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Assessing the Learning of Students with Disabilities in Informal Education

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Assessing the Learning of Students with Disabilities in Informal Education

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Abstract

Informal education, learning that takes place outside the classroom, occurs in a variety of different environments and each informal learning center presents information to students in a different manner. Previous projects have built the framework for accommodating students with disabilities in informal learning environments, but a method is still needed to assess the learning progress of students with disabilities in informal education. Current methods of assessing student learning in both formal and informal learning environments were examined through a literature review and interviews with mainstream, special and informal educators, as well as principals, education coordinators, managers, directors and specialists at various locations. This process included a comparison of assessment of students with and without disabilities. The information obtained was used to develop a list of specific recommendations for future project teams to use in order to develop and implement a successful assessment method, conforming to Universal Design standards, which can be used by students with disabilities in an informal learning environment. The results are presented in the form of a matrix which lists recommendations for mainstream, special and informal educators to consider before, during and after field trips to informal learning centers. The goal of these recommendations is to assist project teams in the creation of an effective assessment method and to make the field trip experience more fun and educational for both students and educators.

Acknowledgements

The team would first like to thank all interviewees that contributed to our project and stuck with us while learned how to conduct a proper interview and figured out the right questions to ask. Many of you pointed the group towards alternate sources of information to investigate which helped out greatly. Your patience and assistance in our interviews was much appreciated as we undertook this expansive project.

More specifically, the team would like to thank the professors at WPI who took time out of their busy schedules to do interviews with us. By interviewing people at our own school first, the group got some great practice at conducting an interview, which none of us had ever previously done. These interviews provided new directions and information for the project and gave us the knowledge and confidence we needed to perform successful interviews with other educators.

Next we would like to thank the formal school teachers, specialists, facilitators, directors and administrators that took part in our interviews. Our team has gained a new appreciation of how busy educators can be during the school day and how much effort it takes from so many different people to operate a school smoothly, so we thank all of the formal educators, at both mainstream and special education schools. The interview notes do not do justice to the extensive amount of valuable information that you provided for our team.

We are also grateful to all of the informal educators that agreed to be interviewed. Our group consists of two Mechanical Engineering majors and one Physics major, so while we had some understanding of assessment in a formal school setting, none of us really knew much, if anything, about informal education before this project began. These interviews shed light on the field trip experience from a different perspective than formal educators, and combined with their information, your answers helped our team investigate a very complex issue.

A special thank you goes out to Christine Reich at the Boston Museum of Science. Christine came recommended highly by people as far away as the Exploratorium in San Francisco, CA. Due to Christine's explanation of assessment versus evaluation, the group almost made a last minute change of the title of this project to *Evaluating the*

Learning of Students with Disabilities in Informal Education. The original title was retained because in many cases these two words might be used interchangeably, but there is a subtle and important difference between the two in the informal education setting which is discussed in detail in the report. Thank you so much Christine for answering questions that we didn't even know we had.

Our gratitude also goes out to the CSIRO project team of Nicholas Simone, Erin Vozzola, and Lynn Worobey, as well as the Zoos Victoria project team of Ben Gilde, Sara Kosmaczewski, Nicole Maglione and Justine Ziobron. The work done by these two teams gave our team the background knowledge to get our project off the ground, which might have never happened otherwise. Thank you to both teams for pointing us in the right direction, and great job on your projects.

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Also, the group would like to thank Joslyn Foley for drawing the Smurf for the cover. The idea behind the Smurf is that informal education is supposed to be fun, so we wanted to create a fun image. To be honest, we are all engineers, and not the greatest artists, so we thank Joslyn for her help.

Last, but certainly not least, we would like to thank our project advisor, Professor Holly Ault. She started us down this path at the beginning of the school year and never let us drop the ball. Professor Ault provided us with countless leads to investigate and contact information for various sources, and her stringent yet entirely necessary deadlines kept the group motivated week after week, while keeping us from getting stuck in 'tunnel vision' mode. Professor Ault was also very gracious during some unfortunate personal tragedies that occurred within the group during the semester, which we can not thank you enough for. Without her guidance, we may have never finished in time.

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Nomenclature

AACSB – The Association to Advance Collegiate Schools of Business

ADA – Americans with Disabilities Act

AD/HD – Attention Deficit/ Hyperactivity Disorder

ASD – Autism Spectrum Disorders

ASHA – American Speech Language Hearing Association

ASL – American Sign Language

BMOS - Boston Museum of Science

CAT – Classroom Assessment Technique

CSIRO- Commonwealth Scientific and Industrial Research Organisation

ESEA – The Elementary and Secondary Education Act

ICBVI – Idaho Commission for the Blind and Visually Impaired

IDEA – The Individuals with Disabilities Education Act

KIRIS – Kentucky Instructional Results Information System

LD – Learning Disability

MCAS – Massachusetts Comprehension Assessment System

MSF – Massachusetts State Frameworks

NCLB – No Child Left Behind

NCLD – National Center for Learning Disabilities

NEAQ - New England Aquarium

SWD - Students with Disabilities

UD – Universal Design

USDE – United States Department of Education

USNEI – U.S. Network for Education Information

VELS – Victorian Essential Learning Standards

WPI – Worcester Polytechnic Institute

Executive Summary

Informal educators are currently trying to improve their services to visitors. Current efforts have focused on increasing accessibility to visitors with disabilities. Informal educators, like their formal counterparts, have a legal and ethical obligation to maximize access to their services. Because of that obligation, there has been a drive by informal educators to accommodate visitors.

Previous projects at WPI have focused on improving accessibility for visitors. Two previous projects, the PAR (Program Accessibility Reference) and the SAM (Student Accessibility Matrix) focused on providing informal educators efficient references to proper accommodations for varied disabilities. By altering their programs, informal educators can enhance access and improve the quality of their services.

To determine if accommodations are effective, informal educators need a means to measure student learning. Without information on what visitors gain from an experience, informal educators have no decisive manner to determine if modifications to their exhibits and programs are effective. If informal educators could measure such data, they could not only prove the effectiveness of program modifications, but modifications to programs could be more precisely applied.

This project seeks to aid informal educators in measuring student learning. By creating a tool to assist in measuring student learning, this project assists informal educators. By helping to improve informal education, the project also helps to improve education in its entirety. If this project could improve informal education's ability to assess student learning, informal educators would benefit.

This project sought to fulfill its goals by creating an assessment tool. The assessment tool was developed after extensive research. Research for the project included an in depth literature review and interviews with experts in the fields of informal education and special education. The research conducted showed that assessment would be adaptable for use in informal education. Research also showed that assessments could be adapted to meet the needs of students with disabilities.

The literature review examined many topics important to informal education and student accessibility, as well as assessment. The difference between formal and informal

education was explored to better frame the place of assessment in informal education. Assessment itself was then reviewed to determine its attributes and applicability to informal education. Disability law was then researched to better understand the motivations behind the recent accessibility movement of education. Assessment of students with disabilities was then probed to better understand current practices of accommodating students. Universal design was studied last to better see how students could be accommodated, and to understand one of the leading paradigms in accommodating persons with disabilities. Some topics of the review are more deeply discussed below.

Formal education is that which takes place in the classroom. It is rigidly structured, and has a set protocol for student teacher interaction. Informal education is unstructured, and encourages students to explore, according to their own interests. Formal education benefits from its structure, while informal education benefits from its lack thereof. Formal education also has less need to worry about student motivation, which is the key source of informal education's strengths.

Assessment is how student learning is measured. The literature review found that there are multiple forms of assessment. Formative assessment is assessment that is used to diagnose student misconceptions, as well as educational curriculum issues. Summative assessment is used to grade or place students into courses. Traditional, or standardized assessment uses hypothetical, limited questions to test student understanding, while authentic assessment uses more open ended and true to life examples to both probe student understanding and to improve it.

Universal design is the concept of designing for the maximum number of users possible. Several changes in building code, as well as service and product design, have come about from the movement. In education, the use of universal design has been modified for instruction. Students are presented multiple options of instruction, response, and assessment. With several options available, the student can be assessed, instructed, and allowed to respond in ways which best enable their education.

After the literature review was conducted, the knowledge gained was used to create a methodology by which further information could be obtained. The information gained during the literature review phase of the project led to a contact list of potential

interviewees, as well as criteria for selecting interviewees. Due to the vast amount of information encompassed in the assessment field, the team felt that interviews would produce the most pertinent information to the project. The methodology also had a time line within which the project would be conducted.

Interviews with formal and informal educators were conducted which produced valuable information for the formation of the final deliverable. Informal educators, for example, rely on student motivation to enhance their programs. Without student motivation, informal education would not be as potent a tool for education. Assessment, if poorly conducted, can inhibit student motivation and thus decrease the value of an informal educational experience.

Another useful fact gained from interviews is the need for better communication between formal and informal educators. While communication is present, better communication would improve the experience for both formal and informal educator. Communication of accommodations offered by the informal education site would assist the formal educator. Feedback on the value of programs would be valuable to the informal educator.

The group, after considering the information gained by the interviews and literature review, created the SMIRF (Suggestions Matrix Incorporating Results from Findings). The SMIRF is a matrix of suggestions for best practice, organized by educator and the time, relative to an informal education excursion, where the suggestions best apply. The educators are organized into formal, special, and informal categories. The formal education category applies to all formal educators, including specialized schools. The special educator category applies to educators dealing with students with disabilities. The informal educator category deals strictly with informal educators. The three categories of time are pre trip, during trip, and post trip.

The SMIRF was designed to be a speedy reference for educators seeking to use informal education, or seeking to use assessments in informal education. The SMIRF is also accompanied by additional suggestions for educators, concerning key points in student motivation. As the SMIRF is small, it can be easily used, as well as adapted to circumstances. Its structure also lends to its versatility.

