difference in Mental Demand and Frustration Level for the MPB and HYB groups.

Table 1

Mental Demand and Frustration Levels for the MPB and HYB Groups

Group	N Obs	Variable	Mean	Std Dev
MPB	29	mendem	13.0733303	4.1502846
		frustra	10.8694425	4.8294060
HYB	48	mendem	12.2577991	4.0172616
		frustra	10.1910265	4.1005630

Note: Means for the MPB group are slightly higher than for the HYB group.

The independent variable age level was not relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .22, F (8, 120) = 1.36, p = .220, η = .53. The age levels addressed in this test were 19-29, 30-39, 40-49, and 50-59 (see Table 2). With the exception of the 50-59 age level participants, there appears to be little difference in Mental Demand and Frustration Level across age levels

Table 2

Mental Demand and Frustration By Age Level

Age	N Obs	Variable	Mean	Std Dev
19-29	18	mendem	12.70	4.42
		frustra	10.58	4.77
30-39	31	mendem	12.34	4.30
		frustra	9.95	3.94
40-49	22	mendem	12.99	3.61
		frustra	11.56	4.12
50-59	4	mendem	9.76	3.10
		frustra	4.99	3.33

The independent variable program delivery was not relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .91, F (4, 120) = 1.39, p = .242, η = .05 (see Table 3). There appears to be little difference in Mental Demand and Frustration Level by distance, face-to-face, or hybrid program delivery type.

Table 3

Mental Demand and Frustration Level By Program Delivery Type

Delivery	N Obs	Variable	Mean	Std Dev
Distance	41	mendem	12.44	3.96
		frustra	10.24	4.15
Face-To-Face	25	mendem	13.24	4.13
		frustra	10.82	4.86
Hybrid Program	10	mendem	11.15	4.49
		frustra	9.86	4.31

The independent variable previous education level was not relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .87, F (8, 120) = 1.10, p = .368, η = .07 (see Table 4). The previous education levels within the sample were high school diploma, associate’s degree, bachelor’s degree and master’s degree. The descriptive statistics appear to indicate a linear trend of decreased mental demand as the means are observed in ascending level of academic accomplishment from high school diploma to master’s degree. This linear trend appears to be less obvious for frustration level, however.

The independent variable prior braille experience was relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .84, F (2, 60) = 5.54, p = .006, η = .08 (see Table 5).

Table 4

Mental Demand and Frustration By Previous Education Level

Education	N Obs	Variable	Mean	Std Dev
High School Diploma	2	mendem	17.51	1.01
		frustra	12.79	0.01
Associate's Degree	2	mendem	12.75	1.37
		frustra	11.73	4.05
Bachelor's Degree	48	mendem	12.69	3.89
		frustra	10.66	4.17
Master's Degree	23	mendem	11.92	4.59
		frustra	9.54	5.06

Table 5

Mental Demand and Frustration By Prior Braille Experience

Braille Experience	N Obs	Variable	Mean	Std Dev
No prior braille experience	53	mendem	13.67	3.48
		frustra	11.61	4.25
Had prior braille experience	23	mendem	9.94	4.24
		frustra	7.58	3.24

Note: Participants without prior braille experience had higher mean averages of Mental Demand and Frustration Level than participants that had prior braille experience.

The independent variable college term was relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .75, F (4, 120) = 4.67, p = .002, η = .13 (see Table 6). Posthoc statistical contrasts were performed to determine which terms were relevant within this independent variable. Summer 2008 was found to be relevant in the model at alpha = .05, Wilks' Lambda = .85, F (2, 60) = 5.17, p = .009. Also, Fall 2008 was found to be relevant in the model at alpha = .05, Wilks' Lambda = .83, F (2, 60) = 6.18, p = .004.

Table 6

Mental Demand and Frustration By College Term

Term	N Obs	Variable	Mean	Std Dev
Summer 2008	9	mendem	10.65	5.27
		frustra	8.88	5.30
Fall 2008	53	mendem	12.63	3.71
		frustra	10.03	3.96
Winter/Spring 2009	14	mendem	13.41	4.54
		frustra	12.70	4.72

Question 2: Temporal (time) Demand and Effort Level in the MPB and HYB Groups

Temporal demand and effort level mean scores from participants in the MPB and HYB groups who submitted data using the NASA-TLX instrument were analyzed using a MANOVA design. The independent variable, technology group was not found to be relevant in the model at alpha = .05, Wilks' Lambda = .97, F (2, 60) = 1.03, p = .361, η = .02 (see Table 7). Therefore the null hypothesis was not rejected for Research Question 2. There appears to be a slightly higher temporal demand level in the MPB group compared to the HYB group but little difference in Effort Level exists between the groups.

The independent variable age level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .87, F (8, 120) = 0.87, p = .540, η = .07 (see Table 8). There appears to be little difference in Temporal Demand and Effort across age levels 19-29, 30-39, 40-49, and 50-59.

Table 7

Temporal Demand and Effort Level for the MPB and HYB Groups

Group	N Obs	Variable	Mean	Std Dev
MPB	28	temdem	10.28	4.41
		effort	13.96	4.15
HYB	48	temdem	8.68	4.11
		effort	13.73	4.02

Table 8

Levels of Temporal Demand and Effort By Age Group

Age	N Obs	Variable	Mean	Std Dev
19-29	18	temdem	8.07	5.34
		effort	14.35	4.62
30-39	31	temdem	9.03	4.29
		effort	13.36	4.31
40-49	22	temdem	10.75	2.98
		effort	14.38	3.45
50-59	4	temdem	7.99	4.26
		effort	11.22	0.65

The independent variable program delivery type was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .93, F (4, 120) = 1.09, p = .364, η = .04 (see Table 9). There appears to be little difference in Temporal Demand and Effort by distance, face-to-face or hybrid program delivery type.

Table 9

Levels of Temporal Demand and Effort By Program Delivery Type

Delivery	N Obs	Variable	Mean	Std Dev
Distance	40	temdem	8.64	4.21
		effort	13.92	4.01
Face-To-Face	24	temdem	10.25	4.65
		effort	14.26	4.19
Hybrid Program	10	temdem	9.44	3.77
		effort	12.38	4.09

The independent variable previous education level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .86, F (8, 120) = 1.17, p = .322, η = .07 (see Table 10). Previous education levels were high school diploma, associate's degree, bachelor's degree, and master's degree. The trend of the mean scores of Temporal Demand and Effort seems to decrease somewhat with increased level of education attained.

Table 10

Means of Temporal Demand and Effort By Previous Education Level

Education	N Obs	Variable	Mean	Std Dev
High School Diploma	2	temdem	12.98	2.65
		effort	18.98	0.26
Associate's Degree	2	temdem	11.13	0.75
		effort	14.01	3.76
Bachelor's Degree	47	temdem	8.97	4.05
		effort	14.11	3.86
Master's Degree	23	temdem	9.41	5.02
		effort	12.77	4.40

The independent variable prior braille experience was found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .80, F (2, 60) = 7.63, p = .001, η = .11 (see Table 11). Participants without previous braille experience had higher mean averages of Temporal Demand and Effort than did participants with previous braille experience.

Table 11

Means of Temporal Demand and Effort By Prior Level of Prior Braille Experience

Braille Experience	N Obs	Variable	Mean	Std Dev
No prior braille experience	51	temdem	10.27	4.35
		effort	15.04	3.34
Had prior braille experience	23	temdem	7.06	3.35
		effort	11.13	4.31

The independent variable college term was found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .84, F (4, 120) = 2.83, p = .028, η = .08 (see Table 12). A posthoc contrast analysis determined that the Summer 2008 term was statistically significant at alpha = .05, Wilks' Lambda = .88, F (2, 60) = 4.15, p = .021 in contrast with winter/spring 2009.

Table 12

Means of Temporal Demand and Effort By College Term

Term	N Obs	Variable	Mean	Std Dev
Summer 2008	8	temdem	8.69	4.83
		effort	11.16	5.06
Fall 2008	52	temdem	8.81	3.89
		effort	14.09	3.82
Winter/Spring 2009	14	temdem	11.33	5.19
		effort	14.36	4.12

Question 3: Physical Demand and Own Performance in the MPB and HYB Groups

Physical demand and effort level mean scores from participants in the MPB and HYB groups who submitted data using the NASA-TLX instrument were analyzed using a MANOVA design. The independent variable technology group was not found to be relevant in the model at alpha = .05, Wilks' Lambda = .99, F (2, 60) = 0.20, p = .822, η = .01 (see Table 13). Therefore, the null hypothesis was not rejected for Research Question 3. There appears to be little difference in Physical Demand and Own Performance level for the MPB and HYB groups.

Table 13

Levels of Physical Demand and Own Performance for the MPB and HYB Groups

Group	N Obs	Variable	Mean	Std Dev
MPB	27	physdem	8.87	4.11
		perform	5.95	3.59
HYB	47	physdem	9.20	4.52
		perform	4.73	2.47

The independent variable age level was not relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .83, F (8, 120) = 1.51, p = .162, η = .09 (see Table 14). There appears to be little difference in Physical Demand and Own Performance by age level.

The independent variable program delivery type was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .93, F (4, 120) = 1.23, p = .303, η = .04 (see Table 15). There appears to be little difference in physical demand and own performance by distance, face-to-face, or hybrid delivery type.

Table 14

Levels of Physical Demand and Own Performance By Age Level

Age	N Obs	Variable	Mean	Std Dev
19-29	18	physdem	8.24	4.74
		perform	5.43	3.5
30-39	30	physdem	9.02	4.00
		perform	5.07	2.91
40-49	22	physdem	10.33	4.56
		perform	5.17	2.54
50-59	4	physdem	6.36	2.72
		perform	4.91	3.91

Table 15

Levels of Physical Demand and Own Performance By Program Delivery Type

Delivery	N Obs	Variable	Mean	Std Dev
Distance	40	physdem	9.11	4.45
		perform	4.59	2.45
Face-To-Face	24	physdem	8.90	4.27
		perform	6.29	3.64
Hybrid Program	10	physdem	9.35	4.57
		perform	4.85	2.52

The independent variable previous education level was not relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .81, F (8, 120) = 1.68, p = .111, η = .10 (see Table 16). Mean scores for Physical Demand appear to decrease with increasing level of previous education but there appears to be little difference in the mean scores for Own Performance.

Table 16

Levels of Physical Demand and Own Performance By Previous Education Level

Education	N Obs	Variable	Mean	Std Dev
High School Diploma	2	physdem	16.28	0.96
		perform	4.68	2.83
Associate's Degree	2	physdem	12.01	1.54
		perform	7.20	1.49
Bachelor's Degree	47	physdem	9.37	4.24
		perform	4.78	2.90
Master's Degree	23	physdem	7.60	4.14
		perform	5.85	3.13

The independent variable, prior braille experience was found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .90, F (2, 60) = 3.47, p = .037, η = .05 (see Table 17). Participants without prior braille experience reported higher levels of Physical Demand and Own Performance than participants who had prior experience with braille.

Table 17

Means of Physical Demand and Own Performance By Prior Level of Previous Braille Experience Level

Braille Experience	N Obs	Variable	Mean	Std Dev
No prior braille experience	52	physdem	9.91	4.18
		perform	5.71	3.12
Had prior braille experience	22	physdem	7.10	4.19
		perform	3.92	2.16

The independent variable college term was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .86, F (4, 120) = 2.26, p = .067, η =

.07 (see Table 18). There appears to be little difference in Physical Demand and Own Performance between Summer 2008), Fall 2008, and Winter/Spring 2009.

Table 18

Means of Physical Demand and Own Performance By College Term

Term	N Obs	Variable	Mean	Std Dev
Summer 2008	8	physdem	7.68	4.04
		perform	5.08	3.54
Fall 2008	52	physdem	9.55	4.34
		perform	4.63	2.51
Winter/Spring 2009	14	physdem	8.13	4.52
		perform	7.26	3.46

Question 4: Braille Proficiency in the MPB and HYB Groups Measured By the National Literary Braille Competency Test – Practice Test Protocol

The National Literary Braille Competency Test – practice test protocol (NLBCT-practice) consists of braillewriting and braille proofreading tasks using either manual or electronic braille assistive devices dependent upon the device most used in their programs. Most participants completed both tasks in between 1 and 2 hours even though a maximum 3-hour timeframe was allowed. Except for a few exceptions, participants in the MPB group produced braille using the manual Perkins Braillewriter while most participants in the HYB group produced braille using the electronic brailler emulator, Perky Duck installed on an ordinary computer. To earn a passing grade on this test, participants had to achieve in the vicinity of less than five errors on each task. Overall, there were 42 participants in the HYB group in this component of the study and, of that number, 11 passed and 31 did not pass the test. Overall, there were 30 MPB group participants and, of that number, 14 passed and 16 did not pass the test.

Braillewriting and braille proofreading mean scores from participants in the MPB and HYB groups were analyzed using a MANOVA design. The independent variable, technology group was not found to be relevant in the model at alpha =.05, Wilks' Lambda = .99, F (2, 53) = 0.39, p = .678, η = .01 (see Table 19). Therefore, the null hypothesis was not rejected for Research Question 4. There appears to be little difference in performance on braillewriting and braille proofreading tasks for the MPB and HYB groups.

Table 19

Mean Scores for Braillewriting and Proofreading (NLBCT Practice Test) By Technology Group

Group	N Obs	Variable	Mean	Std Dev
MPB	30	braillewriting	90.00	6.46
		proofreading	75.47	10.05
HYB	42	braillewriting	86.63	10.08
		proofreading	83.61	10.87

The independent variable age level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .92, F (6, 106) = 0.72, p = .636, η = .04 (see Table 20). There appears to be little difference in performance on braillewriting and braille proofreading tasks by age level.

The independent variable program delivery type was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .88, F (4, 106) = 1.77, p = .140, η = .06 (see Table 21). There appears to be little difference in performance among participants on braillewriting and proofreading tasks in distance, face-to-face or hybrid delivery programs.

Table 20

Mean Scores for Braillewriting and Proofreading (NLBCT Practice Test) By Age Level

Age	N Obs	Variable	Mean	Std Dev
19-29	14	braillewriting	90.14	8.54
		proofreading	87.00	11.25
30-39	29	braillewriting	87.50	9.37
		proofreading	84.71	9.46
40-49	21	braillewriting	87.10	10.51
		proofreading	82.10	11.81
50-59	8	braillewriting	88.29	6.47
		proofreading	84.75	9.68

Table 21

Mean Scores for Braillewriting and Proofreading (NLBCT Practice Test) By Program Delivery Type

Delivery	N Obs	Variable	Mean	Std Dev
Distance	39	braillewriting	85.47	9.93
		proofreading	82.42	10.99
Face-To-Face	26	braillewriting	90.50	7.65
		proofreading	86.46	10.11
Hybrid Program	7	braillewriting	93.14	5.64
		proofreading	87.43	7.89

The independent variable previous education level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .90, F (8, 106) = 0.70, p = .687, η = .05 (see Table 22). There appears to be little difference in performance on braillewriting and braille proofreading tasks by previous education level.

Table 22

Mean Scores for Braillewriting and Proofreading (NLBCT Practice Test) By Previous Education Level

Education	N Obs	Variable	Mean	Std Dev
High School Diploma	2	braillewriting	91.00	4.24
		proofreading	89.00	7.07
Associate's Degree	2	braillewriting	95.00	7.07
		proofreading	87.00	7.07
Bachelor's Degree	42	braillewriting	87.90	10.28
		proofreading	84.49	9.99
Master's Degree	24	braillewriting	86.83	7.87
		proofreading	82.67	11.83
Doctoral Degree	2	braillewriting	94.00	5.66
		proofreading	96.00	2.83

The independent variable prior braille experience was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .90, F (2, 53) = 3.03, p = .057, η = .05 (see Table 23). There appears to be little difference in performance on braillewriting and braille Proofreading tasks between participants with braille experience and those without previous braille experience.

The independent variable college term was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .97, F (4, 106) = 0.35, p = .841, η = .02 (see Table 24). There appears to be little difference in performance on braillewriting and braille proofreading tasks between participants in Summer 2008, Fall 2008, and Winter-Spring 2009.

Table 23

Mean Scores of Braillewriting and Proofreading (NLBCT Practice Test) By Prior Braille Experience Level

Braille Experience	N Obs	Variable	Mean	Std Dev
No prior braille experience	51	braillewriting	86.57	10.02
		proofreading	83.52	10.58
Had prior braille experience	21	braillewriting	91.50	5.58
		proofreading	86.48	10.25

Table 24

Mean Scores for Braillewriting and Proofreading (NLBCT Practice Test)By College Term

Term	N Obs	Variable	Mean	Std Dev
Summer 2008	13	braillewriting	89.54	7.80
		proofreading	87.69	5.22
Fall 2008	49	braillewriting	87.71	10.11
		proofreading	84.78	10.35
Winter/Spring 2009	10	braillewriting	87.25	5.23
		proofreading	77.56	14.48

Question 5: Braille Proficiency in the MPB and HYB Groups Measured By the National Certification in Literary Braille Test – NCLB

The National Certification in Literary Braille test – NCLB consisted of four tasks which, with breaks interspersed, usually required about 8 hours for completion. Section 1 consisted of a braillewriting task to be performed on the Perkins braillewriter. Section 2 consisted of a braillewriting task to be performed on the slate and stylus. Section 3 consisted of a braille proofreading task and Section 4 consisted of a battery of multiple choice questions on background knowledge of literary braille. To earn a passing grade on this test, participants had to pass all four sections. Overall, there were 22 participants in the HYB group in this component of the study and, of that number, 3 passed and 19 did not pass the test. Overall, there were 17 MPB group participants and, of that number, 8 passed and 19 did not pass the test.

As the NCLB test is a secure instrument, participants' exact scores could not be disclosed by the National Blindness Professional Certification Board (NBPCB). Rather, in order to preserve the integrity of the test, raw scores for Sections 1 (Perkins Braillwriter) and 3 (braille proofreading) were predicated on a base of 0-100. Raw scores from Sections 2 (slate and stylus) and 4 (multiple choice) were predicated on a scale of 0-50.

Perkins braillewriting, slate and stylus, braille proofreading, and multiple choice mean scores from participants in the MPB and HYB groups were analyzed using a MANOVA design. The independent variable technology group was not found to be relevant in the model at alpha =.05, Wilks' Lambda = .85, F (4, 24) = 1.03, p = .413, η = .08 (see Table 25). Therefore, the null hypothesis was not rejected for Research Question 5. There appears to be little difference in performance on Perkins braillewriting, slate and stylus, braille proofreading, and multiple choice question tasks for the MPB and HYB groups.

The independent variable age level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .67, F (12, 63.79) = 0.85, p = .596, η = .10 (see Table 26). There appears to be little difference in performance on Perkins braillewriting, slate and stylus, braille proofreading and multiple choice question tasks by age level.

Table 25

Mean Scores for Perkins Braillewriting, Slate and Stylus Braillewriting, Braille Proofreading, and Multiple Choice Tasks (NCLB Certification Test) By MPB and HYB Groups

Group	N Obs	Variable	Mean	Std Dev
MPB	17	Perkins	89.00	5.28
		slate & Stylus	44.65	4.90
		proofreading	90.71	4.61
		multiple choice	46.12	2.60
HYB	22	Perkins	83.82	10.85
		slate & stylus	41.82	4.89
		proofreading	85.27	6.36
		multiple choice	44.77	2.37

Table 26

Mean Scores for Perkins Braillewriting, Slate and Stylus Braillewriting, Braille Proofreading, and Multiple Choice Tasks (NCLB Certification Test) By Age Level

Age	N Obs	Variable	Mean	Std Dev
20-29	9	Perkins	87.22	7.76
		slate & stylus	45.00	3.43
		proofreading	89.56	4.88
		multiple choice	46.22	2.86
30-39	16	Perkins	86.31	8.31
		slate & stylus	41.31	5.62
		proofreading	86.44	5.21
		multiple choice	44.81	1.60
40-49	8	Perkins	82.13	13.46
		slate & stylus	43.38	5.37
		proofreading	85.38	8.93
		multiple choice	44.50	3.63
50-59	6	Perkins	89.00	6.32
		slate & stylus	44.33	4.46
		proofreading	91.00	5.51
		multiple choice	46.67	1.97

The independent variable program delivery type was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .62, F (8, 48) = 1.63, p = .141, η = .15 (see Table 27). Face-to-face participants performed slightly higher on Perkins braillewriting, slate and stylus braillewriting, braille proofreading and multiple choice question tasks than participants in the distance and hybrid delivery groups.