The SMIRF has the capacity to breed a new set of improvements to informal education. The direction that the SMIRF has taken is somewhat new for WPI IQPs. While the PAR and SAM, mentioned earlier, sought to improve informal education, they did not do so by offering a means to evaluate student learning. While they evaluated student accessibility, they did not provide a method by which program modifications could be measured. The SMIRF provides the foundation for tools to be created which measure informal education with respect to student learning. Because of its new direction, the SMIRF is a uniquely valuable IQP, and stands to pave the way for future IQPs in informal educational assessment.

1. Introduction

In the realm of informal education, there is a disparity between the knowledge gained by the mainstream population and those with various disabilities. Informal education programs do not provide equal benefits for students with disabilities (SWD). In 1990, the Americans with Disabilities Act (ADA) mandated that discriminating against people with disabilities is a legal offence (ADA, 2008). The old practice was to institutionalize or marginalize students with differing abilities. This has given way to trying to accommodate differences in the education setting, in light of the fact that those with disabilities have the potential to contribute a great deal to society. Stephen Hawking, a renowned astrophysicist, is a prime example of how physical ability is by no means a measure of ones ability to contribute to society.

There has been extensive debate amongst lawmakers and educators about the issue of accessibility in education. While much is being done on the legal end to ensure that education is equal for all students, there is still confusion amongst educators as to how to implement legislation such as the ADA. The ADA requires companies and institutions, including informal educators, to make reasonable accommodations for people with disabilities. Ideally, the law would not have to be put in place to ensure equal benefits to all students. However, a general lack of concern for the needs of those with different abilities has necessitated the ADA, which requires educators to use limited resources to accommodate their students the best they can.

Considerable research has been done into how formal education can assist SWD while informal education has not benefitted as much. Though research has been done to assist students with differing abilities in informal education settings, this research is incomplete and must be continued. The benefit posed by improving informal education, that which lies outside the classroom, is tremendous. Accessible informal education would instill curiosity and interest in SWD, as well as inform them. Many students with disabilities are not reaching their full potential because of the lack of research in accommodating their special needs.

Significant steps have been taken by Worcester Polytechnic Institute (WPI) students to improve the quality of informal education for SWD (Simone et al., 2007;

Gilde et al., 2008), but the scope of their research does not encompass assessing the results of their programs. This project will concentrate on assessing how previously developed frameworks have impacted the learning of students with and without disabilities. This should be done for two reasons. First, as part of a general program to identify problem areas in assessing the learning outcomes of informal education programs and, more importantly, to test if the other projects done in accommodation, in fact, improve the experience of all students.

This project will use a literature review and interviews to determine the limitations of student learning assessment presented by a variety of physical, sensory and cognitive disabilities, methods of assessing what SWD have learned, and a means for informal educators to develop this information into useful feedback to determine the relative success of their programs. This feedback can be used to correct remaining educational disparities and provide a relaxed and enjoyable environment for SWD, allowing them share in the same learning experience as their peers.

2. Literature Review

In order to create an assessment tool for the completion of learning objectives in an informal environment it is first necessary to research and identify the key components that would allow for a proper understanding of the subject. To do this, a literature review was performed to identify current standings and practice and identify information that would need to be obtained from sources other than literature. This literature review describes different educational settings and identifies current methods of assessment. Also, it was necessary to build familiarity with different disabilities, disability legislation and reform and concepts of Universal Design (UD) so that an assessment tool that is useful to all students can be created.

2.1 Educational Settings

An educational setting is an environment in which learning takes place. Learning is a durable change in the internal knowledge of a person (Straka, 2004). This learning may occur in a number of different settings from classrooms to leisure activities such as a trip to a museum (Colardyn, 2004). A formal education environment will be considered an environment in which primarily formal education occurs and an informal education environment will be considered an environment in which primarily informal education occurs.

2.1.1 Formal Education

Formal education may be defined as an environment in which highly structured learning occurs, such as classroom learning with instruction from a teacher. The goal of formal learning is typically to achieve certification of a student's knowledge in the form of a diploma or other form of formal recognition (Colardyn, 2004). Formal education in the United States is characterized by three stages: primary school, secondary school and higher education. Primary and secondary school comprise the first 12 years of a U.S. student's education. During this time, there are clear goals as to what a student needs to learn in each grade level. To accomplish these goals, teachers employ educational curricula which combine classroom learning with assessment tools such as homework, reports and tests to determine if a student has developed the necessary understanding of

the topics covered and progress to the next grade level (U.S. Network for Education Information, 2008).

2.1.2 Informal Education

With formal education defined as structured, classroom based learning, informal education must then be defined as a less structured, out of class learning experience. More elaborately, formal education uses educational texts and instructor created sets of exercises. Contrastingly, informal education uses a more "hands-on" approach, encouraging a student's natural creativity and interests. Informal education providers range from museums of art, science, and history to zoos and aquariums.

2.1.3 Comparing Formal vs. Informal Education

In any educational program, there is specific information that an instructor would like to convey to a student. That information can be summarized in a learning goal that provides a student with the knowledge of what the instructor is trying to convey. A learning goal is typically a very general statement such as: The student will be able to play volleyball. The learning goal can then be broken down into subcategories called learning objectives. These more specific statements define the minor accomplishments needed to complete the learning goal. Learning objectives for the learning goal of volleyball could be: The student will possess a basic knowledge of the rules of volleyball, the student will be able to serve, the student will be able to spike, etc. Different methods of assessment can then be used to determine whether the student has completed the learning goal and objectives (The Association to Advance Collegiate Schools of Business, 2008). Because assessment of learning objectives is used to determine students' understanding of the material that was taught, learning objectives can be found in both formal and informal education.

Formal education derives strength from the fact that a great deal of research has been done to improve formal education programs. This research has led to a standardization of the learning objectives a student needs to meet in order to obtain a diploma, as well as clearly defined methods of teaching and assessing a student's understanding of those objectives (USNEI, 2008). These government mandated standards were created to ensure that every student has an equal opportunity to succeed in life by

providing them with a basic skill set that they can apply to their post-graduation lives, thus making them a self sufficient person with the ability to make contributions to modern society and compete for social and economic advancement.

The moral obligation of providing an equal opportunity for all students through education has also led to increased research into developing accommodations for students with differing abilities in a formal education setting. Formal education benefits from employing instructors that are certified in special education and that can apply their knowledge to adjusting classroom programs to make material more accessible to SWD. This way those students may continue to participate in the same educational programs as their peers. Also, in the case that a disability may preclude a student's ability to participate in the same program as other students, specialized education has been developed to cater to the needs of that student and attempt to provide him or her with the same basic skill set as the other students (USNEI, 2008).

Contrary to formal education, informal education draws strength from its relative lack of structure. With the more versatile programs of informal education, students may develop their own ways of completing a learning objective (Griffin, 2004). The feeling a student has from meeting the learning goal using their own skill set greatly increases his or her feeling of accomplishment, allowing the student to attribute learning to a fun activity, as well as motivating students to continue learning (Middlebrooks, 1999). Associating learning with enjoyment encourages learning by stimulating the interest of a student in the subject area. This interest serves as a student's motivation to accomplish a learning objective while the student's good mood will serve to increase retention of the learning objective (Straka, 2004).

Informal education currently lacks research into accommodating the needs of SWD. Unlike formal education programs which benefit from research and government funding to accommodate those with different learning requirements, informal educators receive much less help in making adjustments to their programs to provide an equal education for all students. The hands on, sensory nature of most informal education programs can manifest many difficulties for SWD. These difficulties can develop into feelings of frustration and inadequacy at being unable to perform a task, thus greatly reducing the enjoyment of the student (Simone et al., 2007).

Research has been done by WPI students into adjusting informal education programs to increase the involvement and subsequent enjoyment of SWD. (Simone et al., 2007; Gilde et al., 2008) However, informal education still has an absence of research in the area of learning assessment that is so prominent in formal education.

2.2 Assessment

Assessment is a general term that encompasses the category of tools, techniques, and procedures that educators use to gather data on student understanding. Assessment is an integral part of a students overall education. Assessment provides educators the means by which important data on student progress can be gathered. Assessment can be divided into sub-types based on what methods are used to gather data, how the data is to be used, or both. Data from assessment can be used to improve curricula, evaluate course materials, or to assist students in understanding difficult material. Just as the uses of assessment data are varied, so are the data collection tools of educators. Wording on tests, types of methods used, and the purpose of the test are all ways in which assessments can vary.

2.2.1 The Need for Assessment

The need for assessment comes directly out of the need to delineate what students must know in order to be successful adults/members of society. Educators organize what students must know into learning goals and objectives. Learning goals are blanket, general statements on what students should learn, whereas learning objectives are far more specific. While neither of them tells an educator how they are to attain these goals, they do offer an objective to direct educator curricula (AACSB, 2008).

In order to ensure that learning goals and objectives are met, educators must assess the understanding of their students. Assessment fulfills the need to assess student learning, while also providing other benefits. Assessment data measures student progress. Data from assessment can be used to diagnose curriculum problems, which can be used to improve curricula.

Because of the value of assessment, research is constantly being done in the field. The value of assessment, if further augmented, will translate to the increased value of education as a whole. In order to benefit education as a whole, assessment of students in

informal education is the topic of research for this project. Several methods exist for assessing students in the formal educational realm. The variety of these methods, and their individual benefits, may be portable to their use in informal education. Due to the current knowledge base on the subject, assessment in formal education is the starting point of this literature review.

2.2.2 Types of Assessment

Assessment is the evaluation of student understanding as it relates to the completion of learning objectives. Older practice used assessment data primarily for determining student grades and course placement. While grading and placement are still uses of assessment data, new and promising uses have been found.

Assessments new use is to increase student understanding of various material. By teaching students in this manner, educators can instruct their pupils in ways not otherwise possible. By using assessment as an instructional tool, educators can challenge students in new ways, prompting them to learn new skills for themselves (Shepard, 2000, 1999).

Student understanding and memory retention has been a long examined topic of education. Earlier theories on learning stated that children learned in small, sequential bits. Early methods reflected such theories, and students were taught in small, discrete portions. Assessment was used to ensure students learned the small portions being taught, as well as the concepts which those portions comprised (Shepard, 2000, 1999).