Table 27

Mean Scores for Perkins Braillewriting, Slate and Stylus, Proofreading, and Multiple Choice Tasks (NCLB Certification test) By Program Delivery Type

Delivery	N Obs	Variable	Mean	Std Dev
Distance	21	Perkins	83.95	11.10
		slate & stylus	41.90	4.99
		proofreading	85.24	6.52
		multiple choice	44.81	2.42
Face-To-Face	15	Perkins	90.00	4.24
		slate & stylus	45.87	3.72
		proofreading	91.87	3.44
		multiple choice	46.60	1.99
Hybrid Program	3	Perkins	81.33	5.77
		slate & stylus	37.00	2.65
		proofreading	83.33	2.52
		multiple choice	43.00	3.46

The independent variable previous education level was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .87, F (12, 63.79) = 0.30, p = .988, η = .03 (see Table 28). There appears to be little difference in performance on Perkins Braillewriting, slate and stylus, braille proofreading, and multiple choice question tasks by previous level of education.

Table 28

Mean Scores for Perkins Braillewriting, Slate and Stylus, Proofreading, and Multiple Choice Tasks (NCLB Certification Test) By Previous Education Level

Age	N Obs	Variable	Mean	Std Dev
High School Diploma	2	Perkins	85.00	5.66
		slate & stylus	43.00	4.24
		proofreading	90.00	5.66
		multiple choice	45.50	2.12
Associate’s Degree	1	Perkins		
		slate & stylus		
		proofreading		
		multiple choice		
Bachelor’s Degree	25	Perkins	85.60	9.84
		slate & stylus	43.12	5.51
		proofreading	86.96	6.48
		multiple choice	45.16	2.46
Master’s Degree	11	Perkins	86.82	8.78
		slate & stylus	42.64	4.52
		proofreading	88.64	6.30
		multiple choice	45.55	2.91

The independent variable prior braille experience was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .95, F (4, 24) = 0.32, p = .859, η = .03 (see Table 29). There appears to be little difference in performance by participants with prior braille experience or without prior braille experience on Perkins braillewriting, slate and stylus braillewriting, braille proofreading and multiple choice question tasks.

Table 29

Mean Scores for Perkins Braillewriting, Slate and Stylus Braillewriting, Braille Proofreading, and Multiple Choice Tasks (NCLB Certification test) By Prior Braille Experience

Braille Experience	N Obs	Variable	Mean	Std Dev
No Prior braille experience	27	Perkins	86.11	9.28
		slate & stylus	43.67	4.24
		proofreading	88.30	6.08
		multiple choice	45.41	2.63
Had prior braille experience	12	Perkins	86.00	9.22
		slate & stylus	41.67	6.47
		proofreading	86.17	6.58
		multiple choice	45.25	2.38

The independent variable college term was not found to be relevant in the MANOVA model at alpha = .05, Wilks' Lambda = .93, F (4, 24) = 0.42, p = .794, η = .04 (see Table 30). There appears to be little difference in performance on Perkins braillewriting, slate and stylus, braille proofreading, and multiple choice question tasks by participants in fall 2008 or winter/spring 2009). Participants in Summer 2008 chose not to participate in the NCLB test component of this study.

Question 6: Attrition in the MPB and HYB Groups

Chi-square tests of association were used to answer Research Question 6. The single dichotomous dependent variable attrition; complete or did not complete, was compared with each independent variable.

Table 30

Mean Scores for Perkins Braillewriting, Slate and Stylus Braillewriting, Braille Proofreading, and Multiple Choice Tasks (NCLB Certificate Test) By College Term

Term	N Obs	Variable	Mean	Std Dev
Fall 2008	2	Perkins	88.00	2.83
		slate & stylus	44.50	3.54
		proofreading	91.50	0.71
		multiple choice	45.00	1.41
Winter/Spring 2009	37	Perkins	85.97	9.37
		slate & stylus	42.97	5.12
		proofreading	87.43	6.33
		multiple choice	45.38	2.59

The independent variable technology group was not found to be associated with attrition as shown in Figure 1 below, $\chi^2(1, N = 94) = 0.007$, $p = .934$. Therefore, the null hypothesis was not rejected for Research Question 6. As 50% of cells in the analysis have expected counts of less than 5, Chi-square may not be a valid statistic.

The independent variable gender was not found to be associated with attrition as shown in Figure 2 below, $\chi^2(1, N = 94) = 0.442$, $p = .506$. As 50% of cells in the analysis have expected counts of less than 5, Chi-square may not be a valid statistic.

The independent variable age was not found to be associated with attrition as shown in Figure 3 below, $\chi^2(4, N = 93) = 2.253$, $p = .689$. As 60% of cells have expected counts of less than 5, Chi-square may not be a valid statistic. Age levels in the analysis are 20-29 (level 1), 30-39 (level 2), 40-49 (level 3), 50-59 (level 4), and 60-69 (level 5).

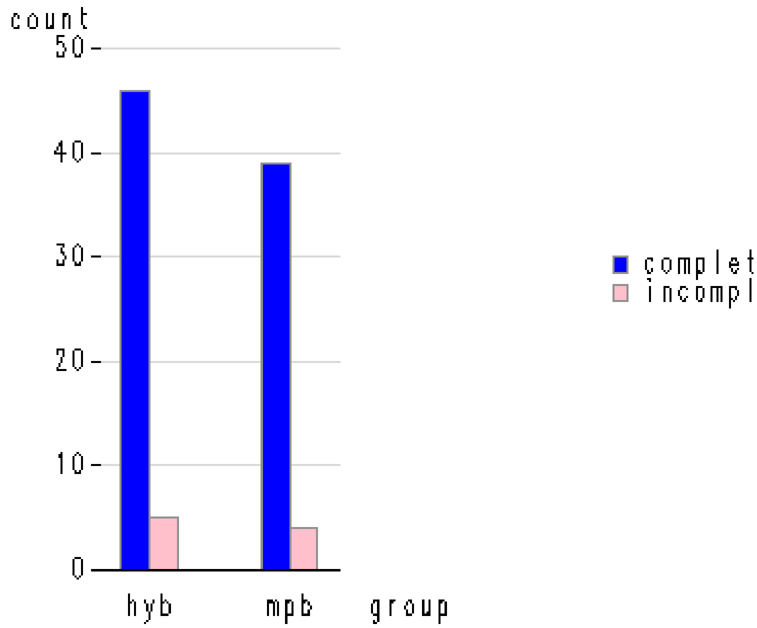

Figure 1. Attrition in the HYB and MYB Groups

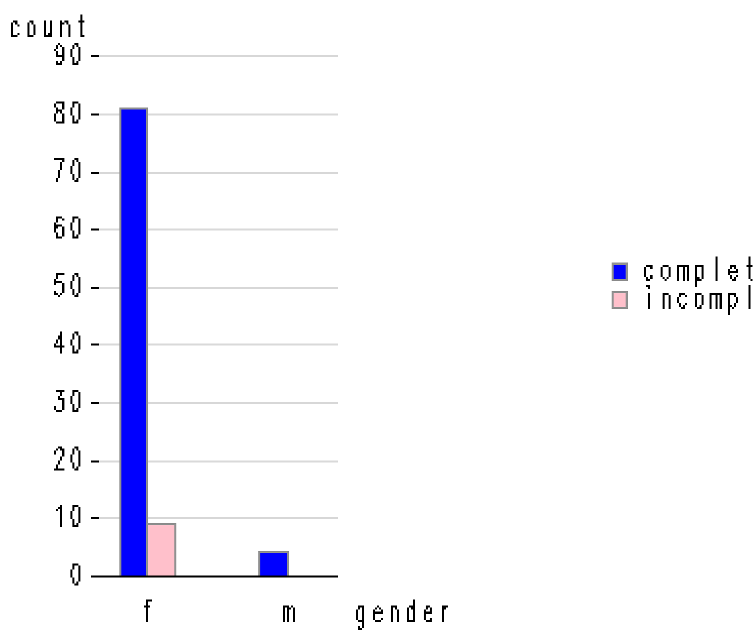

Figure 2. Attrition Rates By Gender

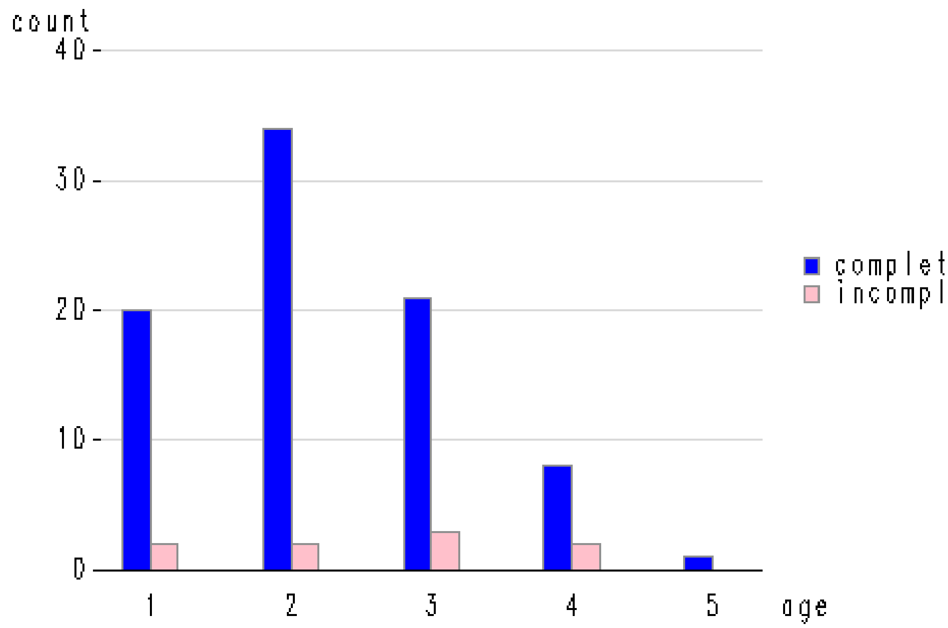

Figure 3. Attrition Rates By Age Level

As an independent variable type of program delivery was not found to be associated with attrition as shown in Figure 4 below, $\chi^2(2, N = 94) = 1.1856$, $p = .5528$. As 50% of cells have expected counts of less than 5, Chi-square may not be a valid statistic.

As an independent variable previous education level was not found to be associated with attrition as shown in Figure 5 below, $\chi^2(2, N = 94) = 1.1856$, $p = .5528$. As 70% of cells have expected counts of less than 5, Chi-square may not be a valid statistic.

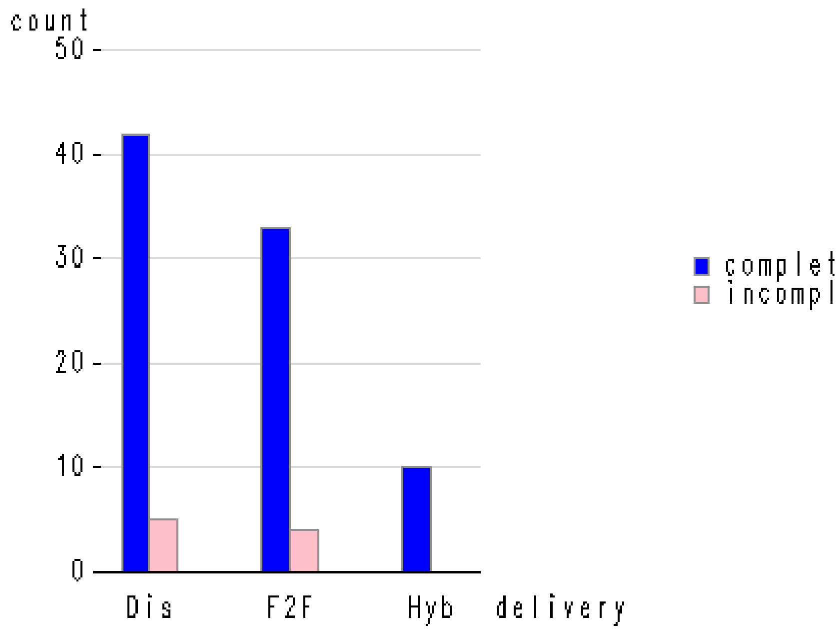

Figure 4. Attrition by Program Delivery Type

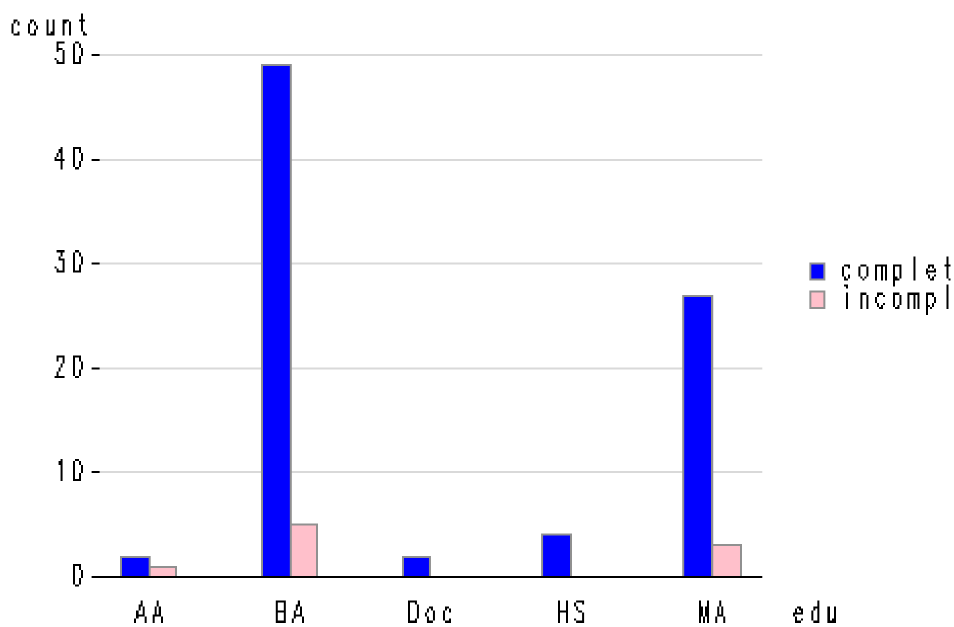

Figure 5. Attrition By Previous Education Level

As an independent variable previous braille experience was not found to be associated with attrition as shown in Figure 6 below. As 25% of cells have expected counts of less than 5, the Fisher's Exact Test $p = .0575$ result is reported instead of the Chi-square result.

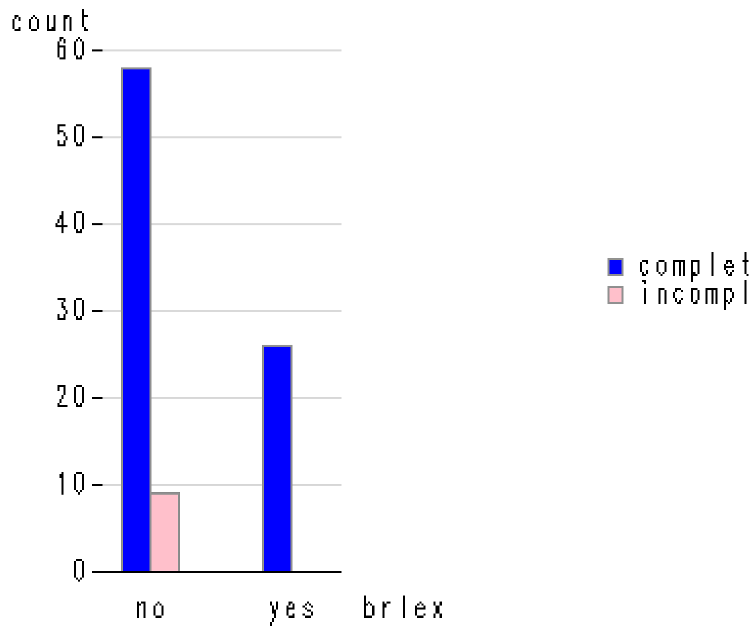

Figure 6. Attrition By Prior Braille Experience

As an independent variable school was not found to be associated with attrition as shown in Figure 7 below, $\chi^2(17, N = 94) = 1.1838$, $p = .3654$. As 81% of cells have expected counts of less than 5, Chi-square may not be a valid statistic.

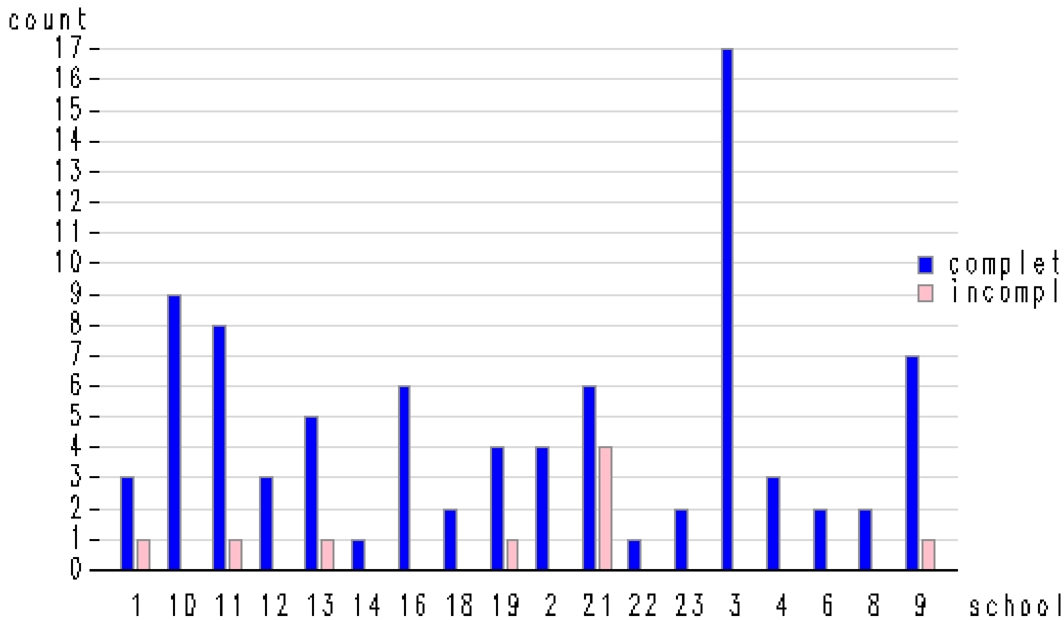

Figure 7. Attrition By School

As an independent variable college term was not found to be associated with attrition as shown in Figure 8 below, $\chi^2(2, N = 94) = 0.3140$, $p = .8547$. As 33% of cells have expected counts of less than 5, chi-square may not be a valid statistic.

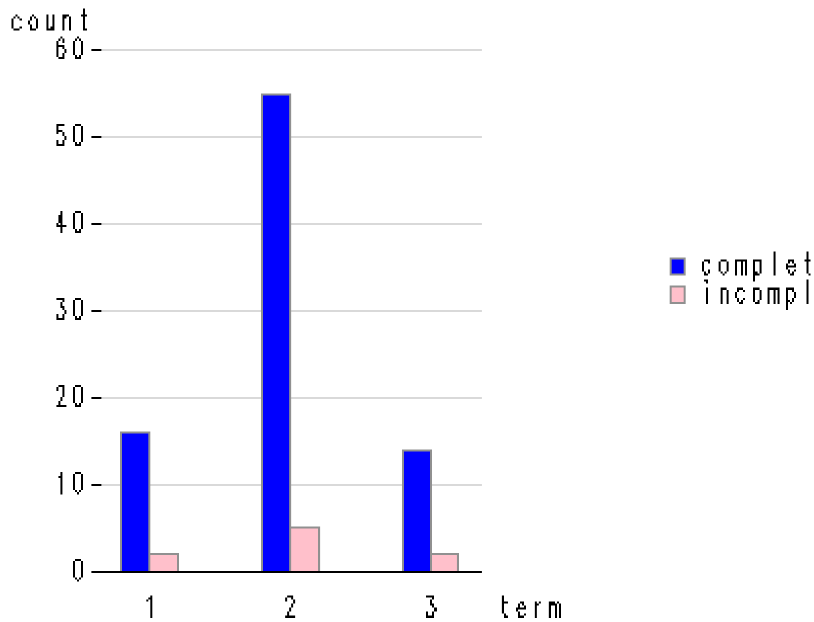

Figure 8. Attrition By College Term

CHAPTER V

QUALITATIVE ANALYSIS

This chapter includes results from the thematic analysis of interviews from five participants from each of the MPB and HYB groups. One interview was obtained from an MPB participant that did not complete the literary braille course. The same semi-structured interview schedule was used for each interview. However, in order to capture individual experiences as thoroughly as possible, participants were encouraged to speak freely on any topic item and to expand their descriptions beyond the scope of the interview schedule questions.

Glaser and Strauss' (1967) constant comparison method was employed to identify emerging themes from the transcripts. Emerging themes were sorted into categories (Bogdan & Biklen, 1992) and the frequency of each theme was tabulated across all transcripts (Miles & Huberman, 1984). Themes that occurred in the highest frequencies were taken to be the most meaningful results from the qualitative analysis (see Table 31). Interpretation of the results from both quantitative and qualitative data took place simultaneously for the purpose of triangulation of the data (Kelle & Erzberger, 2004; Tashakkori & Teddlie, 1998).

Table 31

Emergent Themes from MPB and HYB Participants

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
1	Physical perceptions of Perky duck, Perkins and slate and stylus	45	37	82
2	Perceptions of efficiency of Perky duck, Perkins and slate and stylus	9	28	37
3	Instructional design issues/comments	12	19	31
4	Mental effort attributed to Braille code Complexity; Comparisons with foreign language learning	11	6	17
5	Time pressure for lesson completion attributed to extraneous (lifestyle) factors rather than technology	7	3	10
6	Muscle memory typical with using the Perkins does not easily transfer to Perky Duck	4	5	9

Theme 1 – Physical perceptions of Perky Duck, Perkins Braillewriter and the Slate and Stylus

About half of the data from the transcripts in this thematic category pertained to physical perceptions of the technology devices that were unique to the users. Participant MPB1 stated with regard to the slate and stylus,

> . . . with the slate and stylus you have the added demand of having to just keep up with where you are but with the brailler you don’t have to do that because it will keep your place for you.

With regard to the Perkins Braillewriter, participant MPB3 noted,

> I think the clanking noise from the brailler was annoying at first . . .

Participant HYB4 mentioned with regard to Perky Duck that,

> . . . I would be typing something and the line would disappear. Some of the immediacy of not being able to, you know how when you are writing a document (in a word processor) and you accidentally erase a line you can hit undo when you are typing. Perky Duck doesn't have that feature. I could not get it back so I would have to retype a line.

In comparing the Perkins and the slate and stylus, participant MPB2 stated,

> It got easier but I found switching back and forth difficult. If I had been using the slate and stylus, it was a little harder to switch back to using the braillewriter.

The second largest body of information from this thematic category pertained to positive perceptions of Perky Duck as compared to the Perkins Braillewriter. Participant HYB3 stated that,

> I am glad that I have the experience on the Perkins Brailler, but I will not be doing any of the assignments (in future coursework) on that, at all. I'm just using the computer (Perky Duck).

With regard to the ability to concentrate effectively while doing braille lessons, participant HYB4 stated,

> I think that the actual black and white dots on the screen helped me focus on those and the black and white dots on paper, on the simbraille, really helped me to gain more of a focal point.

Participant HYB5 wondered why braille proficiency cannot usually be demonstrated on electronic devices and stated,

> . . . it's like the difference between a typewriter and a computer and I really don't understand why we're being forced to use the brailler for my state braille exam. You know, why don't we have the option to use Perky Duck when everybody else is in the computer age . . . it's compatible with other (electronic) braille devices like the BrailleNote . . .

The third, fourth, and fifth largest bodies of information within this category occurred in almost equal frequencies. These included comments about having to mentally and physically reverse the braille cells while using the slate and stylus. Participant MPB1 stated,

> . . . it is more difficult to do slate and stylus because you have to really know your contractions backwards and forwards.

Participant MPB2 stated,

> It took me a while to catch on to what seemed to me as a sighted person as entering letters reversed using the slate and stylus. It got easier . . . but I found switching back and forth difficult.

With regard to increased perceived mental effort needed to use the slate and stylus, participant HYB1 said,

> The slate and stylus took a lot of mental effort because of the changing around . . . I had to use post-it notes, one with the regular braille cell and the other with the reversed braille cell.

A number of participants noted the difficulty of making corrections in a braille draft on the Perkins Braillewriter or slate and stylus. Participant MPB4 said,

> . . . for the most part I was comfortable with the Perkins Brailler, but there was always that part that you can't mess up because you can't fix it. Erasing is very, very hard. If you make a mistake, you pretty much have to start over.

Similarly, participant HYB3 stated the opinion that,

> When I put my fingers on a brailler, I am much more cautious and slower at getting the letters down because it is very painful to make a mistake on a brailler. A lot of times you can't fix it at all if it's a formatting problem or you've got too many errors. You just have to start over and you may not have time.

Some participants in the HYB group noted the ease of making corrections to a braille draft composed on Perky Duck as compared to the Perkins Braillewriter. Participant HYB4 said,

> I liked the fact that if I made a mistake I could backtrack and get rid of it without having to go over it and possibly make holes on my braille paper.

Similarly, participant HYB5 stated the opinion that,

> I mean its just the pressure's off of making those mistakes and having to worry about you know, fixing those mistakes because it is so much easier to fix on a computer.

The weight and physical appearance of the Perkins Braillewriter were considered undesirable by some. Participant MPB4 stated that although she liked the Perkins,

> I don't like the fact that the thing weighs a ton.

Similarly, participant HYB2 stated,

> The Perkins is a pain to carry around.

Participant MPB4 recalled a parent's initial impression of the Perkins Braillewriter:

> I don't want my kid carrying that thing around because it looks like an ancient typewriter.

Theme 2 – Perceptions of efficiency of Perky Duck the Perkins Braillewriter and the Slate and Stylus

Within this thematic category, the largest amount of information from the interview data pertained to positive impressions of Perky Duck. Items most important to the participants were the ability to braille at increased speed, the ease of correcting mistakes, and the user-friendliness of the computer application. Participant MPB5 stated the opinion that,

> I think with Perky Duck you go a little faster (compared with the Perkins Braillewriter).

Similarly, participant HYB3 said,

> Well, I felt when I was on the Perky (Duck) brailler on the computer, I went very, very, fast because it is so easy to correct mistakes and just like typing (with a word processor), you make lots of mistakes and you go back and clean them up and you're all good. When I put my fingers on a brailler, I am much more

> cautious and slower at getting the letters down because it is very painful to make a mistake on the brailler.

Participant HYB4 stated the opinion that,

> I guess the quickness of it . . . I think the ability to see what I was writing in front of me as opposed to behind a roller (on a Perkins). The screen was very beneficial seeing what was up the vertical screen. The vertical, visual feedback made a big difference.

Participant HYB5 compared the Perkins and Perky Duck in this statement,

> I think it is a million times easier, quite much easier to use Perky Duck than the Perkins. It is a pretty simple program, Perky Duck. That made it easy . . . it's pretty simple to attach it to emails and send it off that way. For the attachment features it was very user-friendly . . . so that in general made it easy to use.

Theme 3 – Instructional Design Issues and Comments

Within this thematic category, participants made positive comments about immediate feedback from both face-to-face programs using the Perkins Braillewriter and distance programs that relied primarily on Perky Duck to submit braille lessons. The convenience of on-line distance delivered programs was discussed as well as a general desire for additional time to be incorporated into programs. In reference to Perky Duck as used in an on-line delivery program, participant HYB2 stated the opinion,

> I'm sure it's far easier for the teacher than to go through paper braille. So that increases the ability of the teacher to be responsive and my instructor was extremely responsive with quick turnaround and great guidance. And that would be a good bit more difficult without the assistive technology (Perky Duck) realistically. . . . If I were teaching (a braille course), I would use Perky Duck. Given the frustrations that I had with it, I'd still use it. I think that it certainly more than makes up for the negative.

Participant HYB4 made this similar observation,

> The instructor could get right back to me with corrections and point out my mistakes at which point I would go back on the document and see where I had made my mistakes and chide myself.

With regard to the convenience of the on-line environment, participant HYB2 stated,

> Well, given the on-line environment, I could time my work when it suited me and that was very nice. . . . And the assignments were all put on (on-line) at once so I could do them at my own pace . . . I got most if not all of them in early.

Participant HYB2 made this statement regarding the length of literary braille courses,

> I think that the course should be at least one more credit hour.

In the context of perceived mental demand, participant HYB5 said,

> . . . I really believe that it should be a 3 semester course 'cause I just think it went too fast . . . well, I still haven't mastered last week, I'm not ready for this week.

Theme 4 – Mental Effort Attributed to Braille Code Complexity: Comparisons With Foreign Language Learning

Within this thematic category, participants described the increasing perceived mental effort necessary as braille lessons progressed and built upon each other into the full literary braille code. A few of the participants who are proficient in foreign languages mentioned some parallels with the process of learning literary braille. With regard to increasing perceived mental effort, participant MPB1 stated this opinion,

> . . . in one lesson we picked up, I don't even know how many contractions, but it was all of the dot-5, dot 4-5 and dot 4-6 contractions. So, maybe like 20 or 30 contractions in one lesson.

Similarly, participant MPB4 said,

> . . . you are concentrating so much on remembering where your fingers go, but by the end, you're concentrating on the planning ahead, the getting ready to do it by looking over what you're going to type and getting it all contracted and following the rules.

Participant MPB5 made this comparison with learning a foreign language,

> I don't think it had anything to do with the kind of technology we were using. I think it is totally exclusive linguistics and memorization.

With regard to the perceived mental effort needed to learn a foreign language participant HYB5 stated,

> I think that it takes a lot of the same mental capacities that you'd need to learn a foreign language, definitely. You are using a lot of the same skills. You know, you are having to memorize different symbols and yes it's like learning a different language, for sure. . . . It hasn't become fully automatic yet, but I'm still working on the dot-5s and the ending stuff. I can do a lot of it, but those last lessons I am still memorizing.

Theme 5 – Time pressure for Lesson Completion Attributed to Extraneous (Lifestyle) Factors Rather Than Technology

Within this thematic category, participants indicated that a variety of extraneous factors were responsible for perceived temporal demand encountered in completing braille lessons. The type of braille assistive technology devices used were not believed to have any impact in regard to this. With regard to stress levels encountered, participant MPB2 stated this opinion,

> . . . some lessons were harder than others, but other courses are obviously going on at the same time and when there's a fairly difficult braille assignment to do at the same time as I was trying to study for a test or complete a paper or some other project, that's kind of when the stress level would go up.

Participant HYB1 made this similar statement,

> Especially if I was doing it late at night and I was tired and I found that I was making a lot of mistakes. . . . I was taking a transcribing course at the same time. So when I started to get heavy on both loads, I would rush sometimes. . .

Concerning perceived temporal demand participant HYB3 said,

> . . . there were a couple of weeks when I had a lot of stuff going on with IEPs that work became a priority.

Theme 6 – Muscle Memory Typical With Using the Perkins Does Not Easily Transfer to Perky Duck

In this thematic category, participants made comments about the more positive impact of the Perkins Braillewriter on muscle memory in learning literary braille compared to using Perky Duck. Participant MPB5 stated this opinion,

> I think probably most of the people in my course at the end of the course preferred the Perkins (to Perky Duck) because it is a much more mechanical process so that it's easier to memorize.

Similarly, participant HYB2 said,

> I am not a print typist . . . I didn't get any feel from the keys (Perky Duck) . . . my muscle memory wasn't even the same because the feel, the responsiveness was much different. I might not have felt that way if I had done Perky Duck first.

CHAPTER VI

DISCUSSION AND IMPLICATIONS

This chapter presents and interprets the findings of this study, discusses the limitations of the research design, and suggests areas of possible future research with regard to cognitive load theory and braille assistive technology. It also presents the implications of the research for instructional design in literary braille instruction.

Mental Demand and Frustration Levels in the MPB and HYB Groups

There was no statistically significant difference between the MPB and HYB groups in the study by levels of mental demand and frustration. It was expected that HYB participants who submitted a large number of braille lessons using the Perky Duck brailler emulator would have markedly reduced ratings on the mental demand and frustration scales of the NASA-TLX instrument (see Table 1 in Chapter IV), but this was not the case. The interview transcript information from participants, however, appears to run contrary to the statistical results in that some participants made strong statements in favor of using Perky Duck over the Perkins Braillewriter. These qualitative findings would seem to indicate that participants who used both manual and electronic braille assistive technology devices experienced high levels of element interactivity (Chandler & Sweller, 1996) in the process of using two or more braille assistive technology devices while learning literary braille. Considering that HYB participants had fairly high expectations for development of proficiency on both the Perkins Braillewriter and Perky Duck compared to MPB group participants who generated braille primarily on the Perkins Braillewriter alone, this in itself had the potential for creating higher levels of extraneous cognitive load. Sweller (1994) posited that, in situations of this nature, different elements have varying levels of interaction in the learning process. Few of the respondents in the HYB group made negative associations with having to learn to use Perky Duck. This suggests that germane cognitive load (Van Geven, Paas, & Tabbers, 2006) was positively impacted and that high levels of expertise with this device were attained fairly quickly.

The independent variable prior braille experience was found to be relevant in the MANOVA model with mental demand and frustration as dependent variables on the NASA-TLX instrument (see Table 5 in Chapter IV). Participants with prior experience in literary braille reported significantly less mental demand and frustration than participants who began their programs with no previous experience with literary braille. Previous braille experience usually took the form of a formal course in braille at the university level in a prior degree, independent work in a braille course from the *Hadley School for the Blind* or a braille transcriber course, current employment as a teacher of students with visual impairments on state department of education temporary certificates/licenses, or long-term work with a family member who used braille as a primary literacy medium. It is not surprising that these teachers in training would have an advantage over their colleagues who had no previous experience with literary braille. What is surprising is that approximately 30% of the sample in the study fell into the category of having had prior braille experience. This is an important factor for the study as many of these participants would have acquired considerably increased expertise in literary braille prior to taking their courses, thereby, reducing much of the element interactivity experienced by participants new both to braille and to braille assistive technology devices. Coming into a braille course with prior experience would have positively impacted germane cognitive load by reducing extraneous cognitive load levels (Kirschner, 2002). This reduction in extraneous cognitive load in approximately one-third of the sample might also explain to some degree why there were no statistical differences between the MPB and HYB groups on any measures.

The independent variable college term was found to be relevant in the MANOVA model with mental demand and frustration as the dependent variables (see Table 6 in Chapter IV). Posthoc statistical contrasts determined that Summer 2008 and Fall 2008 were significant in comparison with Winter/Spring 2009. There appears to be a linear trend of increased levels of mental demand and frustration reported by the participants as the terms progressed. Lower ratings on both dependent variables reported by participants in the summer programs may be attributable to the compressed course design which necessitated fairly focused study with immediate feedback from instructors during several days of the week.

Programs during the Summer 2008 term were, for the most part, face-to-face delivered; however, delivery type as an independent variable was not significant in any of the MANOVA tests. Some of the programs in the Winter/Spring 2009 term consisted of two terms/semesters in length incorporating elements of both literary and Nemeth Braille instruction. This type of instructional delivery arrangement might have the effect of lessening levels of mental demand and frustration as participants were given considerably more time to develop expertise in literary braille and with braille assistive technology devices. However, the quantitative results indicate that mental demand and frustration levels were the highest in the Winter/Spring 2009 term. Also, qualitative data from participants during Winter/Spring 2009 indicate fairly high levels of mental demand and frustration despite having literary braille instruction spread over two semesters/terms.

Temporal Demand and Effort Levels in the HYB and MPB Groups

It was anticipated that temporal demand and effort levels would be lower for the HYB than for the MPB group. While temporal demand mean scores from the NASA-TLX instrument are slightly lower for the HYB group (see Table 7 in Chapter IV), there was no statistical difference between the MPB and HYB groups on these two dependent variables. The interview information from participants seems to provide data suggesting that effort levels were reduced when producing braille on Perky Duck as compared to the Perkins. A resonant theme in this regard was that, while producing braille on the Perkins, participants experienced high levels of element interactivity (Sweller, 1994) in having to be cognitively aware of the manual operation of the Perkins, the location of the cursor head on the line of a page as well as the proper usage of the rules of contracted literary braille. The most salient concern was the awareness that, if an error was made, erasure was usually not an option requiring the participant to start over.

The level of mental effort needed to produce braille on Perky Duck appears to have been very much reduced as participants would produce their braille lessons, save them as electronic files, and correct errors later. Several comparisons were made between using Perky Duck and a typical computerized word processor for drafting print documents. Increased mental demand was reported by both MPB and HYB participants in producing braille on the slate and stylus. It appears that element interactivity was a contributing factor as sighted teachers in training had to visually and physically reverse the braille cells using this device.

Temporal demand from the qualitative perspective was attributed mostly to factors not directly related to learning literary braille in both MPB and HYB groups. These included the pressures of other classes, professional and family responsibilities.

The independent variable prior braille experience was found to be relevant in the MANOVA model with temporal demand and effort level as the dependent variables from the NASA-TLX instrument (see Table 11 in Chapter IV). As participants with previous braille experience reported significantly reduced levels of temporal demand and effort level, it is reasonable to conclude that extraneous cognitive load levels were reduced by higher levels of expertise in the literary braille code and the use of braille assistive technology devices; thus, these participants had made the transition from extraneous to germane cognitive load by engaging existing short-term memory resources to accomplish the tasks presented to them in their braille lessons (Kirschner, 2002).

The independent variable college term was found to be relevant in the MANOVA model with temporal demand and effort level as the dependent variables (see Table 12 in Chapter IV). Post hoc statistical contrasts revealed that Summer 2008 was statistically different when contrasted with Winter/Spring 2009. As was mentioned earlier, lower NASA-TLX ratings on both dependent variables reported by participants in the Summer 2008 term may be attributable to the compressed course timeframes which necessitated fairly focused study with immediate feedback from instructors during several days of the week. As reported by participants interviewed during this term, this compressed instructional design format allowed for very intensive braille instruction with immediate face-to-face feedback from instructors. Some participants mentioned that they preferred this format to taking a braille course during the Fall or Winter/Spring terms because of reduced course loads and professional responsibilities allowing more time to focus solely on literary braille. Although braille instruction occurred for several days per week and assignments were completed on most evenings, the NASA-TLX ratings on temporal demand and effort for the Summer 2008 term appear to have been minimized in comparison to the Winter/Spring 2009 term. This immersion type of experience in literary braille instruction appears to be similar to an instructional design approach in which separately conveyed components of a learning task appeared to reduce intrinsic (task-related) cognitive load elements (Gerjets et al., 2004).