The key flaw of early educational practice was its resemblance to mass production. The earliest theories of modern education were forged at a time when industrialization was seen as one of humanities greatest achievements. Such beliefs led to teaching, in the past, being nearly uniform for all students. In contrast, current educational practice not only accounts for, but also values the varying differences of individual pupils (Shepard, 2000, 1999).

Modern educators, unlike their earlier counterparts, follow the slogan of "All children can learn." Following that sentiment, research has been conducted throughout the educational field. Such research has contributed to the use of assessment as a multipurpose instrument. In its current form, assessment is seen as an analytical tool, diagnostic tool, and instructional device (Boston, 2002; Brown, 2001).

When assessment is used to instruct, diagnose curriculum problems, locate student misconceptions, or a combination of such purposes, it is called formative assessment. Formative assessment is not for grading students or rating their understanding of material, but rather to improve student learning. Formative assessment is only a recent development, and is still being experimented with. Its successful application in several venues, however, asserts its utility and future place in education (Boston, 2002).

The alternative use of assessment; to examine student understanding in order to grade, provide evidence of government standard compliance, or place students, is known as summative assessment. Where formative assessment is used to probe and improve student understanding, summative assessment is for grading and placing students in classes based on their mastery of the material being taught. One could compare formative and summative assessments to diagnosing problems in a machine and analyzing its performance. One is used to develop and improve it, while the other to rate it (Boston, 2002).

Formative and summative assessment is merely two different facets of the same entity. To use assessment as a whole is to combine both of these facets to best effect. The same assessment can be used to grade students as well as give them feedback. The essay, discussed later in detail, is a common example of such combination.

Another subdivision of assessment is that of authentic versus standardized assessment. Authentic assessment is the use of open ended, near real life problems to provoke learning while also assessing student understanding. Standardized assessment is the use of simplified, hypothetical situations, and having the student work them out (Shepard, 1999; Mueller, 2008).

An example of standardized assessment is the classic science report. The student is made to research a particular concept in some field of science, and then must write a paper on it. An example of the same science report, done as an authentic assessment, would be to have the student do the research, but then apply the knowledge by designing an experiment or device.

The benefit of authentic assessment over standardized assessment is its capacity to reach higher levels of cognition. Standardized assessment merely has students solve

simple problems, whereas authentic assessment forces the pupil to probe much deeper. Standard assessment takes what has been done in the book or in class. Authentic assessment requires student creativity as well as understanding (Mueller, 2008; Forehand, 2005).

The differing assessment types can overlap. A standardized assessment can still be a formative and a summative assessment, simultaneously. An authentic assessment can be completely summative. The factor which delineates formative from summative assessment is the way in which the data is used. The factor for separating authentic from standardized or traditional assessment is the type of questions asked.

2.2.3 How Educators Use Assessment

Instructors use assessment as a means of gathering data on student understanding and knowledge retention. These data can then be used to determine if learning outcomes have or have not been met. They can also certify that federal mandates have been obeyed, or even simply to find out who the smartest student in the class is. The data can be used for any purpose in its raw form, but it is up to the educator to decide both what data to gather, and how it should be used. As will be demonstrated later, different assessment tools gather different information. Furthermore, different information has different uses to the instructor.

In his work, "*Assessment: a Guide for Lecturers*", Brown offers many thoughts on how students should be assessed and how testing ought to be conducted. Within the work, there are repeated lists of questions for the teacher to ask, such as "Does the specific assessment task match the outcomes and skills?" (Brown, 2001, p7) By that, he means to say that the tool being used should be appropriate to the job, meaning that the tool obtains information based on the skills relevant to what the instructor is trying to teach, as well as on the students' overall understanding of the material. This can be best demonstrated by example.

If a teacher asks a student to draw a graph of some function, and provides information on the function, the teacher does not just ask about the student's understanding of algebra. By making a student draw the graph, the teacher also inquires if a student understands the concept of a Cartesian plane, whether he or she can appropriately plot functions, and can use derived formulae as well. These are variables

that Brown suggests instructors inquire about when designing tests, essays and other tasks for students to complete. In short, assessments should be related to what has been taught by the instructor.

Related to that end, as well as to the world for which instructors aim to prepare their students, a recent trend in assessment is what has been called “Authentic Assessment”. This form of assessment does not use the standard set of rigid examples and questions to investigate student understanding. Instead, it offers the examinee a problem that is closer to something they are likely to encounter; more open ended and less defined (Shepard, 1999; Mueller, 2008).

The benefit of authentic assessment is its need for the students to, in some capacity, use the knowledge they have gained. A brief aside to Bloom's Taxonomy is warranted to better elaborate the importance of using knowledge versus reciting it. The taxonomy separates the levels of understanding for a topic into six levels. Reciting information is the first level, where using it begins at the second and third levels (Brown, 2001).

Once the data have been gathered, it is then up to the instructor to determine its use. While the use of the data must certainly affect the type of assessment used, other factors must also be considered. Again, the use of the data comes under the realms of formative and summative assessments. If just to differentiate students for class placement, summative assessment is the typical choice. However, if the test is to diagnose problems, or to prompt or probe for a deeper understanding of a subject, then formative assessment is the more appropriate choice. These two types of assessment are not mutually exclusive however. For example, providing feedback on an otherwise summative task can provide a formative aspect. Alternatively, grading an otherwise formative activity can give a summative aspect.

There are also, more mundane and common reasons for assessment. One is to check if students have been keeping up on the material. Another is punishment of the class, as a whole, for not keeping up or for disrespect of faculty. The punitive aspect, however, may backfire, lowering self esteem of students and sometimes creating negative feelings between administrators and students. This would then potentially lower performance and understanding while also decreasing the students’ motivation to learn.

Other, more inviting examples are how assessment is used for reward or to motivate students. To motivate understanding and enjoyment, the instructor could assign a task designed to be both challenging and amusing. Reward could take the form of a more intriguing project for a student having excelled in the course, such as a more in depth look at a particular topic. These uses, however common, are not what come to mind when assessment is mentioned.

The uses of assessment have one particular thing in common; data. If no data can be acquired on student understanding or progress, then the instructor has no ability to determine the level of that understanding. If no information is given to the teacher on student performance, the teacher cannot give feedback, which is of great help to students. Thus, data must be gathered. There are a myriad of ways to perform this function, some of which will be examined below.

2.2.4 Tools for Assessment

Several techniques exist for assessment. The techniques vary widely, from small scale spelling quizzes to large scale, as statewide testing. While assessments vary in size and question type, they all have one thing in common. Assessments are used to gather some type of data.

A common form of assessment is the standardized test. Children take these tests to ensure that their instruction complies with governmental standards. Examples of standardized tests are the Massachusetts Comprehensive Assessment System (MCAS), and Kentucky Instructional Results Information System (KIRIS). As the tests are governmentally controlled, educators have limited influence on the content of the tests. Because of this, educators must prepare students to be ready for any material that may be presented.

Standardized tests are an important tool for educators. The standards on which the tests are based are also an important tool. Without standards, educators could not create programs without inquiring about what students had to learn. Standards tell educators exactly what students must know, allowing educators to concentrate on teaching rather than deciding what to teach.

An example of standards is the Massachusetts Curriculum Frameworks. The frameworks set objectives for students to meet throughout their school experience, for

each subject and each grade taught. A trait also seen in the frameworks is suggestions on how to teach students what the standards mandate. This is, according to critics of standardized tests, as well as standards, not a common occurrence.

Essays are another common form of assessment where a question, relatively open ended, is left to the students to answer. The data gathered by essays are typically on research skills, writing habits, depth of understanding, as well as memory of basic facts and procedures. Essays come in many types, such as the short essays used for test questions, to reports, completed by the students over several days or even weeks. Essays also provide an opportunity for the educator to examine the thought process of an individual and tailor feedback to their student's particular needs (Brown, 2001).

Another type of assessment, related to the essay, is the presentation. Presentations evaluate the depth of understanding, fact retention, thought process, and research skills, but de-emphasize the student's writing aptitudes. Presentations challenge a separate set of skills, such as public speaking and organizational skills. The feedback for this assessment is even greater as now the student can not only be evaluated by the teacher, but their peers as well (Brown, 2001).

Another useful aspect which can be added to some other tools is group work. Group work evaluates the ability of a student to work in a team and further examines the student's ability to organize. Typically, groups write reports or give presentations. Hence these assignments can also evaluate knowledge, research skills, and public speaking skills. Other skills, depending on what type of assignment is to be done by the group, can be assessed as well (Brown, 2001).

A ubiquitous element of education is the multiple choice question. Multiple choice questions are a very speedy method for probing what students remember. A student is given a question and a choice of answers, one of them being correct, and is asked to choose. While multiple choice questions are easy for instructors to create and grade, the usefulness of multiple choice questions for assessing higher levels of understanding, however, is disputed (Simkin & Kuechler, 2005).

Asides gathering information on student learning, educators are also tasked with interpreting that information. To this end, there are assorted tables, charts, and papers published by assessment experts, at the educators' disposal. Several tables are present in

Brown's work. Mentioned in the work, and accompanied with a brief table, is Bloom's Taxonomy of Learning Objectives. As the taxonomy is such important and powerful tool, it will be discussed here in detail.

Blooms Taxonomy has become a key component of modern educational theory. It is so powerful because it makes an earnest attempt to quantify student knowledge and understanding. It quantifies learning with six levels; Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. *Knowledge* refers to merely knowing a fact. *Comprehension* is being able to understand the fact. *Application* is being able to use the fact, while *Analysis* consists of being able to use the fact to better organize a task into components. *Synthesis* is the ability to take different tasks and bring them together, and *Evaluation* is the capacity to make an informed and proper judgment (Simkin & Kuechler, 2005).

Bloom's hierarchy has been used by many educators since its creation in 1956 to better educate their students (Krathwohl, 2002). This becomes a tool when provided with the ability to recognize the signs that a student is at some level of understanding. An example of what signs educators look for is in a table in "Multiple-Choice Tests and Student Understanding: What Is the Connection?" (Simkin & Kuechler, 2005)

Table 1: Bloom's original cognitive taxonomy

Level	Description	Evidence of Ability
1. Knowledge	Rote memory; recognition without (necessarily having) the ability to apply learned knowledge	Answer strongly cued T/F or multiple-choice questions
2. Comprehension	Information has been assimilated into students frame of reference	Student can understand problems similar to those given in class
Translation	Gives meaning to information	Can put into own words
Interpretation	Changing from one form of representation to another	Can classify material according to experience
Extrapolation	Use information in new context	Ability to predict consequences
3. Application	Abstracts from learned material to solve new (analogous) situations	Uses learned techniques and knowledge in the production of solutions to novel (but structurally similar) situations
4. Analysis	Decompose learned material into components and understand the relationships between them	Recognize unstated assumptions; identify motives; separate conclusions from supporting evidence
5. Synthesis	Combine the elements of learned knowledge (abstracted in the application level and explicated into separate units in the analysis level) into new integrated wholes	Knowledge creation; fill gaps in existing knowledge or procedures to solve unstructured problems
6. Evaluation	Makes judgments about the value or worth of learned information	Produces judgments of worth concerning directions of knowledge acquisition

As can be seen in Table 1, there are several ways a teacher can, through simple observations, discern the level of understanding a student has on a particular subject. The table itself makes sense when one considers the definitions of each of the levels of the

hierarchy. However, there are other tools which are used to evaluate the results of assessments. One such tool, similar to this table, is the rubric.

The rubric is itself a type of table. In its rows, it has, for a specific portion or trait of an assessment task to be performed by a student, what the teacher expects from a student at various levels of understanding. This can also be used to grade papers, in which case it has the standards required for certain grades to be met for those portions of the report. This device has a great deal of flexibility for instructors, and can also assist students should the instructor choose to hand out a copy. There are several types of rubric, but the vast majority of them have the table format in common (Mueller, 2008).

2.3 Educational Legislation and Reform

The federal government has enacted many pieces of legislation to help ensure that SWD receive equal opportunity and access to education. At the forefront of these policies are four key laws: The Elementary and Secondary Education Act (ESEA), No Child Left Behind (NCLB), The Individuals with Disabilities Education Act (IDEA), and the ADA.

2.3.1 United States Legislation

ESEA was passed by Lyndon Johnson in 1965. There were several reasons for the implementation of this law. First, declining SAT scores around the country raised government concern about the quality of public schools. Second, surveys regarding academic proficiency demonstrated that the United States was far behind when compared to the international level (West & Peterson, 2003, pp. 4-5; Nichols & Berliner, 2007, p. 4). Lastly, an achievement gap between low income and minority students versus those from more affluent backgrounds was shown to exist. These were the reasons for the passage of the ESEA (Nichols & Berliner, 2007, p.4; Kantor, 1991, p. 51).

Based on prior research, which found a "correlation between low educational attainment and poverty", Johnson and Heller developed an educational reform designed to provide government funding to schools with a large proportion of disadvantaged students (Nichols & Berliner, 2007, p.4; Kantor, 1991, p. 51). The goal was to provide equal opportunity education to children from lower-class families. Title I of the ESEA legislation outlines the criteria for schools to receive federal funding. Thus, any school receiving funding from the government is referred to as a "Title I" school.

While ESEA did not pertain specifically to students with disabilities, President Bush's NCLB, passed in 2002, made key changes to the old laws. NCLB aimed to narrow educational achievement gaps, and to hold schools and administrators accountable for the academic progress of their students (Abernathy, 2007, p. 3; NCLB, 2002, 20 § 6301 (3), (4)). Schools receiving federal funding under Title I are held to stringent standards each year. In order for schools to continue receiving federal funding they must develop and conduct an annual student assessment to test proficiency levels in three core areas: reading, math, and language arts.

NCLB requires Title I schools to develop their own individual testing curricula with the expectation that these schools will make small gains in Adequate Yearly Progress (AYP), and the AYP is then used for determining Annual Measurable Objectives (AMO) for all students. Schools can make the choice to not participate in NCLB, but federal funds would then be withdrawn (Abernathy, 2007, p. 4). The goal of NCLB is ultimately to provide incentive for educators to ensure that no student, or group of students, is left behind in reading, language and mathematics abilities.

AYP means that each state must develop, and administer, a standards-based accountability program that demonstrates student proficiency levels in reading, language arts and mathematics. Proficiency levels are determined and analyzed based on yearly standardized test scores. These tests are designed by each state individually and approved by the U.S. Department of Education (USDE) (Abernathy, 2007, p. 5; Sunderman et al., 2005, p. 5). These tests allow states to observe the rise, fall, or consistency of their students' scores each year. States can then get an idea of which schools need increased academic support if they are not achieving AYP. The goal is to have all schools be 100% proficient by the year 2014.

NCLB also mandates that states develop AMO to assess whether AYP is being achieved and, if not, take action to raise student scores (Sunderman et al., 2005, p. 23). AMO is the score that each state wishes to achieve for their schools every year. If a school demonstrates 70% proficiency in one of the core subjects in a particular year, the goal for the next year would be to increase that number by 5% each year to reach 100% Proficiency by 2014. NCLB aims to produce gains in core subjects that are viewed to be

the most important for all students. If the AMO score is reached, a school has achieved AYP.

For schools or school districts that fail to reach their AMO targets, NCLB has a five year series of sanctions to attempt to get that school or district back on track. These sanctions are intended to be a way of encouraging schools and educators to make sure that student proficiency is moving towards 100%. The following section lists the sanctions for those schools failing to make AYP:

> 1 year- School is identified as, "in need of improvement."
>
> 2 years- School remains, "in need of improvement." Schools must improve their curriculum plans and inform parents of the school's "improvement status" and allow for the option of transferring the child, and appropriate school funds to help facilitate that transfer, to a different school within the same district. This process is known as "inter-district transfer."
>
> 3 years- Districts must provide supplemental educational services to students in "failing" schools, including, "tutoring, remedial, and other academic services." Additionally, schools must improve their aforementioned "improvement plan" and are subject to the same consequences as they were after 2 years of failure.
>
> 4 years- Corrective action is taken, such as, replacing staff with higher qualified educators and an overhauling of the school or district's curriculum.
>
> 5 years- School restructuring includes, but is not limited to, replacing all staff and contracting out for "private management, state intervention, or other restructuring efforts."
>
> (NCLB, 2002, 20 § 6311; Sunderman et al., 2005, p. 24; Abernathy, 2007, p. 8)

The next crucial piece of legislation is The IDEA (formerly known as Education for all Handicapped Children Act of 1975). IDEA has four main purposes: To ensure that all children with disabilities have available to them a free appropriate public education that emphasizes special education and related services designed to meet their unique needs and prepare them for further education, employment, and independent living, to ensure that the rights of children with disabilities and their parents are protected, to assist States, localities, educational service agencies, and Federal agencies to provide for the education of all children with disabilities, and to assess and ensure the effectiveness of efforts to educate children with disabilities (USDE, 2008).

IDEA requires public school systems to develop Individualized Education Programs (IEPs) for each student. The specific details contained in each IEP reflect the individualized needs of each student. Each student's IEP must be developed by a team of knowledgeable persons and must be at least reviewed annually. The team includes the child's teacher, the parents, the child (if deemed appropriate), a qualified agency representative in the field of special education; and other individuals may be added at the parents' or agency's request (USDE, 2008).

Finally, there is the Americans with Disabilities Act of 1990. The purposes of the ADA are as follows: to provide a clear and comprehensive national mandate for the elimination of discrimination against individuals with disabilities, to provide clear, strong, consistent, enforceable standards addressing discrimination against individuals with disabilities, to ensure that the Federal Government plays a central role in enforcing the standards established in this chapter on behalf of individuals with disabilities, and to invoke the sweep of congressional authority, including the power to enforce the fourteenth amendment and to regulate commerce, in order to address the major areas of discrimination faced day-to-day by people with disabilities (ADA, 2008).

Title II of the ADA requires that state and local governments provide equal opportunity for people with disabilities to benefit from all of their programs, services, and activities (e.g. public education, employment, transportation, recreation, health care, social services, courts, voting, and town meetings) (ADA, 2008).

These four pieces of legislation helped establish the framework for equal opportunity education in America. The ESEA, NCLB, and IDEA addressed a growing national concern about the state of public education in this country. The ADA addresses a more broad concern for the equality of all people with disabilities, but education is still mentioned specifically within its purpose. While these laws do not all pertain specifically to informal education, many of the provisions within the laws mandate that all buildings and programs, not just schools, provide access to SWD. This would force informal educators to update their current programs and buildings, and adapt to conform to a more UD.

2.3.2 Strengths and Weaknesses of U.S. Disability Laws

Overall, American disability laws and policies have helped create many important changes. Laws require schools to provide equal opportunity and access to their programs and events. Other provisions require buildings to meet certain codes to provide access to SWD. The formation of IEPs also helped students with disabilities reach their full potential by giving them a support group to work with, and requiring that teaching assistants be certified to accommodate the unique needs of each student. Additionally, under IDEA, parents can file an appeal with public and state education agencies if they feel these policies have not been upheld (USDE, 2008).

Despite all of the positive advancements that have come as a result of these laws being passed, there are a number of concerns regarding the specifics of these regulations. One of the main concerns is that even though the federal government has passed these laws, realistically, state and local officials may have a hard time implementing and maintaining so many policies effectively. While these laws clearly have good intentions, issues such as lack of properly trained staff members and overcrowding in the classroom make it difficult to dedicate enough time to each student with disability (Schmidt, 2008).