Physical Demand and Own Performance Levels in the MPB and HYB Groups

It was anticipated that the physical demand and own performance ratings associated with the Perkins Brailler in the MPB group would be higher compared to levels reported by participants in the HYB group who at least 50% of the time used the computerized Perky Duck brailler emulator to prepare braille lessons. There was, in fact, little difference between the MPB and HYB groups on these two dependent variables in the MANOVA analysis (see Table 13 in Chapter IV). Interview data from participants in the MPB and HYB groups seemed to be in alignment with the quantitative results. It appears that there is no difference associated with physical demand or own performance ratings while learning to perform 6-key entry brailling on either the Perkins Braillewriter or using the computerized Perky Duck brailler emulator. Minimal extraneous cognitive load impact appears to be associated with these devices as measured by the physical demand and own performance rating scales of the NASA-TLX instrument.

The independent variable prior braille experience was found to be relevant in the MANOVA model with physical demand and own performance as the dependent variables from the NASA-TLX instrument (see Table 17 in Chapter IV). Participants with prior braille experience reported significantly lower levels of physical demand and higher levels of perceptions of own performance than participants without prior braille experience. This indicates that participants with prior braille experience had developed considerable levels of expertise with regard to the braille code and braille assistive technology devices prior to starting their courses and had begun to make the transition from extraneous to germane cognitive load by engaging existing short-term memory resources to accomplish literary braille lessons (Kischner, 2002). This is of particular interest when considering the increased degree of familiarity participants with prior braille experience had with the 6-key entry technique required for both the Perkins Braillewriter and Perky Duck production of braille.

Literary Braille Proficiency in the MPB and HYB Groups According to the NLBCT – Practice Test Protocol Standard

It was anticipated that participants in the HYB group would achieve higher levels of proficiency in the literary braille code (NLBCT practice test protocol standard) than participants in the MPB group on braille writing and braille proofreading tasks. Although mean scores from participants in the MPB group were slightly higher than the mean scores from the HYB group on both tasks, these differences between the technology groups were not statistically significant (see Table 19 in Chapter IV). To earn a passing grade on the NLBCT practice test, participants had to pass both the braille writing and the proofreading sections of the test with scores of approximately 95%. The mean average score for MPB participants on the braille writing section was 90.0% as compared with a mean average score of 86.6% for participants in the HYB group. The mean average score for MPB participants on the braille proofreading section was 85.4% as compared with a mean score of 83.6% for participants in the HYB group. Of 30 MPB participants who completed the NLBCT practice test protocol, 14 passed and 16 did not pass the test. Of 42 HYB participants who completed the NLBCT practice test protocol, 11 passed and 31 did not pass the test.

Demonstration of Braille competency on the Colorado Braille Proficiency Test requires that examinees produce hard-copy braille on a Perkins Braillewriter as opposed to the use of electronic devices, such as the BrailleNote notetaker or Perky Duck brailler emulator (T. Anthony, personal communication, November 13, 2005). Similarly, examinees that take the National Literary Braille Competency Test (NLBCT) for the National Certification in Literary Braille (NCLB) must demonstrate braille proficiency by producing braille transcriptions using both the Perkins Braillewriter and the slate and stylus (International Braille Research Center, n.d.). What is unique to this study is that participants were allowed to use the braille assistive technology device with which they were most familiar (either the Perkins Braillewriter or Perky Duck) to complete the NLBCT practice test protocol. Special adjustments in the grading process were made by the National Blindness Professional Certification Board NBPCB test graders to accommodate for either manual or electronic production of braille and to minimize the impact of any bias that tactual braille readers grading the tests might have had when encountering the braille drafts produced electronically on the Perky Duck brailler emulator.

As no statistical differences were detected between technology groups or by any other independent variable in the MANOVA model this indicates that during the course of studying literary braille participants appear to have acquired highly developed schemas (Paas et al., 2003). These constructs of long-term memory appear to be permanent in duration with regard to the type of braille assistive technology device used on the braillewriting task. Mean scores on the braille proofreading task for the MPB and HYB groups were slightly lower than the braille writing mean scores (see Table 19 in Chapter IV). This pattern was consistent throughout the statistical analysis. It does not appear that the type of braille assistive technology device used by sighted teachers in training has a noticeable impact upon braille proofreading skill acquisition.

A number of coordinators of professional preparation programs elected to use the NLBCT practice test protocol as a component of the final exam for their students during the study. When presented with the grading criteria used by NBPCB for this test, several of the coordinators expressed differences of opinion with regard to “embedded errors” in the braille proofreading section of this test. In each of these situations, the program coordinators adhered to their own criteria for grading purposes. This feedback from program coordinators raises some questions about the validity of the NLBCT practice test protocol with regard to what is considered in the field to be appropriate instruction concerning the use and implementation of formatting rules of literary braille. These opinions are similar to concerns raised by Allman and Lewis (1996) in a content validation of the NLBCT.

Literary Braille Proficiency in the MPB and HYB Groups
According to the NCLB Test Standard

It was anticipated that participants in the HYB group would achieve higher levels of proficiency in literary braille code (NCLB test standard) scores than participants in the MPB group on braille writing tasks using the Perkins Braillewriter and slate and stylus, a braille proofreading task, and multiple choice questions on background knowledge of literary braille. Although mean scores from participants in the MPB group were slightly higher than the mean scores from the HYB group on all four tasks, these differences between the technology groups were not statistically significant (see Table 25 in Chapter IV).

To earn a passing grade on the NCLB test, participants were required to pass all four sections with scores of approximately 95%. This expectation level was required for each section of the test as scores are not averaged across sections. Overall, there were 22 participants in the HYB group and, of that number, 3 passed and 19 did not pass. Overall, there were 17 MPB participants and, of that number, 8 passed and 9 did not pass.

Although the majority of participants who took the NCLB test did not pass, it is interesting to consider the scores by different sections and by the different independent variables; technology group (see Table 25 in Chapter IV), age level (see Table 26 in Chapter IV), program delivery type (see Table 27 in Chapter IV), previous education level (see Table 28 in Chapter IV), prior braille experience (see Table 29 in Chapter IV), and college term (see Table 30 in Chapter IV). By viewing the scores by section and by independent variable, it appears that participants in the sample are very similar to each other in acquisition of proficiency in literary braille skills according to the NCLB standard. Considering the variations that exist across teacher preparation programs as observed by Amato (2000) in terms of semester/term length, textbooks, and varying emphases upon different types of braille assistive technology devices, the similarity of the pattern of mean scores across each of the MANOVA independent variables is worthy of note. From the outset of this study, staff at NBPCB emphasized the importance of allowing participants to have 1 to 2 months between the time they finished their literary braille courses and taking the NCLB test to develop expertise on the slate and stylus. In most cases, this was possible. The mean scores of 44.65 out of 50 possible points for MPB participants and 41.81 out of 50 possible points for HYB participants are viewed as a relatively high level of proficiency on this braille assistive technology device which the interview data indicate was fairly challenging to participants in both technology groups.

For participants that took the NCLB test, it appears that high levels of element interactivity (Sweller, 1994) associated with the intrinsic and extraneous cognitive load factors of learning literary braille were, for the most part, transferred to germane cognitive load. Participants were apparently able to form complex schemas (Paas et al., 2003) in long-term memory to efficiently combine the requisite skills to produce braille on two very different manual braille assistive technology devices using the rules of the literary braille code.

Questions arose from participants and instructors about the process used for circling embedded errors in the braille proofreading section of the NCLB test. It appears that this method of demonstrating the ability to proofread literary braille is not widely used across all personnel preparation programs which may call into question the validity of the NCLB test in evaluation of this braille competency.

Attrition in the MPB and HYB Groups

Chi-square tests of association were conducted to assess rates of attrition in the sample. It was anticipated that rates of attrition would be higher in the MPB group as compared to the HYB group. However, the independent variable technology group was not found to be associated with attrition (see Figure 1 in Chapter IV). The independent variables gender (see Figure 2 in Chapter IV), age level (see Figure 3 in Chapter IV), program delivery type (see Figure 4 in Chapter IV), previous education level (see Figure 5 in Chapter IV), previous braille experience (see Figure 6 in Chapter IV), school (see figure 7 in Chapter IV), and college term (see Figure 8 in Chapter IV) were also not found to be associated with attrition rates.

The rate of attrition for the MPB group was 9% and for the HYB group was also 9%. These attrition rates were considerably less than anticipated for the entire sample. However, these percentages reflect only reported information and the actual percentages may have been higher.

Limitations of the Study

A primary limitation to this study is the use of the NASA-Task Load Index scales to infer quantities of perceived cognitive load in the participants. Cognitive load is theoretically a construct of short-term memory which cannot be measured directly. The rating scales of the NASA-Task Load Index used in this study make use of participant self-reporting with regard to quantities of perceived mental demand, physical demand, temporal demand, frustration level, effort level, and own performance upon completion of literary braille tasks. At best, the NASA-Task Load Index instrument allows for only subjective reporting upon a few aspects of conscious short-term memory. From participant reported ratings, it was then necessary for the researcher to infer the type and extent of perceived cognitive load. An ameliorating factor of the research design was the extensive exposure time that participants had to the computerized instrument usually over the length of a full semester, quarter, or trimester. Due to this frequent exposure to the instrument, participants developed high levels of expertise with regard to entering NASA-Task Load Index ratings upon completion of tasks. Fortunately, the Internet webpage was reliable and accessible for the entirety of the study and did not present any known access issues for the participants.

As this research is observational in nature and not purely an experimental design, the intent was to preserve as much ecological validity as possible within each personnel preparation program and with regard to the unique characteristics of each participant. As noted by Amato (2000), there was considerable variation within programs in Canada and the United States. This lack of consistency across 18 different personnel preparation programs created some issues with regard to drawing generalizable conclusions using the same instrumentation across the sample. The assumptions of MANOVA; normality, homogeneity of variance, and independence were not tested in this study due to the logistical difficulties encountered in running these analyses on such a large volume of statistical tests.

Although the National Literary Braille Competency Test for National Certification in Literary Braille has been pilot tested and validated (Waugh, 2008), the National Literary Braille Competency Test – practice test protocol is not a validated instrument. Its braille writing and braille proofreading sections were, however, developed by the National Blindness Professional Certification Board based upon the structure and format of the NCLB certification test components.

Finally, of 30 college/university programs approached for potential participant recruitment, only 18 programs participated in this study. From those 18 programs, only 94 literary braille students chose to participate in the study. According to class sizes mentioned by some coordinators, there were approximately 45 or more literary braille students that elected not to participate in the study from among the 18 participating schools.

Implications and Recommendations for Future Research

No statistically significant differences in perceived cognitive load between MPB and HYB technology groups were determined by this study. However, qualitatively it appears that differences do exist and that several participants who used both the Perkins Braillewriter and the computerized Perky Duck brailler emulator had a definite preference for Perky Duck. What may have been a confound in the quantitative measures between the MPB and HYB groups is that the MPB groups tended to focus on using both the Perkins Braillewriter and the slate and stylus where participants in the HYB group in many cases needed to demonstrate proficiency the Perkins Braillewriter, the slate and stylus, and the computerized Perky Duck brailler emulator. It would appear that using Perky Duck did not seem to increase extraneous cognitive load levels for HYB participants from either the quantitative or qualitative measures. This would suggest that, for sighted teachers in training, the use of Perky Duck or other computerized brailler emulators may be able to facilitate efficient learning of literary braille whether used as the only braille assistive technology device or in combination with the Perkins

Braillewriter and slate and stylus. As teacher training programs increasingly adopt distance delivery components, follow-up research on the abilities of teachers to efficiently serve their students who read braille after completion of training programs may help determine the efficacy of use of both manual and electronic assistive technology devices in the training process.

Distance and hybrid program delivery participant statements about the efficiency and ease of sending email attachments of braille assignments via the Internet as opposed to relying upon the postal system were particularly strong. Also, the ability to receive immediate feedback from instructors via the Internet was very highly regarded. The interview data clearly indicated that, for participants who had busy professional and social lives, Perky Duck was much preferred over the Perkins Braillewriter. Participants conveyed that braille documents could be saved as electronic files and later completed or edited for errors using the same methods for generating print documents on typical computerized word processors.

The finding that previous braille experience was relevant in three separate MANOVA tests of data obtained from NASA-Task Load Index rating scales was unexpected. Increasing numbers of teachers in training appear to have the perception that proficiency with the Perkins Braillewriter for state and national level certification is higher than that acquired upon completion of a literary braille training program at the college or university level. It seems that, in light of the increased usage of electronic devices by students who read braille (Farnsworth & Luckner, 2007; Kelly, 2001), the field may wish to reconsider the amount of emphasis currently placed upon the Perkins Braillewriter for teacher training purposes. Further research is needed on the impacts of electronic braille assistive technology devices upon students who read braille at all age levels and in various educational settings.

High levels of frustration, mental demand, and physical demand reported by sighted teachers in training while using the slate and stylus for braille production raises the question of whether competency with this assistive technology device should continue to be a component of teacher training programs. Allman and Lewis (1996) found that proficiency in use of the slate and stylus should not be considered a valid competency in the teacher certification process. Despite the relatively high performance levels of participants on the slate and stylus section of the National Literary Braille Competency Test for National Certification in Literary Braille, the field needs to consider whether or not competency using this device is a profitable use of instructional time in a literary braille course.

Lower than anticipated scores from both MPB and HYB groups on the multiple choice section of the National Literary Braille Competency Test for National Certification in Literary Braille suggest that there may be some instructional gaps with regard to what is considered appropriate background knowledge by the field and what is tested. It would seem that there is a fairly large amount of variation in what is considered to be important within this competency item. Perhaps future research could help to efficiently categorize what, in fact, is an appropriate body of background knowledge for pre-service teachers learning literary braille.

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APPENDIX A

DATA COLLECTION WEBPAGE

UNIVERSITY *of*
NORTHERN COLORADO

The Cognitive Load Impacts of Assistive Technology Devices Used by Sighted Teachers in Training During Literary Braille Instruction

Lead Investigator	**Research Advisors**	
Charles R. Farnsworth Jr. *Department of Graduate Interdisciplinary Studies* Telephone (970) 405-2293 charles.farnsworth@unco.edu	Dr. Jeffrey Bauer *Department of Educational Technology* Telephone (970) 351-2368 jeffrey.bauer@comcast.net	Dr. Jamis Perrett *Department of Applied Statistics and Research Methods* jamis.perrett@unco.edu

Consent Form (word doc)
Please read this document completely. By inserting your name and date on this form and submitting it as an email attachment to the lead investigator at charles.farnsworth@unco.edu you provide informed consent for participation in this research study.

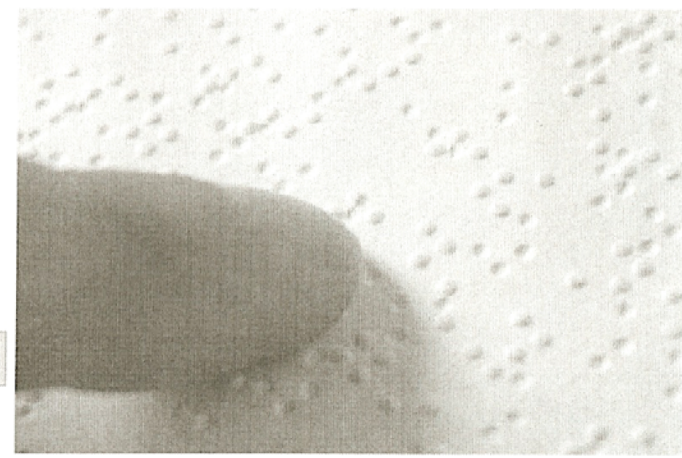
Personal Information Sheet (word doc)
To be emailed to the Lead Investigator after submitting the consent form

Instructions (pdf file)
View the Nasa TLX Tutorial
PRACTICE using the Nasa TLX

Ready? **Take the Nasa TLX**

EBAE '02 Link

This is a link to the English Braille American Edition 1994 with the 2002 revision for use as a reference during the NCLB practice test



APPENDIX B

IRB CONSENT FOR PARTICIPATION FORM

UNIVERSITY of NORTHERN COLORADO

Informed Consent for Participation in Research
University of Northern Colorado

Project Title: The Cognitive Load Impacts of Assistive Technology Devices Used by Sighted Teachers in Training During Literary Braille Instruction

Researcher: Charles Farnsworth Jr., Doctoral candidate, Department of Graduate Interdisciplinary Studies

Phone Number: (970) 405-2293, email: Charles.Farnsworth@unco.edu

Research Advisor: Jeff Bauer, Ph.D., Department of Educational Technology

Phone Number: (970) 351-2368, email: Jeff.Bauer@unco.edu

With the help of Dr. Bauer, my research advisor, I am studying the cognitive load impacts of braille assistive technology devices such as the Perkins Braillewriter and Perkins emulators such as Perky Duck in the learning of literary braille by sighted teachers in training. Your participation will involve logging on to an Internet website hosting an electronic version of the NASA-Task Load Index (TLX) cognitive load instrument. This instrument consists of six separate rating scales involving cognitive load measurement which will require only about 10 minutes of your time after you complete each weekly assignment in your literary braille course. **It will be important for you to submit your ratings within 15 minutes of completing each lesson**.

At the conclusion of your course you will take a practice version of the National Literary Braille Competency Test using the assistive technology device on which you learned literary braille (either a Perkins Braillewriter or a Perkins Brailler emulator such as Perky Duck). You will only need to complete the transcription and braille proofreading components of the practice test and it is anticipated that this may take about 3 hours with breaks interspersed. Some participants will be requested to participate in a semi-structured telephone interview with me of about 30 minutes duration. If you are requested to give an interview we will schedule it at a time that is convenient for you.

One to two months after the completion of your literary braille course and the NLBCT – Practice Test, I will arrange a time to administer to you the actual National Literary Braille Competency Test. This will involve (a) the embossing of braille using the Perkins Braillewriter, (b) embossing of braille using the slate and stylus, (c) several paragraphs of braille which you will be required to read and make corrections to, and (d) a multiple choice test dealing with general knowledge about literary braille. The total time allowed for taking the NLBCT is 5 hours, but usually it is administered over an 8 hour time slot with breaks interspersed.

To maximize confidentiality, your electronic responses to the NASA-TLX instrument and the transcribed interviews will be coded with alphanumeric indicators to protect the identities of all participants. These documents will be stored in a secure file cabinet in the researcher's office during the course of the study. Any electronic files stored on computer hard drives will likewise be labeled with alphanumeric indicators to protect the identities of the participants. The list connecting names of participants to alphanumeric indicators will be kept locked in the research advisor's office for 3 years and the written and electronic files of the transcripts will remain in the research advisor's office for 3 years.

To maximize confidentiality with regard to responses you may give on the National Literary Braille Competency Test (NLBCT) and the NLBCT (Practice Test), all test response documents will be designated with alphanumeric indicators similar to those used for the NASA-TLX responses to protect the identities of all participants. Test response documents with these alphanumeric indicators will be sent to National Professional Blindness Certification Board (NPBCB) for grading and the results will be reported to the researcher only. The list connecting names of participants to alphanumeric indicators will be kept locked in the research advisor's office for 3 years.

I foresee no risks to participants beyond those that are normally encountered in daily interaction with faculty members or students in typical higher education settings. The names of participants will not appear in any professional report of this research. Participants who complete NASA-TLX rating scale entries for each consecutive week of their literary braille course will receive a **Texaco gift card worth $10.00** which can be used to purchase fuel, snacks, and services at Texaco and Chevron branded service stations throughout the United States. **If you successfully pass all components of the National Literary Braille Competency Test the National Professional Blindness Certification Board will award you the *National Certification in Literary Braille* credential**. The test administration is usually priced at $250.00, but you will receive this at no charge, whatsoever.

Please feel free to phone me if you have any questions or concerns about this research and please retain one copy of this letter for your records.

Thank you for assisting me with my dissertation research.

Sincerely,

Charles Farnsworth Jr., MSc. Ed. (TVI)
Doctoral Candidate, Department of Graduate Interdisciplinary Studies
University of Northern Colorado
Greeley, Colorado

Participation is voluntary. You may decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact the Sponsored Programs and Academic Research Center, Kepner Hall, University of Northern Colorado, Greeley, CO 80639; 970-351-1907.