Another concern is whether or not it is economically viable to expend valuable resources on individuals who may not be able to contribute to the economy of his or her community. The argument is that for every dollar that is spent on special education, a dollar will be taken away from those people that will be fully competing for economic advancement (Cizek, 1999).

The NCLB has also created widespread controversy. The current status model of NCLB places schools with multiple sub-groups at the highest risk for sanctions from the federal government. While NCLB recognizes that schools with multiple subgroups perform poorly on annual standardized tests, these schools are required to produce the largest annual proficiency gains. In essence, NCLB contradicts itself. On top of that, the school will be sanctioned if just one subgroup from one grade fails to meet AMO in any of the three core subjects. Therefore, the more subgroups contained in a particular school or school district, the more opportunities that school or district has to fail, and failure for multiple years in a row will result in increased sanctions for that school, which clearly will not help educators increase test scores (Schmidt, 2008).

The government and NCLB have also been criticized for failing to incorporate educators and administrators into their policymaking. Since the educators and administrators are the people that are actually affected by these policies, it would make sense to include them in discussion on how to improve current rules and regulations (Schmidt, 2008).

Another criticism of NCLB is that schools are required to be 100% proficient in the core subjects by the year 2014. This provision was intended to create a deadline, narrow achievement gaps, and push all schools towards 100% proficiency. While this is a noble effort by the federal government, at the local level, school administrators view as unrealistic and unattainable. Since SWD have a tendency to work at a slower pace, "requiring all subgroups in a school and all schools within the state to attain equal standards of proficiency in the same amount of time is highly unrealistic…" (Schmidt, 2008, p. 32)

NCLB demonstrates that the government has all intentions of narrowing the nationwide achievement gap. Along with IDEA, ESEA and the ADA, NCLB has laid an important groundwork for providing equal opportunity education to SWD, as well as many other subgroups. This is an important step towards equality and while the laws are not perfect, they do reflect that the government recognizes the need for change and improvement, and is willing to do something about it.

2.4 Disabilities and the Barriers They Create

There are a myriad of disabilities that can affect the learning styles of a student. This section of the literature review will focus on sensory, physical and learning disabilities (LDs) and attempt to identify the barriers to learning that these disabilities present, as well as some examples of what can be done to overcome these barriers.

2.4.1 Sensory Disabilities

Sensory disabilities can be broken down into the two main categories of hearing and visual disabilities. The degree of impairment in each of these groups can range from minor deviations from the norm to a complete loss of sensory function.

According to the American Speech Language Hearing Association (ASHA) approximately 28 million Americans have a hearing impairment with 17 in 1000 children

under the age of 18 affected by hearing loss. Hearing loss can be congenital, meaning it is present at birth, or it can be acquired. Acquired hearing loss in children can be caused by disease or injury such as measles, mumps, head injury and noise exposure (ASHA, 2008).

The main categories of hearing loss are conductive and sensorineural. Conductive hearing loss results in sound being unable to conduct through the outer or middle ear normally. A person with conductive hearing loss will generally only have mild to moderate hearing impairment as their inner ear still has the ability to decipher sound. For this reason, conductive hearing loss can generally be counteracted simply by amplifying sound into the ear though the use of a hearing aid. Sensorineural hearing loss is caused by insensitivity of the cochlea in the inner ear or impairment of the auditory nervous system function. Sensorinuel hearing loss can range from mild to complete deafness (ASHA, 2008).

Hearing loss creates many barriers to students in an educational setting. Students with partial hearing loss may misunderstand things the instructor is saying and those without any residual hearing will be unable to hear anything said and would have to rely on reading lips or require an interpreter. Also, hearing loss can cause the peers and educators of a student with hearing loss to become frustrated with the difficulty in communicating with the student. Students with hearing loss can develop speech differences which cause them to be self conscious about their speaking which increase the communication barriers caused by hearing loss (ASHA, 2008). Problems faced by the profoundly deaf are visual overloading and a language barrier caused by American Sign Language (ASL). Because a deaf student has to rely mostly on visual stimuli to obtain information, visual overloading can be a problem. For instance, if a student with deafness relies on reading the instructors lips to understand what they are saying, they may not be able to simultaneously view a graph on an overhead projector. Also, in the case of students that have a teaching assistant that is signing to them, there can be issues with communicating spoken English and translating it into ASL. Because there are not direct translations for all English words into ASL some of the material can be lost in translation (Simone et al., 2007).

The barriers posed by hearing loss are by no means insurmountable. Most conductive hearing loss can be counteracted with the use of a hearing aid. Though

hearing aids also pose the risk of amplifying background noise, this too can be overcome by having an instructor wear a microphone which transmits what they are saying directly to a student's hearing device. For severe hearing loss an interpreter may convert spoken word into ASL and sign the verbal information to a student. As mentioned above, there can be a language barrier between ASL and English but this can be minimized by concise wording on the part of the instructor and experienced translation by the teaching aide providing the signing for the student. Also, the use of visual text such as PowerPoint presentations and overhead projectors can circumvent a student's need to hear much of what is being said. By placing text and graphs together on a PowerPoint slide, visual overloading can be reduced by eliminating a deaf student's need to hear what is being said while looking at the item being discussed. (Simone et al., 2007; Gilde et al., 2008)

As with hearing impairment, there are varying degrees of visual impairment. Visual impairment can range from mild loss which can be corrected by glasses or contacts to complete blindness. A person is considered legally blind in the U.S. if they have a field of vision of less than 20 degrees or they cannot with the help of corrective lens see at 20 yards what someone without impairment could see at 200 yards (Idaho Commission for the Blind and Visually Impaired, 2008). Visual impairment can be congenital or a result of injury to the optic nervous system from trauma or disease.

The difficulty in seeing material that is being covered can greatly devalue an educational program for a student. Students with complete blindness will be unable to visualize concepts being taught, and thus will require different methods of teaching the material to put it in terms that students with no vision will understand. This and other important concerns, such as safety with exhibit animals and obstacles, are amongst the prime concerns with visually impaired students.

Most cases of slight visual impairment can be simply corrected with glasses or contacts. The barriers caused by significant or complete blindness are compensated for by using teaching methods that appeal to the non-visual senses (Simone et al., 2007; Gilde et al., 2008). For example, a student may not be able to see a volcano, but a model could be made which the student can feel to develop an understanding of the structure of a volcano.

2.4.2 Physical Disabilities

For the purposes of this report, disabilities that affect the mobility of students will be termed physical disabilities. The causes for physical disabilities vary from trauma to birth defects, to complex genetic issues. A few examples of more common physical disabilities will be discussed below.

Paralysis is a common physical disability. There are several causes for this symptom. The most obvious cause is trauma to the spine, which can leave the legs paralyzed (paraplegia) or the body completely immobile (quadriplegia). The placement of the causal injury along the spinal column is the sole determining factor for which extremities are paralyzed, if trauma is the cause of paralysis (Gilde et al., 2008).

Paralysis can also be caused by genetic issues, such as Spina Bifida, a birth defect, and Multiple Sclerosis, a genetic disorder. Spina Bifida is a birth defect where the spinal cord is exposed to amniotic fluid or, in severe cases, at birth. Spina Bifida can manifest no symptoms at all, or result in loss of limb use. Multiple Sclerosis (MS), another factor which can induce paralysis, is a genetic disorder. The cause of paralysis in MS is damage to the nerves resulting from the disintegration of the nerve sheath that surrounds the nerve (Gilde et al., 2008).

Another condition capable of disabling a student is cerebral palsy. Cerebral palsy, unlike spinal trauma, MS or Spina Bifida, affects the brain itself. Specifically, it damages areas of the brain responsible for movement. While Cerebral Palsy is not a progressive disease, it is permanent. The effects of Cerebral Palsy can be mitigated with mobility aids and therapy, but the underlying cause will always be present. Paralysis is not caused by cerebral palsy, but the inability to properly control movements is (NINDS website, 2008).

Neurological disorders are not the sole cause of physical disabilities. Muscular Dystrophy, a genetic condition, also causes physical disabilities. Muscular Dystrophy (MD) stems from a genetic defect which makes the body, or parts thereof, unable to produce dystropin, an important muscle protein. MD renders its sufferers weak, and eventually unable to move as the disease progresses. The least severe forms of MD affect the face, hands, or other smaller portions of the body. The most severe forms of Muscular dystrophy are fatal (Gilde et al. 2008).

Whilst the effects of physical disabilities can be dramatic, there are some accommodations available to assist students in overcoming them. One common example is the wheelchair. This device allows a student with only the use of their arms to move around large spaces with relative ease. It does, however, have limitations concerning stairs and rough terrain. Thus, elevators and ramps are standard on buildings today. Another example of an assistant is a scribe, who can take notes for a student who cannot write. Lastly, other aides are available to ensure the safety and well-being of a student with physical disabilities (Gilde et al. 2008).

2.4.3 Learning Disabilities

According to the Learning Disabilities Association of American, learning disability (LD) or learning impairment refers to a "neurological disorder that affects one or more of the basic psychological processes involved in understanding or in using spoken or written language" (LDAA, 2008). The National Center for Learning Disabilities (NCLD) defines an LD as "neurological disorders that interfere with a person's ability to receive, process, store or respond to information", (NCLD, 2008) which can create a gap between a person's ability and their performance. A learning disability can result in difficulty speaking, listening, reading, writing, spelling, reasoning, and organizing information (LDAA, 2008).

Some of the most common types of LDs are dyslexia, dyscalculia, dysgraphia, and dyspraxia, with dyslexia being the most prevalent. Dyslexia hinders a person's ability to read, write and spell. In general, the person has difficulty "establishing awareness of elements of linguistic structure" (NHCC, 2005). The person may also exhibit one or more of the following symptoms; slow reading, decoding errors (especially with the order or letters), trouble with spelling and penmanship, and trouble with mathematical computations (LDAA, 2008).

Dysgraphia is a learning disorder that affects a person's ability to write. A person suffering from dysgraphia may have difficulty spelling and printing legibly, as well as producing writing that is consistent in size and shape. They may also struggle with punctuation and capitalization. Furthermore, people may also have a writing and thinking at the same time (when taking notes, for example), which results in a slower work pace (NHCC, 2005).