_________________________________ ____________________
Participant's Signature Date

_________________________________ ____________________
Researcher's Signature Date

APPENDIX C

PARTICIPANT’S PERSONAL INFORMATION SHEET

UNIVERSITY of NORTHERN COLORADO

The Cognitive Load Impacts of Assistive Technology Devices Used By Sighted Teachers in Training During Literary Braille Instruction

Please fill out this information sheet and submit as an email attachment to Charles.Farnsworth@unco.edu

Participant's Personal Information Sheet

Name:

Age range:

☐ 20-29 years old
☐ 30-39
☐ 40-49
☐ 50-59
☐ Other

Mailing address:
Street: City: State/Province:
Postal or Zip code: Country:
Email address:
Telephone number:

Gender: ☐ female ☐ male

Vision status:
☐ Normal vision without using prescription glasses or contact lenses.
☐ Normal vision with the use of prescription glasses or contact lenses.
☐ Legally blind.
☐ Blind.

Name of the college or university which you are attending:

Street address:

City: State/Province: Country:

My literary braille instruction will take place:
☐ entirely using face-to-face classes in my institution's classrooms
☐ entirely using on-line classes via distance delivery systems such as Blackboard, WebCT, etc.
☐ using a combination of face-to-face and on-line settings

In what literary braille course are you currently enrolled (please provide the course identification number used by your institution):

Date on which this course begins:

Date on which this course ends:

What degree will you receive upon completion of this program?

What certification will you apply for upon completion of this program?

What is the highest degree or diploma that you attained prior to enrolling in this program?

Teaching experience prior to entering this program:
(Please check all boxes that may apply.)

☐ General education ☐ Special Education

☐ Pre-kindergarten – 3rd grade years of experience

☐ 4th grade to 8th grade years of experience

☐ 9th grade to 12th grade years of experience

☐ Higher Education years of experience

☐ Other teaching experience:

Non-teaching experience in the field of education
(Please check all boxes that may apply.)

☐ Certified Braille transcriber years of experience

☐ Paraprofessional years of experience

☐ Other non-teaching experience:

Prior to taking this course did you have any university or college level training in literary braille?

☐ yes ☐ no

Prior to taking this course did you have any training from the Hadley School for the Blind in literary braille or any other similar program?

☐ yes ☐ no

Prior to taking this course did you have any informal training in literary braille such as:

☐ School district in-service presentations

☐ Experience with braille-reading persons such as in a home or school setting

☐ Other informal training (please give some details):

I enrolled in this literary braille course to:
(Please check all boxes that may apply)

☐ fulfill course requirements to become a certified teacher of students who are visually impaired or blind (TVI)

☐ fulfill course requirements to become a certified orientation and mobility specialist (COMS)

☐ fulfill course requirements to become a rehabilitation teacher of persons who are blind or visually impaired

☐ use this as a refresher to hone my knowledge of the literary braille code.

☐ learn literary braille out of personal interest

☐ other (please give some details):

APPENDIX D

NASA TASK LOAD INDEX

Figure 8.6

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

APPENDIX E

NASA-TASK LOAD INDX – INSTRUCTIONS SHEET

UNIVERSITY *of* NORTHERN COLORADO

<u>The Cognitive Load Impacts of Assistive Technology Devices Used by Sighted Teachers in Training During Literary Braille Instruction</u>

Charles R. Farnsworth Jr., Lead Investigator
Jeffrey Bauer, Research Advisor

How To Use the NASA-TLX Rating Scales

First of all, I want to thank you for taking your valuable time to participate in my dissertation research study.

When you open the hotlink on this webpage entitled "Ready? Take the Nasa-TLX" you will be taken to a screen entitled NASA Task Load Index. You will notice a brief three line description about the NASA TLX. Don't worry too much about this if it appears in any way confusing to you.

Beneath the solid dividing line, you will see three fields in a horizontal row entitled "**Name,**" "**Task,**" and "**Date**." Do not place your actual name in the "name" field. Instead, for the sake of confidentiality, place your unique alpha-numeric identifier (which I will assign to you) in the "Name" field.

In the "Task" field, please indicate the lesson you have just completed in literary braille such as "Lesson 1 – braille alphabet" as a brief indicator describing the task.

Place the date that you submit the lesson in the "Date" field. **<u>It is important to make your ratings entries within 15 minutes after you complete each literary braille lesson!</u>**

There are six scales for you to register your impressions of the lesson that you have just completed and these scales will remain the same for every lesson that you complete.

Mental Demand simply means "How mentally demanding was the task?" In the case of our example of learning the braille alphabet, you may feel that the mental demands of the task were very low, very high, or somewhere in between on this rating scale. When you have decided where to place your rating on the scale, simply move your cursor arrow along the horizontal line and left-click with your mouse. A vertical red line will appear on the line at that position and you can adjust its location to the left or to the right by simply moving the mouse pointer in either direction and using the left-click function.

Physical Demand means “How physically demanding was the task?” Reflect on the physical demand of the task of learning, for example, the braille alphabet and place your mark accordingly on the associated scale.

Temporal Demand simply means “time demand.” Answer the question “How hurried or rushed was the pace of the task?” and place your mark accordingly on the associated scale.

Performance refers to “own performance.” Answer the question “How successful were you in accomplishing what you were asked to do?” and place your mark accordingly on the associated scale.

Effort means that you should respond to the question “How hard did you have to work to accomplish your level of performance?” Again, place your mark accordingly on the associated scale.

Frustration means that you should respond to the question “How insecure, discouraged, irritated, stressed, and annoyed were you? This is the last rating scale. Simply place your mark on it as you did in the previous scales then press the “Submit” button at the bottom, center of the page.

If you press the “**Submit**” button and have omitted information in the name, task, or date fields or have not placed a mark on one or more of the rating scales, a red sentence will appear that says

Please ensure name, task, date and all six bars are filled in before clicking 'Submit'

As soon as you have entered information for all scales and in each of the fields for name, task, and date press “Submit” again. You will then see the following prompt:

“Thanks, your form was successfully sent.”

Please go through this sequence within 15 minutes of completing each braille lesson.

Thanks very much for your willingness to participate in my dissertation research study. Feel free to contact me by email or telephone at any time if you have any questions about the study.

Sincerely,

Charles R. Farnsworth Jr.
Doctoral Candidate
Department of Graduate Interdisciplinary Studies
University of Northern Colorado
Charles.Farnsworth@unco.edu 970-405-2293

APPENDIX F

PROCTOR AFFIRMATION FORM – NLBCT PRACTICE TEST

UNIVERSITY *of*
NORTHERN COLORADO

The Cognitive Load Impacts of Assistive Technology Devices Used by Sighted Teachers In Training During Literary Braille Instruction

Lead Researcher: Charles R. Farnsworth Jr.
Doctoral Candidate
Department of Graduate Interdisciplinary Studies
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Proctor Affirmation Form – NLBCT Practice Test Administration

I affirm that the participant ____________________________ was administered the

NCLBT practice test components under the following conditions:

- She/he had no reference materials except for the *English Braille, American Edition, 1994* (EBAE).
- She/he took the test in a private location, sequestered from other persons.
- She/he did not exceed the 3 hour time limit for completion of the test administration.

Proctor's signature: ________________________________

Proctor's professional title: __________________________________

Date of NLBCT practice test administration: ___________________________________

Please return this form with all test items prepared by the participant in the enclosed self-addressed envelope to:

Charles R. Farnsworth Jr.
1208 18th Street
Greeley, CO 80631

Please feel free to contact the researcher with any questions at Charles.Farnsworth@unco.edu or by telephone at 970-405-2293.

APPENDIX G

NLBCT PRACTICE TEST PROTOCOL

UNIVERSITY of
NORTHERN COLORADO

The Cognitive Load Impacts of Assistive Technology Devices Used by Sighted Teachers In Training During Literary Braille Instruction

Lead Researcher: Charles R. Farnsworth Jr.
Charles.Farnsworth@unco.edu

NCLB – Practice Test General Instructions
This examination consists of two sections:

1. Braille writing using a Braille writer or an electronic Braillewriter emulator such as Perky Duck.

2. Proofreading, identifying Braille errors

Test requirements:

- No reference materials are allowed other than English Braille American Edition (EBAE). EBAE can be used for all sections of the test. However, well prepared candidates should not need to rely heavily on EBAE to complete the test.
- A maximum of 3 hours is allowed for completion of both components of this test. (If breaks need to be taken due to fatigue etc, the clock may be stopped while a break is taken and re-started when the break is over.)
- This test must be taken in a quiet, private location with no assistance or interference from other individuals.

Section One: Braillewriter or electronic braillewriter emulator (e.g. Perky Duck)

Please transcribe each passage using a braillewriter or electronic brailler emulator. If using a braillewriter, use a 40-cell Braille line. (If you use an electronic braillewriter emulator, please disregard the 40 cell Braille line instruction. Instead, create your Braille draft just as you would usually do while completing lessons on your electronic braillewriter emulator for your Braille instructor.) Start each passage on a separate Braille page on line 1. Use the maximum space possible on each Braille line without hyphenating (except where a hyphen already exists).

Formatting instructions are indicated in brackets. For example, [center and italicize] might be written before a heading which is to be centered and italicized. Do not transcribe instructions which are given in brackets.

Skip one line between the heading and the following paragraph. Skip a line before and after any list. Start each new list item in cell 1 and start runovers in cell 3. Paragraphs and lists should be single spaced.

If you make a mistake that can't be corrected by adding or erasing one or two dots, or if your correction is tactilely discernible or confusing, take a fresh piece of paper and start over. Erasures that are readily detectable by touch will result in a loss of points. Pen or pencil notes will not be considered by the evaluator when your test is scored.

You will start with a score of 100. One point will be deducted for each error. If the same error is repeated, only one point will be deducted for all occurrences in that particular passage.

Note: Scores are primarily based on accuracy. Speed is only assessed to the extent that candidates complete the test in the given timeframe. It is the candidate's responsibility to check carefully for legibility, formatting, capitalization, and punctuation.

Please note that the actual NCLB examination section will likely contain 2-3 passages to be transcribed. The single passage contained here is a sample only.

Please transcribe the following passage:

[Center and italicize heading]
Omit Needless Words

Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts. This requires not that the writer make all sentences short, or avoid all detail and treat subjects only in outline, but that every word tell. Many expressions in common use violate this principle. Consider the following examples:

used for fuel purposes
used for fuel

this is a subject that
this subject

Her story is a strange one.
Her story is strange.

the question as to whether
whether/the question whether

there is no doubt but that
doubtless/no doubt

-----------------End of section one--------------------

<u>*Section Two: Proofreading*</u>

The text that follows is a print version of the Braille passage that you will proofread for errors in formatting, usage of rules of contracted Braille and spelling. This passage may be used while you proofread the Braille text so as to eliminate confusion between Braille symbols that may have more than one meaning. While proofreading the Braille passage please use a pencil to circle errors. You are <u>not</u> required to make corrections to the Braille passage.

Concise Writing

As the active voice is more concise than the passive, and a positive statement more concise than a negative one, many of the examples given under Rules 14 and 15 illustrate this rule as well.

A common way to fall into wordiness is to present a single complex idea, step by step, in a series of sentences that might to advantage be combined into one.

Macbeth was very ambitious. This led him to wish to become king of Scotland. The witches told him that this wish of his would come true. The king of Scotland at this time was Duncan. Encouraged by his wife, Macbeth murdered Duncan. He was thus enabled to succeed Duncan as king. (51 words)

Encouraged by his wife, Macbeth achieved his ambition and realized the prediction of the witches by murdering Duncan and becoming king of Scotland in his place. (26 words)

(<u>*The Braille document for proofreading is on a separate page.*</u>)

APPENDIX H

SAS CODE FOR RESEARCH QUESTIONS 1-6

SAS CODE FOR RESEARCH QUESTION 1
NASA-TLX Mental Demand and Frustration

```
dm log 'clear';
dm output 'clear';

data h1;
input subject mendem frustra group age delivery edu brlex school term;
cards;
1     3.387248008 2.9395218   2     2     1     2     1     3     2
2     10.67510549 5.316455696 2     2     1     3     1     3     2
3     13.08251289 8.087201125 2     1     1     2     1     3     2
4     9.132749107 7.82538137  2     1     1     2     0     3     2
5     8.108298172 4.273323957 2     2     1     2     1     3     2
6     6.542641606 5.302390999 2     1     1     2     1     3     2
7     8.337808464 7.977240762 2     4     1     2     1     3     2
8     12.64885138 9.80543835  2     2     1     2     1     3     2
9     13.4657759  12.21636193 2     2     1     2     0     3     2
10    17.33239569 14.68510705 2     1     1     2     0     3     2
11    17.98887449 18.65096097 2     3     1     2     0     3     2
12    10.53680263 9.990623535 2     2     1     3     0     3     2
13    11.18846695 8.370839194 2     2     1     3     1     3     2
14    11.25175809 9.043600563 2     1     1     3     0     3     2
15    10.84153774 9.341303329 2     1     1     2     0     3     2
16    13.18917018 8.927566807 2     2     1     2     0     3     2
17    13.71483826 14.59212377 2     3     3     1     0     9     2
18    6.663683246 5.46967566  2     3     3     2     0     9     2
19    3.701179271 2.718814238 2     3     1     3     1     22    2
20    9.35302391  9.489451477 2     2     1     4     1     1     2
21    16.63853727 11.22965642 2     2     1     2     1     1     2
22    16.88818565 12.89146742 2     2     1     3     0     1     2
23    13.04735115 10.09235818 2     3     1     2     1     10    2
24    5.254336615 1.206885004 2     1     1     3     0     10    2
25    17.21987811 11.88935771 2     2     1     2     1     10    2
26    15.16877637 12.59024848 2     3     1     2     0     10    2
27    12.17182372 11.32794187 2     2     1     2     0     10    2
28    12.61134552 7.72620722  2     4     1     2     1     10    2
29    12.88091889 12.82876231 2     3     1     2     0     10    2
30    15.52418046 13.36579033 2     1     1     3     0     10    2
31    14.75855602 6.736990155 2     2     1     2     0     10    2
32    17.69417096 16.25722769 2     3     1     2     0     21    2
33    11.395218   13.57805907 2     3     1     2     0     21    2
34    14.28410689 7.316455696 2     3     1     2     0     21    2
35    14.67597101 14.23888348 2     1     1     2     0     21    2
37    9.789029536 6.877637131 2     3     1     3     1     21    3
38    18.34036568 17.24764687 2     2     1     3     0     21    3
39    16.71488849 16.67972674 2     3     1     2     0     21    3
40    14.17288759 13.87969274 2     2     1     2     0     21    3
41    10.75492264 10.91426395 2     2     3     2     0     18    3
42    12.25316456 7.924050633 2     2     3     3     0     18    3
43    14.4  13.24275668 2     3     3     2     1     12    3
44    4.9395218   4.973277075 2     2     3     3     1     12    3
45    4.680987086 5.376550313 2     2     3     3     1     12    3
51    14.71589311 13.79465541 2     2     1     2     1     4     2
52    17.36708861 15.5161744  2     2     1     2     0     4     2
```

```
53    12.08860759 11.64556962 2     3     1     3     0     4     2
54    16.8009206  12.79759622 2     1     2     0     0     8     2
56    13.96624473 12.0323488  1     3     2     3     0     9     2
57    16.05907173 9.476793249 1     1     2     2     0     9     2
58    14.34599156 5.386779184 1     2     2     3     0     9     2
59    12.02062822 1.674636662 1     4     2     3     0     11    2
61    11.78246601 8.858884201 1     3     2     1     0     11    2
62    11.51547117 14.83737693 1     1     2     2     0     11    2
63    11.05071564 11.33531894 1     3     2     2     0     11    2
65    18.22225829 12.78769519 1     2     2     0     0     11    2
66    13.6954993  11.36867089 1     1     2     2     0     11    2
67    14.36912018 9.290201594 1     1     2     2     1     11    2
68    14.22995781 12.48476324 1     1     2     3     0     19    3
69    15.50687006 17.53759602 1     1     2     3     0     19    3
70    19.75503985 18.01336146 1     1     2     3     0     19    3
71    17.08235662 15.88060634 1     3     2     2     0     19    3
72    15.07863445 16.76895538 1     2     2     2     0     19    3
73    16.33088503 13.61962807 1     2     2     2     0     13    1
75    17.12517581 16.31223629 1     5     2     2     0     13    1
77    12.40350055 6.899515549 1     3     2     2     0     13    1
78    6.082278481 2.569971871 1     4     2     2     1     13    1
79    15.49929677 13.94374121 1     2     3     2     0     2     2
80    10.88406671 6.278882861 1     2     3     2     0     2     2
81    17.71800281 15.86568214 1     3     3     3     0     2     2
83    4.352242538 5.129767872 1     2     2     2     1     16    1
84    14.35238461 13.06354686 1     2     2     2     0     16    1
85    2.991092358 1.528363807 1     1     2     2     0     16    1
86    13.51489579 12.94207902 1     3     2     3     0     16    1
87    8.716276691 7.885180923 1     3     2     2     1     16    1
88    14.5907173  14.91139241 1     .     2     .     .     16    1
89    5.885436645 6.529855517 1     2     1     3     0     14    2

;
run;

proc print data=h1;
run;
quit;

ods rtf style=journal;
/****************************profile plot for
group**********************************/
data profile_group;
set h1;
DV="mendem"; avg=mendem;output;
DV="frustra";avg=frustra;output;
run;
proc sort data=profile_group;
by group DV;
run;

proc means data=profile_group mean;
by group DV;
var avg;
output out=a mean=mean;
run;
```

```
proc gplot data=a;
plot mean*DV=group;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
/****************************************profile plot for
age************************************/
data profile_age;
set h1;
DV="mendem"; avg=mendem;output;
DV="frustra";avg=frustra;output;
run;
proc sort data=profile_age;
by age DV;
run;

proc means data=profile_age ;
by age DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=age;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

/****************************************profile plot for delivery
************************************/
data profile_delivery;
set h1;
DV="mendem"; avg=mendem;output;
DV="frustra";avg=frustra;output;
run;
proc sort data=profile_delivery;
by delivery DV;
run;

proc means data=profile_delivery;
by delivery DV;
var avg;
output out=a2 mean=mean;
run;

proc gplot data=a2;
plot mean*DV=delivery;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

/*****************************profile plot for
brlex************************************/
data profile_brlex;
```

```
set h1;
DV="mendem"; avg=mendem;output;
DV="frustra";avg=frustra;output;
run;
proc sort data=profile_brlex;
by brlex DV;
run;

proc means data=profile_brlex mean;
by brlex DV;
var avg;
output out=a3 mean=mean;
run;
goptions reset=all;
symbol1 v=star i=join;
symbol2 v=circle i=join;
symbol3 v=square i=join;
proc gplot data=a3;
plot mean*DV=brlex;
run;
quit;
/*************** means and std of mendem and frustra for each
independent variable****************************/

proc means data=h1 mean std;
class group ;
var mendem frustra;
run;
quit;


proc means data=h1 mean std;
class age ;
var mendem frustra;
run;
quit;

proc means data=h1 mean std;
class delivery ;
var mendem frustra;
run;
quit;

proc means data=h1 mean std;
class edu ;
var mendem frustra;
run;
quit;

proc means data=h1 mean std;
class brlex ;
var mendem frustra;
run;
quit;

proc means data=h1 mean std;
class  term;
```

```
var mendem frustra;
run;
quit;

/*********************************MANOVA
analysis******************************************/

proc glm data=h1;
class  group age delivery edu brlex  term;
model mendem frustra= group age delivery edu brlex  term /nouni;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;
/**********************************brlex - post hoc stepwise
discriminate analysis***************************/
proc stepdisc data =h1 sw sle=.25 sls=.25;
class brlex;
var mendem frustra;
run;
/****************************term - post hoc contrast
analysis****************************************/
proc glm data=h1;
class  group age delivery edu brlex  term;
model mendem frustra= group age delivery edu brlex  term /nouni;
contrast 'summer08 vs fall08 ' term 1 -1 0;
contrast 'summer08 vs winter/spring09 ' term 1 0 -1;
contrast 'fall08 vs winter/spring09 ' term 0 1 -1;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;

data term1;
set h1;
where term ^=2;
run;
proc print data=term1;
run;

proc stepdisc data =term1 sw sle=.15 sls=.15;
class term;
var mendem frustra;
run;

data term2;
set h1;
where term ^=1;
run;
proc print data=term2;
run;

proc stepdisc data =term2 sw sle=.15 sls=.15;
class term;
var mendem frustra;
run;
ods rtf close;
```

SAS CODE FOR RESEARCH QUESTION 2
NASA-TLX Temporal Demand and Effort

```
dm log 'clear';
dm output 'clear';

data h2;
input subject temdem effort group age delivery edu brlex school term;
cards;
1     7.916080638 4.613220816 2     2     1     2     1     3     2
2     10.45241444 12.78715424 2     2     1     3     1     3     2
3     7.051101735 14.88279419 2     1     1     2     1     3     2
4     7.217353673 12.60521476 2     1     1     2     0     3     2
5     3.80684482  9.113924051 2     2     1     2     1     3     2
6     6.655159187 6.829049994 2     1     1     2     1     3     2
7     11.50875847 10.98452883 2     4     1     2     1     3     2
8     11.53774027 14.13736521 2     2     1     2     1     3     2
9     11.87529301 14.94139709 2     2     1     2     0     3     2
10    3.30207845  16.16658853 2     1     1     2     0     3     2
11    13.19876913 19.32030967 2     3     1     2     0     3     2
12    7.740271917 10.43131739 2     2     1     3     0     3     2
13    5.133614627 10.78293483 2     2     1     3     1     3     2
14    8.452883263 12.69807782 2     1     1     3     0     3     2
15    1.448663854 19.58743554 2     1     1     2     0     3     2
16    4.094585091 16.52953586 2     2     1     2     0     3     2
17    11.65611814 16.67194093 2     3     3     1     0     9     2
18    10.61692878 9.657332822 2     3     3     2     0     9     2
19    3.849760179 4.607811317 2     3     1     3     1     22    2
20    7.388654477 10.50164088 2     2     1     4     1     1     2
21    13.58850713 18.1400155  2     2     1     2     1     1     2
22    14.1854196  17.56504923 2     2     1     3     0     1     2
23    10.99859353 14.45147679 2     3     1     2     1     10    2
24    2.405844663 6.357243319 2     1     1     3     0     10    2
25    6.146272855 16.22362869 2     2     1     2     1     10    2
26    11.61861228 14.55461791 2     3     1     2     0     10    2
27    9.044772621 13.31340835 2     2     1     2     0     10    2
28    8.560712611 11.80028129 2     4     1     2     1     10    2
29    9.722222222 14.48663854 2     3     1     2     0     10    2
30    3.341988532 15.96234989 2     1     1     3     0     10    2
31    2.984060009 15.96108767 2     2     1     2     0     10    2
32    15.03047351 18.08641975 2     3     1     2     0     21    2
33    14.99578059 17.61462729 2     3     1     2     0     21    2
34    12.75386779 15.34458509 2     3     1     2     0     21    2
35    4.767932489 15.71892243 2     1     1     2     0     21    2
37    7.336146273 12.5625879  2     3     1     3     1     21    3
38    16.41566591 18.77096181 2     2     1     3     0     21    3
39    14.11492867 17.60297368 2     3     1     2     0     21    3
40    10.40571243 15.79826175 2     2     1     2     0     21    3
41    9.512423816 11.34962494 2     2     3     2     0     18    3
42    7.473980309 13.07172996 2     2     3     3     0     18    3
43    7.529676512 15.22475387 2     3     3     2     1     12    3
44    2.208157525 7.29676512  2     2     3     3     1     12    3
45    6.463367856 5.537655031 2     2     3     3     1     12    3
51    1.479606188 16.37552743 2     2     1     2     1     4     2
52    14.39662447 18.74261603 2     2     1     2     0     4     2
```

```
53    9.23628692  14.01898734 2     3     1     3     0     4     2
54    14.84976346 19.15739675 2     1     2     0     0     8     2
56    9.127988748 16.44866385 1     3     2     3     0     9     2
57    5.161744023 18.14064698 1     1     2     2     0     9     2
58    5.210970464 14.78199719 1     2     2     3     0     9     2
59    10.03469292 10.39943741 1     4     2     3     0     11    2
61    10.59446789 11.35396156 1     3     2     1     0     11    2
62    10.14592124 14.01547117 1     1     2     2     0     11    2
63    7.688425581 13.30354927 1     3     2     2     0     11    2
65    11.10281655 18.79332107 1     2     2     0     0     11    2
66    5.446554149 16.26581408 1     1     2     2     0     11    2
67    9.868104391 16.64697609 1     1     2     2     1     11    2
68    14.06000938 14.45733708 1     1     2     3     0     19    3
69    17.81348047 15.53824516 1     1     2     3     0     19    3
70    19.49835912 19.98007501 1     1     2     3     0     19    3
71    8.504453821 16.77605876 1     3     2     2     0     19    3
72    17.32387163 17.02979159 1     2     2     2     0     19    3
73    13.35989998 16.3830286  1     2     2     2     0     13    1
75    10.84950774 16.15752461 1     5     2     2     0     13    1
77    9.899984373 11.21112674 1     3     2     2     0     13    1
78    1.863572433 11.68073136 1     4     2     2     1     13    1
79    12.26160338 16.4838256  1     2     3     2     0     2     2
80    10.671087   11.22161945 1     2     3     2     0     2     2
81    16.0302391  17.3326301  1     3     3     3     0     2     2
83    4.402250352 4.839818722 1     2     2     2     1     16    1
84    14.30251886 16.18974556 1     2     2     2     0     16    1
85    3.694327239 3.293483357 1     1     2     2     0     16    1
86    13.00473085 15.93785961 1     3     2     3     0     16    1
87    9.015471167 9.723820483 1     3     2     2     1     16    1
89    6.959468099 6.496611686 1     2     1     3     0     14    2
;
run;
proc print data=h2;
run;
quit;

proc means data=h2 mean std;
run;
ods rtf style=journal;
/****************************profile plot for
group***********************************/
data profile_group;
set h2;
DV="temdem"; avg=temdem;output;
DV="effort";avg=effort;output;
run;
proc sort data=profile_group;
by group DV;
run;

proc means data=profile_group mean;
by group DV;
var avg;
output out=a mean=mean;
run;

proc gplot data=a;
```

```
plot mean*DV=group;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
/****************************************profile plot for
age************************************/
data profile_age;
set h2;
DV="temdem"; avg=temdem;output;
DV="effort";avg=effort;output;
if age=. then delete;
run;

proc print data=profile_age;
run;

proc sort data=profile_age;
by age DV;
run;

proc means data=profile_age ;
by age DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=age;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

/****************************************profile plot for delivery
************************************/

data profile_delivery;
set h2;
DV="temdem"; avg=temdem;output;
DV="effort";avg=effort;output;
run;
proc sort data=profile_delivery;
by delivery DV;
run;

proc means data=profile_delivery;
by delivery DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=delivery;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
```

```
quit;

proc means data=h2 mean std;
class group ;
var temdem effort;
run;
quit;


proc means data=h2 mean std;
class age ;
var temdem effort;
run;
quit;

proc means data=h2 mean std;
class delivery ;
var temdem effort;
run;
quit;

proc means data=h2 mean std;
class edu ;
var temdem effort;
run;
quit;

proc means data=h2 mean std;
class brlex ;
var temdem effort;
run;
quit;

proc means data=h2 mean std;
class  term;
var temdem effort;
run;
quit;

/************************************Manova
analysis***************************************************/
proc glm data=h2;
class  group age delivery edu brlex  term;
model temdem effort = group age delivery edu brlex  term /nouni;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;
/************************************* brlex - post hoc stepwise
discriminate analysis*****************************/
proc stepdisc data =h2 sw sle=.25 sls=.25;
class brlex;
var temdem effort;
run;
/********************************** term -  post hoc Contrast
analysis***********************************************/
proc glm data=h2;
class  group age delivery edu brlex  term;
```

```
model temdem effort= group age delivery edu brlex  term /nouni;
contrast 'summer08 vs fall08 ' term 1 -1 0;
contrast 'summer08 vs winter/spring09 ' term 1 0 -1;
contrast 'fall08 vs winter/spring09 ' term 0 1 -1;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;

ods rtf close;

proc sort data=h2;
by age;
run;

proc means data=h2;
by age;
var temdem effort;
run;
```

SAS CODE FOR RESEARCH QUESTION 3
NASA-TLX Physical Demand and Performance

```
dm log 'clear';
dm output 'clear';

data h3;
input subject physdem perform group age delivery edu brlex school term;
cards;
1     0.583684951 1.315049226 2     2     1     2     1     3     2
2     9.744491327 5.152367557 2     2     1     3     1     3     2
3     7.137834037 2.90201594  2     1     1     2     1     3     2
4     7.717191388 6.213350644 2     1     1     2     0     3     2
5     7.435536803 3.138771683 2     2     1     2     1     3     2
6     3.583940673 3.440736479 2     1     1     2     1     3     2
7     5.783147935 5.44815241  2     4     1     2     1     3     2
8     12.38631036 6.085325832 2     2     1     2     1     3     2
9     6.320909517 3.989685888 2     2     1     2     0     3     2
10    16.01969058 2.664478825 2     1     1     2     0     3     2
11    18.08820699 1.161498407 2     3     1     2     0     3     2
12    4.156118143 6.007969995 2     2     1     3     0     3     2
13    4.812470699 4.507735584 2     2     1     3     1     3     2
14    7.665260197 4.678856071 2     1     1     3     0     3     2
15    1.984294421 1.747538678 2     1     1     2     0     3     2
16    10.7278481  3.444092827 2     2     1     2     0     3     2
17    13.09423347 8.255977496 2     3     3     1     0     9     2
18    5.302817202 2.402506073 2     3     3     2     0     9     2
19    0.732446175 2.224386022 2     3     1     3     1     22    2
20    7.099742147 3.790436006 2     2     1     4     1     1     2
21    9.023508137 0.932288527 2     2     1     2     1     1     2
22    12.89615565 10.43131739 2     2     1     3     0     1     2
23    8.834974215 3.783403657 2     3     1     2     1     10    2
24    1.787779341 3.704875762 2     1     1     3     0     10    2
25    14.24285045 3.76230661  2     2     1     2     1     10    2
26    12.08626348 3.312236287 2     3     1     2     0     10    2
27    11.01734646 9.687060478 2     2     1     2     0     10    2
28    6.247069855 1.591654946 2     4     1     2     1     10    2
29    9.320206282 1.780356306 2     3     1     2     0     10    2
30    8.677918425 4.384939955 2     1     1     3     0     10    2
31    7.637130802 4.561650258 2     2     1     2     0     10    2
32    13.50054696 5.988435693 2     3     1     2     0     21    2
33    15.25738397 4.801687764 2     3     1     2     0     21    2
34    13.53867792 3.367088608 2     3     1     2     0     21    2
35    14.25835768 10.37217354 2     1     1     2     0     21    2
37    5.139240506 5.904360056 2     3     1     3     1     21    3
38    6.651159436 5.628042843 2     2     1     3     0     21    3
39    12.11171388 3.443841672 2     3     1     2     0     21    3
40    10.07681489 8.88023369  2     2     1     2     0     21    3
41    7.774261603 7.600406313 2     2     3     2     0     18    3
42    7.887482419 2.914205345 2     2     3     3     0     18    3
43    14.52995781 6.665541491 2     3     3     2     1     12    3
44    3.383966245 1.195499297 2     2     3     3     1     12    3
45    4.709116481 5.616928781 2     2     3     3     1     12    3
51    14.74437412 5.23347398  2     2     1     2     1     4     2
52    14.83544304 7.201125176 2     2     1     2     0     4     2
```

```
53    11.83684951 8.165963432 2     3     1     3     0     4     2
54    16.96458253 6.680731364 2     1     2     0     0     8     2
56    7.784810127 3.593530239 1     3     2     3     0     9     2
57    7.710267229 3.068917018 1     1     2     2     0     9     2
58    6.576652602 2.988748242 1     2     2     3     0     9     2
59    9.985935302 10.21847164 1     4     2     3     0     11    2
61    10.91983122 6.151898734 1     3     2     1     0     11    2
62    9.985935302 8.186533052 1     1     2     2     0     11    2
63    8.930255647 7.827417887 1     3     2     2     0     11    2
65    15.60027408 2.682029644 1     2     2     0     0     11    2
66    6.291315049 1.960267229 1     1     2     2     0     11    2
67    9.804969526 3.316143147 1     1     2     2     1     11    2
68    11.96554149 8.049695265 1     1     2     3     0     19    3
69    11.81542789 12.22222222 1     1     2     3     0     19    3
70    1.652601969 12.53398969 1     1     2     3     0     19    3
71    1.403344273 9.810907954 1     3     2     2     0     19    3
72    14.74363892 11.1814346  1     2     2     2     0     19    3
73    11.62541022 10.97327707 1     2     2     2     0     13    1
75    14.86357243 13.37271449 1     5     2     2     0     13    1
77    9.034224098 3.545866542 1     3     2     2     0     13    1
78    3.414908579 2.385724332 1     4     2     2     1     13    1
79    11.91561181 4.987341772 1     2     3     2     0     2     2
80    7.834036568 2.139843279 1     2     3     2     0     2     2
81    17.10759494 6.70745429  1     3     3     3     0     2     2
83    3.161431474 1.995624316 1     2     2     2     1     16    1
84    12.1327196  5.31261987  1     2     2     2     0     16    1
85    3.277074543 1.526019691 1     1     2     2     0     16    1
86    11.97672932 5.163022631 1     3     2     3     0     16    1
87    6.829049994 9.700805524 1     3     2     2     1     16    1
88    7.246132208 3.797468354 1     .     2     .     .     16    1
89    5.965989004 2.480501215 1     2     1     3     0     14    2
;
run;
proc print data=h3;
run;
quit;
ods rtf style=journal;

proc means data=h3 mean std;
run;
data profile_delivery;
set h3;
DV="physdem"; avg=physdem;output;
DV="perform"; avg=perform;output;
run;
proc sort data=profile_delivery;
by delivery DV;
run;

proc means data=profile_delivery;
by delivery DV;
var avg;
output out=a1 mean=mean;
run;
proc means data=h3 mean std;
class group ;
var physdem perform;
```

```
run;
quit;


proc means data=h3 mean std;
class age ;
var physdem perform;
run;
quit;

proc means data=h3 mean std;
class delivery ;
var physdem perform;
run;
quit;

proc means data=h3 mean std;
class edu ;
var physdem perform;
run;
quit;

proc means data=h3 mean std;
class brlex ;
var physdem perform;
run;
quit;

proc means data=h3 mean std;
class  term;
var physdem perform;
run;
quit;
proc gplot data=a1;
plot mean*DV=delivery;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
/********************************************MANOVA
analysis*************************************/
proc glm data=h3;
class  group age delivery edu brlex  term;
model physdem perform = group age delivery edu brlex  term /nouni;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;
/************************************ brlex - post hoc stepwise
discriminate analysis***************************/
proc stepdisc data =h3 sw sle=.25 sls=.25;
class brlex;
var physdem perform;
run;
/********************************* term - post hoc Contrast
analysis********************************************/
proc glm data=h3;
class  group age delivery edu brlex  term;
```

```
model physdem perform = group age delivery edu brlex  term /nouni;
contrast 'summer08 vs fall08 ' term 1 -1 0;
contrast 'summer08 vs winter/spring09 ' term 1 0 -1;
contrast 'fall08 vs winter/spring09 ' term 0 1 -1;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;

proc sort data=h3;
by age;
run;

proc means data=h3;
by age;
var physdem perform;
run;
ods rtf close;
```

SAS CODE FOR RESEARCH QUESTION 4
NLBCT Practice Test

```
dm log 'clear';
dm output 'clear';

data h4;
input subject brlwrite proofread group age delivery edu brlex school
term;
cards;
1      82     74     2      2      1      2      1      3      2
2      88     60     2      2      1      3      1      3      2
3      94     88     2      1      1      2      1      3      2
4      82     86     2      1      1      2      0      3      2
5      86     90     2      2      1      2      1      3      2
6      88     92     2      1      1      2      1      3      2
7      80     76     2      4      1      2      1      3      2
8      92     92     2      2      1      2      1      3      2
9      60     76     2      2      1      2      0      3      2
10     98     94     2      1      1      2      0      3      2
11     98     90     2      3      1      2      0      3      2
12     90     82     2      2      1      3      0      3      2
13     90     94     2      2      1      3      1      3      2
14     88     94     2      1      1      3      0      3      2
15     96     84     2      1      1      2      0      3      2
16     92     90     2      2      1      2      0      3      2
17     100    82     2      3      3      1      0      6      2
18     98     96     2      3      3      2      0      6      2
19     98     92     2      3      1      3      1      22     2
20     98     94     2      2      1      4      1      1      2
22     78     82     2      2      1      3      0      1      2
24     98     98     2      1      1      3      0      10     2
25     94     78     2      2      1      2      1      10     2
26     78     84     2      3      1      2      0      10     2
28     .      92     2      4      1      2      1      10     2
29     62     90     2      3      1      2      0      10     2
30     66     58     2      1      1      3      0      10     2
31     80     74     2      2      1      2      0      10     2
32     98     82     2      3      1      2      0      21     2
34     66     64     2      3      1      2      0      21     2
35     86     68     2      1      1      2      0      21     2
37     86     64     2      3      1      3      1      21     3
38     84     82     2      2      1      3      0      21     3
39     86     66     2      3      1      2      0      21     3
40     82     .      2      2      1      2      0      21     3
42     96     94     2      2      3      3      0      18     3
43     88     92     2      3      3      2      1      12     3
46     84     74     2      4      1      3      0      1      1
48     88     94     2      2      1      3      0      23     1
49     76     84     2      3      1      3      0      23     1
50     90     98     1      2      1      4      0      3      2
53     84     74     1      3      1      3      0      4      2
54     88     84     2      1      2      0      0      8      2
58     96     86     1      2      2      3      0      9      1
59     92     98     1      4      2      3      0      11     2
```

```
61    90    92    1    3    2    1    0    11    2
63    94    86    1    3    2    2    0    11    2
65    94    94    1    2    2    0    0    11    2
66    92    98    1    1    2    2    0    11    2
67    94    90    1    1    2    2    1    11    2
68    94    92    1    1    2    3    0    19    3
71    .     52    1    3    2    2    0    19    3
72    .     78    1    2    2    2    0    19    3
73    78    84    1    2    2    2    0    13    1
74    92    90    1    3    2    2    1    13    1
77    88    92    1    3    2    2    0    13    1
78    90    90    1    4    2    2    1    13    1
79    94    92    1    2    3    2    0    2     2
80    92    80    1    2    3    2    0    2     2
81    84    76    1    3    3    3    0    2     2
82    98    94    1    4    2    3    1    2     2
83    100   86    1    2    2    2    1    16    1
84    98    92    1    2    2    2    0    16    1
85    98    92    1    1    2    2    0    16    1
86    82    88    1    3    2    3    0    16    1
87    94    88    1    3    2    2    1    16    1
88    90    84    1    .    2    .    .    16    1
89    82    78    1    2    1    3    0    14    3
90    98    100   1    2    2    2    1    9     2
91    80    70    1    2    2    3    0    9     2
92    68    78    1    2    2    2    0    9     2
93    82    76    1    4    2    3    0    9     2
94    92    78    1    4    2    2    0    9     2
;
run;
proc print data=h4;
run;
quit;

ods rtf style=journal;

proc means data=h4 mean std;
run;

/****************************profile plot for
group***********************************/
data profile_group;
set h4;
DV="brlwrite"; avg=brlwrite;output;
DV="proofread";avg=proofread;output;
run;
proc sort data=profile_group;
by group DV;
run;

proc means data=profile_group mean;
by group DV;
var avg;
output out=a mean=mean;
run;

proc gplot data=a;
```

```
plot mean*DV=group;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
/****************************************profile plot for
age************************************/
data profile_age;
set h4;
DV="brlwrite"; avg=brlwrite;output;
DV="proofread";avg=proofread;output;
if age=. then delete;
run;

proc print data=profile_age;
run;

proc sort data=profile_age;
by age DV;
run;

proc means data=profile_age ;
by age DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=age;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

/****************************************profile plot for delivery
************************************/
data profile_delivery;
set h4;
DV="brlwrite"; avg=brlwrite;output;
DV="proofread";avg=proofread;output;
run;
proc sort data=profile_delivery;
by delivery DV;
run;

proc means data=profile_delivery;
by delivery DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=delivery;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
```

```
/********************************means and std for each independent
variable********************************/
proc means data=h4 mean std;
class group ;
var brlwrite proofread;
run;
quit;


proc means data=h4 mean std;
class age ;
var brlwrite proofread;
run;
quit;

proc means data=h4 mean std;
class delivery ;
var brlwrite proofread;
run;
quit;

proc means data=h4 mean std;
class edu ;

var brlwrite proofread;
run;
quit;

proc means data=h4 mean std;
class brlex ;
var brlwrite proofread;
run;
quit;

proc means data=h4 mean std;
class  term;
var brlwrite proofread;
run;
quit;
proc sort data=h4;
by age;
run;

proc means data=h4;
by age;
var brlwrite proofread;
run;
quit;
proc glm data=h4;
class  group age delivery edu brlex  term;
model brlwrite proofread = group age delivery edu brlex  term /nouni;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;
ods rtf close;
```