Dyscalculia causes people to have trouble with problem solving and grasping new concepts (LD Online, 2007). People afflicted by dyscalculia may have trouble organizing information logically, recognizing mathematical patterns, understanding concepts related to time, and finding alternative approaches to solving problems. Some people with dyscalculia have trouble interpreting the information seen with their eyes, while others might have difficulty processing the information they receive aurally (NCLD, 2008).

Dyspraxia, sometimes called motor planning, refers to any number of difficulties with motor skills. Dyspraxia can cause difficulty with basic tasks such as raising their hand, multi-step tasks like getting dressed, or with establishing spatial relationships between two objects. Some people with dyspraxia can also experience difficulty with coordination, speech, and writing (NCLD, 2008).

Learning impairments are often coupled with other disorders involving attention and behavior. Attention Deficit/Hyperactivity Disorder (ADD/ADHD) is a neurological condition that stems from a "genetic dysfunction and not by poor child rearing" (LD Online, 2007). ADD and ADHD can make it difficult for children to sit still and pay attention for long periods of time due to the fact that they have trouble controlling their responses involving movement, speech, and attentiveness (Gilde et al., 2008). ADD and ADHD can manifest themselves in different ways. One person might fidget constantly and have a hard time sitting still, and another person may appear be sitting quietly in their seat while their mind is wandering and they are not actually paying attention.

Autism Spectrum Disorders (ASDs) are not technically classified as LDs but rather intellectual impairments. However, ASDs can directly affect a person's ability to learn. The most common types of ASDs are Autism and Asperger's Syndrome. Autism is generally diagnosed during early childhood and can affects different aspects of a child's developments, such as social interaction, communication skills, and cognitive function. Additionally, people with autism often suffer from physical problems, including, but not limited to allergies, epilepsy, digestive disorders, persistent viral infections, sensory integration dysfunction, and sleeping disorders (NAA, 2008). Many people with Autism also have a tendency to "under- or over-react to sensory stimuli". Finally, individuals with Asperger's Syndrome may be extremely intelligent but tend to restrict their learning

to one subject excessively, preventing them from becoming a well-rounded person (Gilde et al., 2008).

Other less common types of LDs include: nonverbal LD, speaking and listening disabilities, and auditory processing disorder. Individuals with certain disorders, such as auditory processing disorder, frequently possess stronger abilities in visual learning, while those people with nonverbal LDs may develop early reading and spelling skills, and be very well-spoken (Lerner, 2000).

Students with disabilities are faced with many challenges and barriers that they must work to overcome. Previous research notes three major barriers encountered by SWD: communication and comprehension, performance, and behavior (Gilde et al., 2008).

Communicating can be difficult for students that suffer from dyspraxia, due to the lack of fine motor coordination. Also, many LDs can cause students to have difficulty committing information to their long-term memory, which can cause problems with tasks such as taking tests. Comprehending material may also be a challenge. Autistic students, for example, will frequently become overly focused on one subject area and can often retain large amounts of information but still lack a fundamental understanding of the subject. Students with LDs also experience trouble imagining and comprehending concepts that they are not familiar with. Answering questions can also be a serious challenge for SWD, as many have difficulty understanding the questions and formulating an appropriate response. Some students may just repeat part of the question over and over again. Other students may struggle to pay attention or follow an instructor, and subsequently can not participate actively in the class (Gilde et al., 2008).

Trouble with comprehending material and communicating effectively can, in turn, lead to poor performance. If a student can not remember what he or she was taught throughout the course of a class, it will be difficult to perform well when it comes time to be tested. Further, if a student can not communicate with the instructors and fellow classmates, it will be difficult to assess the problem that he or she is having, and complicate matters even more. Many students also have habits that are hard to break, so it is often beneficial to follow a schedule to keep them on track and give them a sense of structure (Gilde et al., 2008).

Behavioral issues are common in SWD. Aside from having problems paying attention, students with LDs tend to have extreme reactions to sensory stimulation. Bright or flashing lights in a classroom can be very distracting, as well as certain sounds that could be bothersome to students with LDs. Students will respond differently to different types of stimulus, so it can also be difficult for the instructors to cater to each student individually, as their needs vary on a case to case basis (Gilde et al., 2008). These issues demonstrate the need for a UD to assist the students and the teachers in creating the least restrictive environment.

In the informal setting, SWD encounter many of the same obstacles they would in a classroom. Lighting may be too dim or too bright. Exhibitions that present new material to students may cause feelings of inadequacy as certain students may have very limited experience with a certain subject. For example, one may take a student with Autism to the lightning show at the Boston Museum of Science (BMOS). The thunder clap caused by the lightning and the bright light emitted from the strikes may scare an Autistic child and deter them from learning more about the subject. A student with dysgraphia may be asked to fill out a checklist of items that they encountered at the New England Aquarium (NEAQ), but if they have a severe impairment, they may have trouble performing such a task. Everyday tasks that may seem common place to people without disability can be troublesome to those with disability. With that in mind, our group's intention is to help enable informal educators to assess the learning outcomes of SWD, allowing educators to improve the quality of education and thus the quality of life for those students faced with such issues.

2.4.4 Assessment of Students with Disabilities

One key concern to educators is how to assess a student who has a disability. It is not only an ethical concern, but a legal one as well, with requirements having to be met both for SWD, as well as those students without disabilities. While the tests a teacher administers can be easily designed with all students in mind, or even tests custom tailored for students, most educators exert very little control over standardized tests. A positive point for the standardized test is that research has shown it to be reliable. While more research must be done, educators currently have some methods of assessing SWD. Some

of these are illustrated in the example the KIRIS below (Simkin and Kuechler, 2005; Kortez, 1997).

The KIRIS test is one of the most inclusive statewide tests in the United States for students with disabilities. It is administered to almost every single student, regardless of learning differences. Its purpose, similar to the MCAS, is to ensure that the educational standards set by its respective state are met. The test, however, is performed by those with differences with the aid of accommodations. These vary from something as simple as larger print for the vision impaired to the more complex, such as paraphrasing of instructions to those with cognitive problems.

The study in question, done by Kortez, examined the grades of SWD and without who took the KIRIS exams, and what their accommodations were, if any were used. The goal was to investigate whether or not the test discriminated unfairly against SWD. The results were somewhat surprising, and are as follows. For example, the study cites that the accommodated students with disabilities fared noticeably better than normal mainstream students in certain areas. While there are other explanations for this, it does call the validity of these practices into question (Kortez, 1997).

Another thing to be considered with mainstream tests, and education in general, is the familiarity of instructors and test proctors with those they were testing. In a scientific study, Fuchs et al discuss the affects of instructor familiarity on the disabled students. This was done by having four groups of students. Two groups, one with learning differences, the other without learning differences, were made familiar with their instructors through play and other activities. The other two groups, again one mainstream, the other not, were not afforded this privilege. The results showed that familiarity did not make as noted a difference in test scores for the mainstream students as it did for those with disabilities. Furthermore, it indicated that those students who were unfamiliar with their instructors performed poorly when compared to those who were allowed to interact with the educators before testing (Fuchs et al, 1985).

These types of research are of continuing debate amongst teaching professionals. While Fuchs et al do not offer their own specific argument; other works may offer an explanation. The students, feeling safer and more valued by their teacher wanted to do better for them out of friendship, and thus they worked harder and attained better scores.

While this argument is not supported by the data for those without disabilities, it stands to reason that it is a valid hypothesis and could possibly be the topic of further investigation (Shepard, 2000).

2.5 Universal Design

Universal Design is the idea of designing something for as many people as possible without having to create modifications to it. Examples of it exist nearly everywhere, such as the gentle sloping ramps from sidewalks to the street. While this does accommodate wheelchairs, it also accommodates walkers and those who can move unassisted as well. A key feature, sometimes not intended, is the positive effects UD typically has on all users.

The movement, like its cousin in education, came about due to various reforms in culture and law. Examples of some of the laws, examined above, are the IDEA, NCLB, and the ADA. The unifying theme of these regulations is their goal; improvement of education for the disabled. These laws, however, only set standards to meet. What they do not do, the gap that UD helps to fill, is suggest how to meet them. With that said, the genesis of UD in education can now be better examined.

The creator of the movement is Ron Mace, who originally conceived it for use in architecture and other building/city layout fields. With its success, professionals in other fields began to see its potential elsewhere. Education soon began to use UD to improve education of SWD. When it was ported to education, the original seven principles of UD were condensed down to three (Zeff, 2007). These new principles condensed the principles for UD into a simpler, more applicable system to education, called Universal Design for Learning.

The three UDL principles are to allow for multiple forms of teaching students and answering teacher questions, as well as catering to the students' interests. The point of multiple forms of instruction is to be able to explain the material in multiple ways, to accommodate students with different learning styles, as well as choosing a form of instruction such that the students understand it the first time around. What is meant by many ways to answer is that, when students are tested, some flexibility should be given to the methods they choose to answer the question with. Furthermore, the tests should be worded so that the students understand what is asked of them.

The last principle is related to motivating the students, a factor explained by Shepard in "*The Role of Classroom Assessment in Teaching and Learning*". If students are motivated they will strive to learn more and, in theory, retain more information. By taking advantage of this, the last principle further improves knowledge retention and understanding for all students. In other applications of these principles, it is seen again and again that motivation is important.

UD in education is, in short, the creation of a curriculum which is inherently friendly to a variety of users with a variety of abilities. Currently there is much research and debate into how to apply UD best to education. What can be agreed on, however, is that there are certain practices currently being employed by educators that do not utilize a UD. This is due to the fact that, in current practice, students are offered accommodations for standardized and other tests that are not, by default, in large print, more simply explained, or given over longer time periods. Though these are accommodations made for the students, due to the fact that the tests were not engineered with these users in mind at their inception make them noncompliant with UD. Currently, UD is beginning to take hold, but in some instances its application to education is limited.