SAS CODE FOR RESEARCH QUESTION 5
NCLB Test

```
dm log 'clear';
dm output 'clear';

data h5;
input subject perkins slate proofread multchoice group age delivery edu
brlex school term;
cards;
1     82    26    76    45    2     2     1     2     1     3     2
2     95    41    83    46    2     2     1     3     1     3     2
3     74    40    80    41    2     1     1     2     1     3     2
5     88    41    89    45    2     2     1     2     1     3     2
8     90    40    84    46    2     2     1     2     1     3     2
9     71    40    85    41    2     2     1     2     0     3     2
10    97    46    95    48    2     1     1     2     0     3     2
11    79    41    85    44    2     3     1     2     0     3     2
12    85    41    85    45    2     2     1     3     0     3     2
13    66    38    78    43    2     2     1     3     1     3     2
15    93    46    89    46    2     1     1     2     0     3     2
16    92    42    91    45    2     2     1     2     0     3     2
19    95    47    92    48    2     3     1     3     1     22    2
24    88    48    92    48    2     1     1     3     0     10    2
25    94    47    88    43    2     2     1     2     1     10    2
28    79    46    82    43    2     4     1     2     1     10    2
29    80    41    91    40    2     3     1     2     0     10    2
32    91    49    85    48    2     3     1     2     0     21    2
34    53    37    66    43    2     3     1     2     0     21    2
35    80    42    86    46    2     1     1     2     0     21    2
48    91    41    88    47    2     4     1     2     0     21    2
54    81    40    86    44    2     1     2     0     0     8     2
57    86    47    91    44    1     1     2     2     0     9     1
58    90    42    92    46    1     2     2     3     0     9     1
59    97    49    97    49    1     4     2     3     0     11    2
61    92    46    89    48    1     3     2     1     0     11    2
63    89    50    94    46    1     3     2     2     0     11    2
65    89    46    94    47    1     2     2     0     0     11    2
66    96    49    95    50    1     1     2     2     0     11    2
67    90    47    92    49    1     1     2     2     1     11    2
79    88    40    86    45    1     2     3     2     0     2     2
80    78    35    83    45    1     2     3     2     0     2     2
81    78    36    81    39    1     3     3     3     0     2     2
82    85    37    95    47    1     4     2     3     1     2     2
90    94    50    95    47    1     2     2     2     1     9     2
91    87    44    86    43    1     2     2     3     0     9     2
92    92    48    88    45    1     2     2     2     0     9     2
93    89    46    94    47    1     4     2     3     0     9     2
94    93    47    90    47    1     4     2     2     0     9     2

;
run;
proc print data=h4;
run;
quit;
```

```
ods rtf style=journal;

proc means data=h5 mean std;
run;
run;
proc print data=h5;
run;
quit;

proc means data=h5 mean std;
run;

/*****************************profile plot for
group************************************/
data profile_group;
set h5;
DV="perkins";avg=perkins;output;
DV="slate";avg=slate;output;
DV="proofread";avg=proofread;output;
DV="multchoice";avg=multchoice;output;

run;
proc sort data=profile_group;
by group DV;
run;

proc means data=profile_group mean;
by group DV;
var avg;
output out=a mean=mean;
run;

proc gplot data=a;
plot mean*DV=group;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;
/****************************************profile plot for
age************************************/
data profile_age;
set h5;
DV="perkins";avg=perkins;output;
DV="slate";avg=slate;output;
DV="proofread";avg=proofread;output;
DV="multchoice";avg=multchoice;output;
run;

proc print data=profile_age;
run;

proc sort data=profile_age;
by age DV;
run;

proc means data=profile_age ;
```

```
by age DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=age;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

/*****************************************profile plot for delivery
***********************************/
data profile_delivery;
set h5;
DV="perkins";avg=perkins;output;
DV="slate";avg=slate;output;
DV="proofread";avg=proofread;output;
DV="multchoice";avg=multchoice;output;
run;
proc sort data=profile_delivery;
by delivery DV;
run;

proc means data=profile_delivery;
by delivery DV;
var avg;
output out=a1 mean=mean;
run;

proc gplot data=a1;
plot mean*DV=delivery;
symbol1 v=star i=join;
symbol2 v=circle i=join;
run;
quit;

proc glm data=h5;
class  group age delivery edu brlex  term;
model perkins slate proofread multchoice = group age delivery edu brlex
term /nouni;
manova h= group age delivery edu  brlex term  / printh printe;
run;
quit;

proc sort data=h5;
by age;
run;

proc means data=h5;
by age;
var perkins slate proofread multchoice;
run;
quit;

ods rtf close;
```

SAS CODE FOR RESEARCH QUESTION 6
Attrition Rates

```
dm log 'clear';
dm output 'clear';

options nodate ls=80;
data h6;
input  subject attrition  gender group age delivery   edu   brlex
school term ;
cards;
1     1     1     2     2     1     2     1     3     2
2     1     1     2     2     1     3     1     3     2
3     1     1     2     1     1     2     1     3     2
4     1     1     2     1     1     2     0     3     2
5     1     1     2     2     1     2     1     3     2
6     1     1     2     1     1     2     1     3     2
7     1     1     2     4     1     2     1     3     2
8     1     1     2     2     1     2     1     3     2
9     1     1     2     2     1     2     0     3     2
10    1     1     2     1     1     2     0     3     2
11    1     1     2     3     1     2     0     3     2
12    1     1     2     2     1     3     0     3     2
13    1     0     2     2     1     3     1     3     2
14    1     1     2     1     1     3     0     3     2
15    1     1     2     1     1     2     0     3     2
16    1     1     2     2     1     2     0     3     2
17    1     1     2     3     3     1     0     6     2
18    1     1     2     3     3     2     0     6     2
19    1     1     2     3     1     3     1     22    2
20    1     1     2     2     1     4     1     1     2
21    1     1     2     2     1     2     1     1     2
22    0     1     2     2     1     3     0     1     2
23    1     1     2     3     1     2     1     10    2
24    1     1     2     1     1     3     0     10    2
25    1     1     2     2     1     2     1     10    2
26    1     1     2     3     1     2     0     10    2
27    1     1     2     2     1     2     0     10    2
28    1     1     2     4     1     2     1     10    2
29    1     1     2     3     1     2     0     10    2
30    1     1     2     1     1     3     0     10    2
31    1     1     2     2     1     2     0     10    2
32    1     1     2     3     1     2     0     21    2
33    0     1     2     3     1     2     0     21    2
34    0     1     2     3     1     2     0     21    2
35    1     1     2     1     1     2     0     21    2
36    0     1     2     4     1     3     0     21    3
37    1     1     2     3     1     3     1     21    3
38    1     1     2     2     1     3     0     21    3
39    1     1     2     3     1     2     0     21    3
40    1     1     2     2     1     2     0     21    3
41    1     1     2     2     3     2     0     18    3
42    1     0     2     2     3     3     0     18    3
43    1     1     2     3     3     2     1     12    3
44    1     1     2     2     3     3     1     12    3
```

```
45    1    1    2    2    3    3    1    12   3
46    1    1    2    4    1    3    0    1    1
47    0    1    2    4    1    2    0    21   2
48    1    0    2    2    1    3    0    23   1
49    1    1    2    3    1    3    0    23   1
50    1    1    1    2    1    4    0    3    2
51    1    1    1    2    1    2    1    4    2
52    1    1    1    2    1    2    0    4    2
53    1    1    1    3    1    3    0    4    2
54    1    1    2    1    2    0    0    8    2
55    1    1    2    1    2    0    0    8    2
56    0    1    1    3    2    3    0    9    1
57    1    1    1    1    2    2    0    9    1
58    1    1    1    2    2    3    0    9    1
59    1    1    1    4    2    3    0    11   2
60    1    1    1    1    2    0    0    11   2
61    1    1    1    3    2    1    0    11   2
62    1    0    1    1    2    2    0    11   2
63    1    1    1    3    2    2    0    11   2
65    1    1    1    2    2    0    0    11   2
66    1    1    1    1    2    2    0    11   2
67    1    1    1    1    2    2    1    11   2
68    1    1    1    1    2    3    0    19   3
69    1    1    1    1    2    3    0    19   3
70    1    1    1    1    2    3    0    19   3
71    1    1    1    3    2    2    0    19   3
72    0    1    1    2    2    2    0    19   3
73    1    1    1    2    2    2    0    13   1
74    1    1    1    3    2    2    1    13   1
75    1    1    1    5    2    2    0    13   1
76    0    1    1    1    2    2    0    13   1
77    1    1    1    3    2    2    0    13   1
78    1    1    1    4    2    2    1    13   1
79    1    1    1    2    3    2    0    2    2
80    1    1    1    2    3    2    0    2    2
81    1    1    1    3    3    3    0    2    2
82    1    1    1    4    2    3    1    2    2
83    1    1    1    2    2    2    1    16   1
84    1    1    1    2    2    2    0    16   1
85    1    1    1    1    2    2    0    16   1
86    1    1    1    3    2    3    0    16   1
87    1    1    1    3    2    2    1    16   1
88    1    1    1    .    2    .    .    16   1
89    1    1    1    2    1    3    0    14   3
90    1    1    1    2    2    2    1    9    2
91    1    1    1    2    2    3    0    9    2
92    1    1    1    2    2    2    0    9    2
93    1    1    1    4    2    3    0    9    2
94    1    1    1    4    2    2    0    9    2
95    0    1    1    1    2    1    0    11   2
;
run;


proc print data=h6;
run;
ods rtf style=journal;
```

```
proc freq data=h6;
tables attrition*(gender group Age Delivery     Edu   Brlex School
term) /chisq;
run;
quit;

/*proc logistic descending;
model attrition=gender group Age Delivery Edu   Brlex School term/
link=logit ;
run;
quit;*/


data gender_freq;
input attrition $ 1-10 gender $ count;
cards;
incomplete m 0
incomplete f 9
complete   m 4
complete   f 81
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'gender' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=gender_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=gender
              space=0
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
```

```
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;

data group_freq;
input attrition $ 1-10 group $ count;
cards;
incomplete mpb 4
incomplete hyb 5
complete   mpb 39
complete   hyb 46
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'group' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=group_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=group
              space=0
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
```

```
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;

data age_freq;
input attrition $ 1-10 age count;
cards;
incomplete 1 2
incomplete 2 2
incomplete 3 3
incomplete 4 2
incomplete 5 0
complete   1 20
complete   2 34
complete   3 21
complete   4 8
complete   5 1
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'age' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=age_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=age
              space=0
              gspace=6
                    width=2
```

```
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;
data delivery_freq;
input attrition $ 1-10 delivery $ count;
cards;
incomplete Dis 5
incomplete F2F 4
incomplete Hyb 0
complete   Dis 42
complete   F2F 33
complete   Hyb 10
;
run;

goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'delivery' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=delivery_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=delivery
              space=0
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
```

```
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;
data edu_freq;
input attrition $ 1-10 edu $ count;
cards;
incomplete HS  0
incomplete AA  1
incomplete BA  5
incomplete MA  3
incomplete Doc 0
complete   HS  4
complete   AA  2
complete   BA  49
complete   MA  27
complete   Doc 2
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'edu' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=edu_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=edu
```

```
              space=0
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;

data brlex_freq;
input attrition $ 1-10 brlex $ count;
cards;
incomplete no  9
incomplete yes 0
complete   no  58
complete   yes 26
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'brlex' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=brlex_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=brlex
              space=0
```

```
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;

data school_freq;
input attrition $ 1-10 school $ count;
cards;
incomplete 1  1
incomplete 2  0
incomplete 3  0
incomplete 4  0
incomplete 6  0
incomplete 8  0
incomplete 9  1
incomplete 10 0
incomplete 11 1
incomplete 12 0
incomplete 13 1
incomplete 14 0
incomplete 16 0
incomplete 18 0
incomplete 19 1
incomplete 21 4
incomplete 22 0
incomplete 23 0
complete   1  3
complete   2  4
complete   3 17
complete   4  3
complete   6  2
complete   8  2
complete   9  7
complete  10  9
complete  11  8
complete  12  3
complete  13  5
complete  14  1
complete  16  6
complete  18  2
complete  19  4
complete  21  6
complete  22  1
complete  23  2
```

```
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'school' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=school_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                  type=sum sumvar=count
              group=school
              space=0
              gspace=1
                  width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                  legend=legend1
                  autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;

data term_freq;
input attrition $ 1-10 term $ count;
cards;
incomplete 1 2
incomplete 2 5
incomplete 3 2
complete   1 16
complete   2 55
```

```
complete   3 14
;
run;


goptions device=png gunit=pct cback=white ctext=black noborder
 ftitle="Arial/bold" ftext="Arial"  htitle=5 htext=4;

axis1 label=none value=none;

axis2 label=(j=c f="arial/bold" 'count' j=c )
 minor=none style=0 offset=(0,0); /* style modifies the style of the
axis- solid or dashed or no line,...*/

axis3 label=(j=c f="arial/bold" 'term' j=c ) offset=(2,2);


pattern1 value=solid color=blue;    ***deep sky blue color;
pattern2 value=solid color=pink;         *** gray color with 'ef'
degree;

legend1 label=none position=(top right) across=1 shape=bar(1.25,2.25)
offset=(0,-35) mode=protect;
*** offset works inconjuction with position, so here the legend at
first has been located at the upper;


proc gchart data=term_freq;
      vbar attrition / discrete noframe /* produce vertical bar chart*/
                    type=sum sumvar=count
              group=term
              space=0
              gspace=6
                    width=2
              subgroup=attrition /* this controls the coloring */
              maxis=axis1 /* midpoint axis */
              raxis=axis2 /* response/numeric axis */
              gaxis=axis3 /* group axis */
                    legend=legend1
                    autoref /* reflines at every major axis tickmark
for the response axis */
              clipref /* put reflines behind the bars */
              cref=grayd9 /* controls the reflines behind the bars
color*/
              coutline=gray90 /* controls the colors of the bars
outlines*/
              name="Barchart" ;
run;
quit;
ods rtf close;
```

APPENDIX I

INTERVIEW DATA BY THEME

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
1	Physical perceptions of Perky duck, Perkins and slate and stylus	45	37	82

MPB1 – experiences: “Many of them (experiences) were pretty stressful, mostly because of time constraints . . . especially if half-way through a page I had made a mistake and had to go back and type that over or try to correct the mistake (Perkins and slate and stylus)”

MPB1 – Technology opinions: “If the brailler could be lighter that would be nice. I know the new Perkins brailler is lighter . . . I don’t like that brailler, per se, I think its going to be another disposable device like a VCR or something. . . . I don’t have any problems with the slate and stylus other than just transposing letters.”

MPB1 – Tech. opinions: “The new Perkins is supposed to have a built-in eraser but it doesn’t . . . I don’t really find it effective and you can’t use the larger paper.”

MPB1 – Tech. opinions: “…it is morer difficult to do slate and stylus because you have to know . . . you have to really know your contractions frontwards and backwards . . .”

MPB1 – mental effort with tech. devices: “. . . it takes more mental effort to do a slate and stylus because (in addition to what you would do with the Perkins) you are also having to concentrate on not only typing. . . but you’ve got to concentrate on reversing the letters and moving right to left and then the physical demand…having to poke multiple dots and so on.”

MPB1 – concentration: “. . . with the slate and stylus you have the added demand of having to just keep up with yhere you are but with the brailler you don’t have to do that because it will keep your place for you.”

MPB1- stress level w/tech devices: “. . . the only problem I have with the brailler is you have to get right over it to see what you’ve typed.”

MPB2 – tech. opinions: “It took me a while to catch on to what seemed to me as a sighted person as entering letters reversed using the slate and stylus. It got easier . . . but I found switching back and forth difficult . . . if I had been using the slate and stylus it was a little harder to switch back to using the braillewriter.”

MPB2 – beneficial components of tech: “. . . my Perkins rang seven spaces from the end of a line which was really nice.”

MPB2 – hindering components of slate and stylus: “I found using a slate and stylus having to mentally reverse characters difficult, but that is the nature of the slate and stylus.”

MPB2 – hindering components of slate and stylus: “I make . . . the most mistakes when I first start . . .”

MPB3 – beneficial components of Perkins: “. . . I don’t even want to speculate on how much longer (it would take) to do it on the slate and stylus. . . . It took me a long time.”

MPB3- hindering components of slate and stylus: “I would have preferred a more comfortable handle on the stylus . . . one with a gell grip would be kind of cool. . . . With the slate and stylus you are writing backwards, also because of the way it’s manufactured you can’t really see if your doing something right or not until you take it (the paper) out. . . . if the device were clear plastic instead of metal it might have been easier to see. . . .”

MPB3 – hindering components of Perkins: “I think the clanking noise from the brailler was annoying at first. . . . I wish that it could be a little lighter.”

MPB4 – opinions of the Perkins: “. . . and just noticing the differences in the different braillers and how you can get used to one and then you have to use another one and then it does something funny and it messes you up completely. . . . I don’t like the fact that the thing weighs a ton.”

MPB4 – Opinions of the Perkins: “. . . the students aren’t always the first ones to say “man that thing looks old” because they don’t know what old looks like. But it’s often the parents who look at it and say “I don’t want my kid carrying that thing around because it looks like an ancient typewriter . . .”

MPB4 – Program changes: “I would have liked to have gotten a chance to play around with a Braille n’ Speak or a BrailleNote or something that we could practice on…because I have a student that has those…”

MPB4 – Program changes: “I think that if I had been able to use an electronic device it would have been easier in terms of the fatigue on my hands...when I’m pressing the keys on the Braille N’ Speak it’s just not . . . as physically demanding as it is on the Perkins where there is punching, you know . . .”

MPB4 – hindering components of the Perkins: “When we came to class and got which ever one (a brailler) you picked that day, oftentimes you would get one, start typing and realize that the papers is not rolling properly . . .”

MPB4 – affect of Perkins on learning braille: “. . . I felt at times like I was really on a rool and I really knew mentally that I was putting things out just right and then I would go “Oh, no . . .I’ve just hit the end of the paper and have to start over again.”