2.6 Summary

The literature review was essential to the next steps of the project. Without understanding the differences between formal and informal education, appropriate assessment tools could be chosen. Without an extensive knowledge of assessment, potential assessment tools could not be created or evaluated. Without an understanding of the laws motivating the reforms, along with some knowledge of the motivations for those laws, the reason behind even creating such a tool would not exist, potentially destroying this project's applicability. With the above research conducted, the team was able to produce a methodology to search for more information as well as to discuss potential directions for the project. The methodology below was used to create this new tool, and was developed with the knowledge summarized above.

3. Methodology

The purpose of this project was to create a system by which assessment could be adapted from formal education to informal education, while accommodating students with disabilities. In pursuing this, the team conducted a great deal of research. The first step in developing this system was an extensive literature review. The information attained was carefully analyzed to determine relevance, as well as to form a knowledge base from which further research could be conducted.

After building a solid knowledge base to interview professionals in the field, more informed research was conducted, namely in the form of interviews. The information gathered from those interviews was synthesized to develop a framework that the team would use to generate a set of recommendations for educators and future project groups regarding the most appropriate type of assessment or evaluation that could be used to assist both formal and informal educators in the assessment of student learning in the informal environment, particularly for students with disabilities. A set of objectives created by the group through literature review and the interviews, and the methods used to accomplish these objectives, are shown below.

Goals

- Gain insight into current issues and practice in assessment
- Establish knowledge base encompassing all disabilities types and the barriers created by these disabilities
- Find out what methods exist to accommodate SWD
- Determine factors which affect assessment of SWD
- Inquire as to what methods formal and informal educators currently utilize to teach SWD, and attempt to apply formal assessment methods to the informal setting, thus, assisting a variety of educators
- Learn what professionals in the field believe can be done to improve student assessment in the informal education setting
- Determine whether informal and formal educators would be interested in working together using an appropriately selected assessment tool, and also whether applying this tool would be too costly or require too much time and resources.

- Determine the learning objectives for SWD in the formal setting from formal educators, and the learning objectives in the informal environment from staff and on-site professionals
- Examine state educational frameworks to see if there is any connection with informal learning objectives
- Make a list of specific recommendations to formal and informal educators. These recommendations, based on the groups' analysis of acquired data, will suggest the most practical assessment technique or techniques that can be implemented to monitor the progress of student learning in an informal education setting
- Open the lines of communication between formal and informal educators. Open communication between formal and informal educators will aid greatly in assessing SWD. Increased communication will ideally help formal educators probe the background knowledge of students, familiarize students with the environment prior to visiting, and allow feedback to be given to informal educators once the students have left the informal setting
- The ultimate goal is to have formal educators perform an assessment of the students before and soon after visiting an informal education center, and send feedback to the informal educators, allowing formal educators to assess the knowledge retention of students when visiting a site, and at the same time, allowing informal educators and staff to adjust their programs and exhibits in accordance with the assessment of the formal educators
- When a technique is selected to assist the informal educator, present it in a manner easily accessed and applied by educators

Literature Review

The team conducted a thorough literature review of books, papers, journal articles, reports, websites and other related documents pertaining to state educational frameworks, informal education learning objectives, UD theories, as well as methods of student assessment, disabilities and disability legislation. This review gave the team crucial information on the various types of disabilities, United States legislation that has helped advance equal rights for people with disabilities, current practice in student assessment utilized in both the formal and informal educational settings, and the theory behind assessment, or as the group found out, evaluation, in informal education settings with primary considerations for SWD. The literature review gave the team a good knowledge of the aforementioned areas, and by doing the review first, this allowed the group to develop independent theories and conclusions that would ultimately lead to the formation of the recommendations for educators and future IQP teams.

Interviews

The group recognized that in order to assist educators in student assessment, professionals in the fields of formal education, informal education, and special education must be solicited for interviews. These professionals had first-hand experience in the field of education, and their insights, along with a careful analysis of the tools currently used by educators, provided sufficient information for the team to make recommendations. Educators were questioned about the validity, feasibility, and applicability of an assessment tool that would require open lines of communication between formal and informal educators, as well as their willingness to participate in such a program. From these interviews, several educators referred the group to alternate sources of valuable information.

Twenty-one interviews were conducted with formal, informal and special educators. Six formal educators, six informal educators and nine special educators were interviewed. Of the six formal educators, four are professors at the collegiate level with experience and interest in student learning assessment. The other formal educators interviewed are a middle school assistant principal and a former science teacher. The six informal educators are represented by an education coordinator, two directors of education, one manager of education, a program educator, and a manager of research and evaluation. All of these educators are employed at various science museums ranging from the BMOS to the Science Discovery Museum in Acton, Massachusetts. The nine special educators interviewed are comprised of two directors of education, a director of assessment, an executive director, an assistant director, a curriculum specialist, two special education teachers and an evaluation team facilitator.

A general understanding of classroom assessment and factors affecting assessment was gained through the four interviews conducted with WPI professors. The motive for these interviews was spurred by the similarity of informal education programs to classroom learning. These interviews gathered data on formative assessment methods, assessment technology, and factors that affect learning. The goal of interviewing the four professors was to identify reliable assessment tools that could potentially be valid in an informal setting or employed in formal settings to provide feedback to informal

educators. An outline of the questions used for the professors' interviews can be found in Appendix C.

The activities of middle school teachers, informal educators, and special educators before going on a trip, during a field trip and after a trip were investigated to gather information about the current practice in student assessment. This material was used to build an understanding of the current state of informal learning assessment. In this area the project group was particularly interested in what schools did to prepare for and review trip activities as well as what informal educators provided in these areas and whether there is an overlap between these two areas. As a general awareness of available services and patterns of activities developed, the project group began to ask questions pertaining to the willingness of educators to employ the services of informal educators and the techniques used by other educators. The list of questions asked during these interviews can again be found in Appendix C.

Specialty schools were contacted to determine what effects certain disabilities can present to assessment of learning and how these issues can be addressed. Interviews were conducted with specialty teachers and coordinators that have experience working with learning, emotional and behavioral, sensory, and mobility impairments. The intent of these interviews was to provide knowledge that would allow for a universally designed process of goal-oriented learning evaluation. To accomplish this, questions for special educators were directed toward what the educators' goals for their students were during field trips and what the educators were doing to assess completion of these goals. Questions used during interviews with special educators can be found in Appendix C.

Document research of state educational frameworks and informal education program objectives was also conducted. After the research, a comparison of informal program learning objectives and state learning standards was conducted to better understand the similarities and differences of formal and informal education. The research was also done to better quantify the capacities of informal education.

Due to the fact that several of the informal educational cites interviewed were situated in Massachusetts, the Massachusetts State Framework (MSF) was examined in particular detail. The Framework was examined using Blooms Taxonomy of educational objectives. Table 2 demonstrates how educational objectives of the educational standards

as well as the informal education programs were evaluated with respect to Bloom's Taxonomy. Verbs listed in the third column of the table, along with the meanings of the taxonomy levels, were compared with those found in the stated objectives of the learning programs. These verbs were taken from the OfficePort website (OfficePort, 2002).

Table 2: Objectives Matrix

Blooms Level	***Explanation of Level***	***Various Associated***
Knowledge	Student knows a fact, and can recite it.	arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state
Comprehension	Student has better grasp of meaning of fact. Can reword and limitedly explain it.	classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate
Application	Student can use a fact to solve a problem.	apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write
Analysis	Student can take various sets of information apart using fact.	analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test
Synthesis	Student can create something, using fact	arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write
Evaluation	Student can pass judgment on the value of something, using fact.	appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate

The overall objective of this project was to aid informal and formal educators by introducing a new and improved tool to evaluate and assess the learning progress of students with disabilities in the informal environment. Research done by this team will form the framework for future IQP groups to proceed with the actual creation of an assessment tool for educators. Interviews indicated where educators thought assessment in informal education could be improved, and in some cases, the group found that there was currently no method of assessing students with disabilities in the informal setting. Thus, we attempted to determine the most appropriate assessment technique to apply, utilizing a UD, that would aid educators everywhere as well as making learning fun and informational outside the classroom. Our schedule for the completion of our deliverable is shown in the Gantt chart below.

Table 3: Schedule for Completion of Project

Task	A-Term	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Literature Review								
Interviews								
Determine Most Appropriate Assessment Method								
Final Results								

4. Findings

The findings of this project are focused on field trips, the learning goals of formal and informal educators on trips, and methods of evaluating student learning resulting from the field trip activity. Information was gathered through document analysis and interviews. Document research was used to determine specific learning objectives of informal educators and compare these goals with state educational frameworks. Interviews were conducted with teachers in the formal education setting, curriculum coordinators, informal educators, special education teachers and educational evaluation professionals. These sources provided data on the purpose of field trips as well as what is being done by formal and informal educators to assess students' learning on their excursions. Additionally, methods used for formative assessments in the formal education setting that could be employed in an informal setting were investigated. Different assessment methods and accommodations for students of differing abilities were also determined. Finally, formal and informal education sources were asked what assessment and evaluation tools they would be able and willing to use to provide a mutually beneficial system for student assessment and program evaluation.

4.1 Learning Objectives in Informal Education Programs

When the team sought out interviewees, background research on the institutions where the interviewees worked was also conducted. While educator websites were used to acquire contact information, informal educational web pages also provided information on informal educational programs. This examination led to the examination of the websites of informal institutions and state curricula. There was one pattern that became clear when informal educational learning objectives were examined: informal educators often modeled their objectives on the state curricula. Due to that trend, when the team examined the stated learning objectives for informal programs, they also examined those of the state. This section will examine the connection between educational curricula and frameworks.