MPB4 – stress level of Perkins while learning braille: ". . . for the most part I was comfortable with the brailler . . . but there was always that part that you can't mess up because you can't fix it…erasing is very, very hard . . . If you make a mistake you pretty much have to start over."

MPB5 – affect of Perkins and slate and stylus on learning braille: "I really at the end, really enjoyed the Perkins. But the slate and stylus was kind of fun too."

MPB5 – affect of tech on concentration: ". . . I needed more concentration using the slate and stylus because I had to reverse the alphabet."

HYB1 – changes in tech: "I would make the Perkins lighter."

HYB1 – mental effort: "When I was on the Perkins…it took a little mental effort but then I would get into a rhythm which I liked. The slate and stylus took a lot of mental effort because of the changing around . . . I had to use post-it notes . . . one with the regular braille cell and the other with the reversed braille cell."

HYB1 – stress level: "Yeah if it was the slate and stylus, it was higher because that hurt my fingers really bad . . . it was like when I was doing the slate and stylus on the NCLB test today. It really hurt my hand and my whole arm so I had to rub my whole arm . . ."

HYB2 – tech opinions: "Yeah, I actually prefer the Perkins Brailler hardcopy. Perky Duck was nice in the sense that it could be emailed."

HYB2 – Tech opinions: "I happen to have a Perkins of my own which affected how I see things . . . and I used it for a while before I ever used the 6-key entry (Perky Duck)."

HYB2 – Helpful elements of tech: "The Perkins is a pain to carry around and mailing hard-copy braille back and forth, it gets flattened."

HYB3 – opinions of tech: "When I put my fingers on a brailler I am much more cautious and slower at getting the letters down because it is very painful to make a mistake on a brailler . . . a lot of times you can't fix it at all if it's a formatting problem or you've got too many errors. You just have to start over and you may not have time."

HYB3 – affect of tech on learning braille: ". . . I kind of felt several times when I was on the brailler that I was distracting other people because of the noise level . . . and I felt that students in a classroom . . . that would bother them a lot. ". . . It would make students in the classroom feel kind of isolated and funny . . . calling attention to themselves."

HYB3: concentration: "If I felt like I was really bothering them (family members) too much I'd just not do it (brailling on the Perkins) and do it some time when they weren't around. But I never had that problem with the computer (Perky Duck).

HYB 3- future tech usage: “I am glad that I have the experience on the Perkins Brailler but I will not be doing any of the assignments (in future coursework) on that, at all. I’m just using the computer (Perky Duck).”

HYB4- tech opinions: “(With Perky Duck) there was a small learning curve for me because I was so used to having a full-key entry (QWERTY) and all of a sudden I’m using a 6-key entry.”

HYB4- tech opinions: “At that point I really had some but very little experience on the braillewriter so it was just a new conditioning that I had to get used to (with Perky Duck). But afterwards it became really easy.”

HYB4 – tech opinions: “To move from Perky Duck to the Braillewriter . . . I really found that for me it was very easy.”

HYB4 – tech opinions: “I really loved using Perky Duck because it was an easy way to share my lessons (as email attachments) I liked the fact that if I made a mistake I could backtrack, I could backspace and get rid of it without having to . . . go over it and possibly make holes on my braille paper.

HYB4 – helpful elements of Perky Duck: “I could look over my paper and see what I was doing so it really facilitated my learning it, because I could see what I was doing instead of rolling up the page and it just made it easier visually.”

HYB4 – helpful elements of Perky Duck: “. . . my familiarity with the computer keyboard itself, even though it’s only 6 keys, I could envision the formation of the braille character and then input it.”

HYB4 – hindering components of Perky Duck: “. . . I would be typing something and the line would disappear. Some of the immediacy of not being able to . . . you know how when you are writing a document and you accidentally erase a line you can hit undo when you’re typing. Perky Duck doesn’t have that feature, I couldn’t get it back so I would have to retype a line . . .”

HYB4 – mental effort with Perky Duck: “I guess seeing it again, the visual aspect so I could see it as I printed it and re-reading it.”

HYB4 – concentration with Perky Duck: “I think that the actual black and white dots on the screen helped me focus on those and the black and white dots on paper, on the simbraille really helped me to gain more of a focal point.”

HYB5 – tech opinions: “…it’s like the difference between a typewriter and a computer and I really don’t understand why we’re being forced to use the brailler for my state braille exam. You know why we don’t have the option to use Perky Duck when everybody else is in the computer age . . . it’s compatible with other braille devices like BrailleNotes . . . ”

HYB5 – tech opinions: “So when I had a literary assignment that was on the brailler is was just like uhhhh! And when I got to do it on Perky Duck it was just like . . . even actually more fun because you know, kind of interesting.”

HYB5 – tech opinions: “…a lot of kids I work with aren’t completely visually impaired and like using the computer and touch-typing. They think that is really fun even though they are learning. I mean its just the pressure’s off of making those mistakes and having to worry about you know, fixing those mistakes because it is so much easier to fix on a computer.”

HYB5 – helpful components of Perky Duck: “. . . at first I wasn’t sure how to print it, it’s weird because you have to put it in a GIF file . . .so that was a little complicated but once you know the process it is easy.”

HYB5 – desired changes to Perky Duck: “I don’t know if you could get cut and paste; that would be neat…those kind of functions so that if you put something in the wrong place . . . (and possibly being able to) change the braille font size.”

HYB5 – helpful components of Perky Duck: “With Perky Duck you can save and go back later if you are in the middle of it and you need to stop. But with the Perkins you can too but lets say like in my office (you are sharing one brailler that is also used by a visually impaired student) for instruction.”

HYB5 – additional comments: “(The slate and stylus) is a necessary evil. I mean I understand why it has to be taught, but learning braille backwards isn’t much fun.

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
2	Perceptions of efficiency of Perky duck, Perkins and slate and stylus	9	28	37

MPB1 – Perkins mental effort: ". . . it's a constant type and then check so there was a lot going back and forth checking that what I had typed corresponded to what was already written . . . it was easier for me to proofread as I typed."

MPB2N – (Perky Duck would be nice) because if you do a whole page beautifully and go back and find "oh no I left out a 4 letter word a third of the way down . . . it would be nice just to be able to go back and fix that without starting over."

MPB4 – helpful components of the Perkins: "there would be times when I would not hear the ding . . . at the end of the line. I would not be paying attention and so I would end up having to start all over again."

MPB4 – future tech use: "I like the Perkins, I would use it again but I would like to see something else that is easier . . . on the fingers and is more correctable."

MPB4 – Perkins-concentration: ". . . if you mess with it (the paper) halfway through you are gonna be stuck."

MPB5 – tech opinions: "I think with Perky Duck you go a little faster (compared to a Perkins)."

HYB1 – tech opinions: "Perky Duck was really easy but I made a lot more mistakes. It was easier to correct . . . whereas with the Perkins that was the one thing I hated because if you made a mistake and made too many, you had to start over. And I hate that."

HYB1 – mental effort: ". . . when I was using the Perkins and the slate and stylus it was right there and then that I had to focus. When I was doing the Perky Duck it was do it and the effort was in the reading it and then going back and correcting it . . ."

HYB2 – tech opinions: "I actually prefer the Perkins brailler hard-copy. Perky Duck was nice in the sense that it could be emailed."

HYB2 – helpful components of Perky Duck: "I think that it helped the teacher to be more responsive. I think it helped me get the material to the teacher more quickly . . . and it was probably better in the sense that I could correct it. And that probably did make it easier, because it's hard to test a really god erasure on the Perkins."

HYB2 – helpful components of Perky Duck: "I guess the ubiquitousness of them. I could use them (Perky Duck) on pretty much any computer . . . the universality, I guess . . . and of course being able to save it and email it from anywhere was very useful."

HYB3 – tech opinions: "Well, I felt when I was on the Perky (Duck) brailler on the computer I went very, very fast because it is so easy to correct mistakes and just like typing you make lots of mistakes and you go back and clean them up and you're all good. When I put my fingers on a brailler I am much more cautious and slower at getting the letters down because it is very painful to make a mistake on the brailler."

HYB3 – helpful components of Perky Duck: ". . . it was easier to send it on-line as opposed to going to the Post office and mailing a letter. But the assignments are easier to correct. It's a lot easier to print it out and to proofread it and send it in as opposed to the old brailler."

HYB4 – tech opinions: ". . . when I did have to use the Perkins I found that the big problem, like when I was doing one of my final projects that I had to braille an actual project . . . it took me hours just because I am a perfectionist and I didn't want any mistakes on it so I would start a new page. So I really like that aspect of Perky Duck."

HYB4 – tech preference: "I guess it would be slightly toward Perky Duck only because of the fact that I could backspace as opposed to having to erase with the braille eraser."

HYB4 – helpful components of Perky Duck: "I guess the quickness of it . . . I think the ability to see what I was writing in front of me as opposed to behind a roller (on a Perkins). . . . The screen was very beneficial. Seeing what was going up, the vertical screen…the vertical visual feedback made a big difference."

HYB4 – additional thoughts: "I thought it was a great way to learn (Perky Duck). I truly enjoyed it. I thought the positive feedback, the immediate feedback the way I was able to get it back and forth. . . . If I had to send something to my instructor 'snail mail' it was just frustrating waiting for her to get it and waiting to hear how I did . . ."

HYB5 – Perky Duck experiences: "I think it's a million times easier, quite much easier to use Perky Duck than the Perkins . . . it's compatible with other braille devices like BrailleNote. . ."

HYB5- tech opinions: ". . . the pressure's off like if I make a mistake I don't have to go back and make a correction with the braille eraser and erase it and if I make a spacing mistake it is going to be so hard to fix that I'm going to have to start all over . . . I can just zip through on Perky Duck and it is more fun. I like braille."

HYB5 – helpful components of Perky Duck: “. . . it is a pretty simple program, Perky Duck. That made it easy. It made it easy that it’s pretty simple to attach it to emails and send it off that way. For the attachment features it was very user-friendly, you know, in general. And it was simple, it wasn’t really complicated, so that in general made it easy to use.”

HYB5 – mental effort: “. . . when I was brailling on the brailler I was thinking the whole time very closely about what I am brailling…but if I made a mistake I was trying to correct it quickly so that I didn’t have to go back . . . I’m writing a line and as I’ve just written it I am checking every few words to see if it’s right or at least every line, and I’m not gonna let go and then just braille, braille, braille. But with Perky Duck I was able to braille the whole thing and then I would go back and check it. So I usually printed it off and then I could proofread it right in front of me, you know. And I would have the screen up and as I found errors on my printed page I would correct them on the screen. Using the Perky Duck made it less cognitively difficult for sure.”

Rank	Theme	MPB frequency	HYB frequency	Overall frequency
3	Instructional design issues/comments	12	19	31

MPB1 – Stress level: "I think it had to do more with the timing of the lesson. You know, if I have time to type it out and proofread it and retype it I'm in a lot more stress than if I know that I've got to pay attention and get it correct the first time or second time, whatever."

MPB2 – Concentration: "I think we learned new things usually with the Perkins and kind of as a review or an assimilation we would do the same thing on the slate and stylus because ford most of us we found the Perkins easier and I think it was easier to learn on the Perkins.

MPB2 – Stress level: ". . . but if there had been fewer Perkins braillers and we had to find another time when another person was not using them of had to stay late . . . I'm a morning person so it was much better for me to braille in the morning than to braille in the evening."

MPB3N – Experiences – ". . . because of given the timeframe of when I am supposed to learn them (contractions) . . . I think that if I had had 10 weeks to learn it I would have done a lot better."

MPB4 – Experiences: ". . . we had another class in addition to the braille class, so it was a lot of work when you got home because I felt some of the times I was actually going home and doing braille for like 8 hours at night."

MPB4 – Experiences: "I liked that we had practices every day in class . . . because we got immediate feedback. There was somebody right there checking our papers as we turned them in."

MPB5 – Changes: "I would probably do Perky Duck more . . . because once we get into the schools and we are teaching, most kids have computers. I imagine that quite a few of them (students with visual impairments) are totally on computer. And I think that is probably what is going to be a lot more prevalent in the future."

HYB2 – Experiences: "Well given the on-line environment, I could time my work when it suited me and that was very nice."

HYB2 – Experiences: “And the assignments were all put on (on-line) at once so I could do them at my own pace . . . now certainly there were deadlines for each assignment but I got most if not all of them in early.”

HYB2 – Technology opinions: “. . . I’m sure it’s (on-line instruction) far easier for the teacher than to go through paper braille. So that increases the ability of the teacher to be responsive and my instructor was extremely responsive with quick turnaround and great guidance. And that would be a good bit more difficult without the assistive technology (Perky Duck), realistically.”

HYB2 – Changes: “I think that the (literary braille) course should be at least one more credit hour.”

HYB2 – I think that it (Perky Duck) helped ease communication between me and the professor.”

HYB2 – Helpful tech. elements: “. . . mailing it (hard-copy braille) back and forth, it gets flattened. Obviously the mail takes a little more time than email.”

HYB2 – Additional comments: “If I were teaching one (a braille course), I would use Perky Duck. Given the frustrations that I had with it I’d still use it. I think that it certainly more than makes up for the negative.”

HYB4 – Changes: “The instructor could get right back to me with corrections and point out my mistakes at which point I would go back on the document and see where I made my mistakes and chide myself.”

HYB5 – Experiences: “I have finished two braille courses and I feel that I have to study all summer to be ready for a (state) braille exam. Like I don’t feel ready.”

HYB5 – Helpful tech. elements: “. . . (with Perky Duck) the pressure is off for making mistakes and so I could focus more on the cognitive task which made it less taxing because you know, especially if it was a timed thing that was a big deal.”

HYB5 – Temporal demand: “So I always felt pressure liked if I was doing it on the brailler right away because I didn’t want to have to take it out then find the exact spot where I was at or if it got crumpled or you know something happened to my paper or you know if it got lost in a pile of other braille papers.”

HYB5 – Mental demand: “. . . I really believe that it should be a 3 semester course ‘cause I just think it was too fast . . . well, I still haven’t mastered last week, I’m not ready for this week.”

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
4	Mental effort attributed to Braille code Complexity; Comparisons with foreign language learning	11	6	17

MPB1 – mental effort: “. . . in one lesson we picked up, I don’t even know how many contractions but it was all of the dot-5, dot 4-5, and dot 4-6 contractions. So maybe like 20 or 30 contractions in one lesson.”

MPB2 – mental effort: “And as we layered concept on top of concept of course therer were more things to remember than there were initially.”

MPB3N- experiences: “. . . I think (at first) it was more like learning the basic alphabet was fine but then it was once dI started turning them further to make words and things. And then once I hit contractions I was having such major issues it was horrible.”

MPB3N – stress: “. . . it consistently grew as the lessons progressed and I got more into working with contractions and all of the new rules that had to be applied for what I was doing. It was just more and more stressful.”

MPB4 - mental effort: “. . . you are concentrating so much on remembering where your fingers go but by the end you’re concentrating on the planning ahead, the getting ready to do it by looking over what you’re going to type and getting it all contracted and following the rules.”

MPB5 – experiences: “The end ones (lessons) were rushed and being very much more difficult to handle.”

MPB5 – helpful components of the Perkins: “I don’t think it had anything to do with the kind of technology that we were using. I think it is totally exclusive linguistics and memorization . . .”

MPB5 – mental effort: “I would have to say it was, it took a lot mentally because you had to memorize it.”

HYB2 – changes: “I don’t think you are getting enough credit for what you are doing. I think that braille should be getting more time in the TVI curriculum than it does. . . . Low vision gets a ton. That’s okay but if you are learning a whole new code, how do you get good at it in 2 semester hours.”

HYB5 – mental effort: “When it was new (literary braille) it was really hard. And um, I’ve studied foreign languages and I’ve done a lot of different things. I’d say that it still is (really hard) because I am studying for the state exam coming up . . . it still is one of the hardest things I’ve ever done. Really hard.”

HYB5 – mental effort: “I think that it takes a lot of the same mental capacities that you’d need to learn a foreign language, definitely. You are using a lot of the same skills. You know, you’re having to memorize different symbols and yes it’s like learning a different language, for sure…It hasn’t become fully automatic yet but…I’m still working on the dot-5s and the ending stuff. I can do a lot of it but those last lessons I am still memorizing.”

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
5	Time pressure for lesson completion attributed to extraneous (lifestyle) factors rather than technology	7	3	10

MPB1 – temporal demand: "It was definitely time-constrained because for example if there was a slate and stylus assignment given on Monday and due on Wednesday, that was a little more time-constrained just because of my schedule . . ."

MPB1 – stress level: "I would say that it depended on how long I had procrastinated the assignment which clearly if I procrastinated it longer the more stress . . ."

MPB2 – temporal demand: ". . . but at times completing Tuesday's homework by Thursday, depending upon what was going on in other classes pretty much determined how much trouble I had with it."

MPB2 – stress level: ". . . well one time I got a braillewriter out of the cabinet and it didn't work very well and of course that does ratchet up stress."

MPB2 – stress level: ". . . some lessons were harder than others but other courses are obviously going on at the same time and when there's a fairly difficult braille assignment to do at the same time as I was trying to study for a test or complete a paper or some other project, that's kind of when the stress level would go up."

MPB4 – temporal demand: ". . . except for the first 3 weeks when we had the other class (simultaneously) and that was a little bit rough."

MPB5 – mental effort: "The only reason I was a little bit more stressed toward the end and I needed a little bit more time was because I had so much to do with my other classes, you know finals and stuff."

HYB1 – hindering components of tech: "Especially if I was doing it late at night and I was tired and I found that I was making a lot of mistakes . . . I was taking a transcribing course at the same time. So when I started to get heavy on both loads I would rush sometimes . . ."

HYB3 – temporal demand: ". . . there were a couple of weeks when I had a lot of stuff going on with IEPs that work became a priority."

Rank	Theme	MPB Frequency	HYB Frequency	Overall Frequency
6	Muscle memory typical with using the Perkins does not easily transfer to Perky Duck	4	5	9

MPB1 – helpful components of Perkins: “I think that there is a little bit of muscle memory in it. I mean knowing which fingers you are going to use to press down, which letters.”

MPB5 – braille learning/Perkins: “Well, of course the Perkins affected memory more because when I’m trying to memorize if I can do things actively, I memorize quite a lot faster.”

MPB5 – helpful tech components: “. . . you’re talking about the brailler and the slate and stylus? Like I said, I really don’t think it had much to do with using it (the devices). It was just a question of coordination.”

MPB5 – additional thoughts: “I think probably most of the people in my course at the end of the course prefer the Perkins (to Perky Duck)…because it is a much more mechanical process so that it’s easier to memorize.”

HYB2 – helpful components of tech: “I am not a print typist . . . I didn’t get any feel from the keys (Perky Duck) . . . my muscle memory wasn’t even the same because the feel, the responsiveness was much different. I might not have felt that way if I had done Perky Duck first.”

HYB2 - tech/concentration: “It (Perky Duck) kind of broke my concentration because when I got into brailling and didn’t hit a key right, I had to go back . . . it was harder . . . I found it harder to braille on it because I had to concentrate harder on the mechanics of entering the braille than on the braille itself.”

HYB2 – tech/stress level: “Because of the difficulty with the mechanics of 6-key entry (Perky Duck) I was probably more stressed by the earlier lessons because I couldn’t get into a flow or because I’d hit the wrong key or I missed a key.”

HYB2 – tech/stress level: “. . . I do think it would have been better if I had used a regular keyboard than my laptop keyboard, looking back. But the laptop keyboard is so much different from the Perkins Brailler it was almost like having to relearn it.”

HYB3 – tech/hindering components: “It (the Perkins) has a much different feel…It’s the muscles that it takes to press down on the brailler are a lot different than the keystrokes” (using Perky Duck).

HYB4 – tech/opinions: “You know I really liked the tactile feedback that I got from the braillewriter . . .