4.1.1 State Educational Frameworks

The Massachusetts State Framework (MSF) was the primary framework to examine during the analysis of informal education centers. The reason for the preference of the MSF was that nearly all of the informal sites where interviewees worked were located in Massachusetts. After the Massachusetts frameworks were examined, the VELS (Victorian Essential Learning Standards) in Victoria Australia were examined. This second examination is due to the fact that some informal education sites where interviewees resided, such as CSIRO, were in Victoria, and cited the VELS. Excerpts from the each set of standards are provided in the appendices (Appendix A) to supplement the information below.

The MSF is divided into 4 strands, Physical Sciences, Earth Science, Technology and Engineering, and Life Science. The Strands are broken down into sets of grade levels for the pre k to 2nd grade range, 3rd to 5th, 6th to 8th, and the four high school years. The majority of the standards, across the 4 strands, were found to cover the Knowledge and Comprehension levels of Bloom's. While the majority of standards met the first two levels of Bloom's Taxonomy, there were several standards that met the Application level as well.

Several examples of objectives at the first two taxonomy levels are scattered throughout the MSF. One example is standard 6.2 on page 94 of the Technology / Engineering strand at the high school level: "Differentiate between digital and analog signals. Describe how communication devices employ digital and analog technologies (e.g. computers, cell-phones)" (Mass DOE, 2008). The objective asks students to cite differences between the two types of electrical signals. This requires that they know what the signals are and their characteristics. This is on the Comprehension level of Bloom's taxonomy (Mass DOE, 2008).

Another observation of the MSF was taken from the Life Sciences strand. The observation was that the objectives rarely reached the Application level of the taxonomy before high school. Another strand of the framework, Physical Sciences, also shares this trait, as does the rest of the framework. In both the Physical Sciences and the Life Sciences strands, the Application level of Blooms Taxonomy was reached with many of

the learning objectives. The Application level was reached in many other high school grade strands, such as Technology and Engineering (Mass DOE, 2008).

While the MSF objectives rarely exceeded the third level of Bloom's Taxonomy, higher level objectives do exist. An example of a higher level objective, on the Analysis level, comes from the Earth Sciences strand of the MSF. High school level objective 1.8 on page 34 of the framework says that students will be able to "Read, interpret, and analyze a combination of ground based observations, satellite data, and computer models to demonstrate Earth systems and their interactions" (Mass DOE, 2008). The verb analyze makes the connection to the fourth level of Bloom's apparent (see Table 3). The activities the students are asked to do, the primary factor in determining the Bloom's level of an objective, involve collecting and analyzing data.

With the learning objectives portion of the standards examined, the team examined the framework for any further information. The group found that the MSF provided additional support to educators to help them structure their classes. While statewide objectives always provide direction, the MSF supported educators further by providing various resources in its appendices. Another form of educator support was examples of "What It Looks Like In the Classroom" (Mass DOE, 2008). The examples are summaries taken from various programs within the state of Massachusetts.

Multiple summaries are provided in the MSF (Mass DOE, 2008). The example is about how an exercise physiology classroom experimented to determine what system of the body was most affected by exercise. The students measured respiratory, cardiac, and muscular responses to exercise. The teacher, throughout the experiment, asked questions and helped to direct the students, and also discussed the results they found at the end of the experiment (Mass DOE, 2008, p.55-60).

Example classroom situations are not the only form of support the MSF provides. Each topic the standards cover has a lengthy introduction. An example of introduction material is found on page 23 for the Earth Science strand. The description for the 3-5 level states:

> *In grades 3–5, students explore properties of geological materials and how they change. They conduct tests to classify materials by observed properties, make and record sequential observations, note patterns and variations, and look for factors that cause change. Students observe weather phenomena and describe them*

> *quantitatively using simple tools. They study the water cycle, including the forms and locations of water. The focus is on having students generate questions, investigate possible solutions, make predictions, and evaluate their conclusions.* (Mass DOE, 2008, p.23)

While the above description was not analyzed in great detail, it did serve to confirm the observations of the standards. Exploring a topic will lead to the first two levels of the taxonomy being fulfilled. Classification is another activity associated with Comprehension on Bloom's. The only sentence that does not support the observations of the standards is "The focus is on having students generate questions, investigate possible solutions, make predictions, and evaluate their conclusions" (Mass. DOE, 2008, p.23). The statement does not explicitly say that students will evaluate, it merely says that the focus is on evaluating. Furthermore, depending on the depth of evaluation, the activity may only attain the comprehension level of Bloom's. An example of such an evaluation could be a student determining if his or her answer was right or wrong. A higher level evaluation would be for the student to answer why they were right or wrong.

The MSF is an excellent example of what government standards can offer. However, they were not the only standards encountered during the target research phase of the interviews. Briefly, the VELS (Victorian Essential Learning Standards), from Australia, were examined (VCAA, 2007).

When the VELS were examined, there were differences in organization from the Massachusetts Frameworks. The high school years, for example, were not lumped together in the VELS as they were in the Massachusetts Frameworks. The VELS are also designated into levels from 1 through 6. Each year after level one represents two years of school for the student, starting at the first year. The first level of the VELS is for the preschool years (VCAA, 2007).

The Science standards of the VELS start at Level 3 in the curriculum (years 3-4). The descriptions showed that the VELS have objectives at the synthesis level of the taxonomy. The VELS divides the objectives into two categories, "Science at Work" and "Science Knowledge and Understanding" (VCAA, 2007). For Level 3, the knowledge and understanding objectives are all at the comprehension level. The "Science at Work" section, however, has an objective at the Synthesis level- planning and designing

experiments. The other objectives in the section, however, are at the Comprehension level (VCAA, 2007).

The Level 4 objectives in the VELS follow a similar trend in attaining the Comprehension goal of Blooms Taxonomy. However, the Science at Work section has objectives at the Analysis level as well as the Synthesis level. The level 5 VELS for the Science curriculum features higher objectives in both categories than level 4. Analysis is reached by one of the "Science Knowledge and Understanding" objectives, while Evaluation is reached in the "Science at Work" section. The highest level of VELS, level 6, has Application level objectives in the knowledge section, and the "Science at Work" section has multiple Evaluation level objectives (VCAA, 2007).

State standards vary between countries and states, both in content and in format. In their entirety, the knowledge portion of the VELS reaches the Analysis level of Bloom's. The other component to the Science VELS, the "Science at Work" component, reaches the evaluation level of Bloom's. The MSF goes up to the Analysis level of the taxonomy in its later years. The MSF bears the most resemblance to the knowledge portion of the VELS in terms of content, but would appear to be exceeded by the "Science at Work" part.

With a brief analysis of formal educational standards, the group then conducted a similar analysis of informal education. Such an analysis was conducted to compare the two areas and discern relations between the two that may not be indicated otherwise.

4.1.2 Informal Education Objectives

Informal educators, despite the fact that they are not required to follow state standards as rigidly as their formal counterparts take care to observe the standards. This is due to the fact that informal education is seen as a supplement to formal education. Additionally, informal educators are behooved economically to provide programs that satisfy state standards. Informal educator standards have been organized in Appendix B

An example of informal educators following state curricula can be seen in the programs offered by the Boston Museum of Science (BMOS). On their website, the BMOS provides the MSF learning standards that their programs fulfill (BMOS, 2008). The BMOS is not the only informal educator to do this. The Ecotarium in Worcester also

follows this pattern, displaying the Massachusetts standards that their programs meet next to the descriptions (Ecotarium, 2008).

Informal educators in Australia also followed their local state curricula, and displayed "VELS sheets" (Victorian Essential Learning Standards) for each program offered (Zoos Victoria, 2008). When the sheets were examined, they were very similar to the framework objectives seen on the United States sites. The Zoos Victoria websites also offered other educator resources, such as teacher notes, for many of the programs listed (Zoos Victoria, 2008).

The teacher notes for the "All But Lost" program at Australia's Melbourne Zoo offer a small section with aims and objectives. The aims appear to be the learning objectives for the student, and the objectives seem to be a set of goals for the informal educator. The aims, when evaluated similarly to the statewide curricula, touch upon the first two levels of Bloom's (Zoos Victoria, Melbourne 2008). One such aim, on page 3 of the teacher notes, is that the program teaches the students that, "animals and plants are interdependent" (Zoos Victoria, Melbourne, 2008). This is clearly on the Comprehension level. Knowledge on Bloom's taxonomy is demonstrated by merely repeating facts. Comprehension is having a clearer understanding of their meaning, which is required to understand the effect of removing a species from the food chain.

The "All But Lost" program was viewed from the "early years" section of the Zoos Victoria website. The "Eat Or Be Eaten", at the Werribee Open Range Zoo, was taken from the middle years section of the larger website. The aims for the program are worded for the informal educators' intentions, while the objectives are aimed at students. Again, the learning objectives, when found, met the second level of Bloom's taxonomy (Zoos Victoria, Werribee, 2008).

Another resource is the "Student Trail" provided on the same portion of the website as its corresponding programs teacher notes and VELS sheet. The student trail is a sheet of related questions for students to answer while they go about the zoo. The student trail is an assessment in itself. As an assessment, it asks students to write down various facts about animals they see, as well as provides interesting trivia (Zoos Victoria, Melbourne 2008). The layout of the student trail is attractive, and the questions are

geared towards the Comprehension level of Bloom's. The significance of these attributes of the student trail will be discussed in the Results chapter.

Zoos were not the only informal education venues researched. The exhibits offered at the Boston Museum of Science (BMOS) were also carefully examined. Its exhibits, like the zoo's programs, are aligned with its respective government standards. The BMOS follows Massachusetts Frameworks as well as various national standards.

An example of a BMOS exhibit with standards connections is the "A Birds World" exhibit. The exhibit delves into what it is like to be a bird, and educates visitors about bird body language and alarm calls. It also offers entertaining activities, such as its sneaking corridor, where visitors try to avoid setting off a robin's alarm call (BMOS, 2008). This has an accompanying pamphlet with bird information. This pamphlet, along with the website description, gives clues to its learning goals for the informal educator. That goal is to inform the visitors about the habits and language of birds (BMOS, 2008). The program's connections to statewide objectives are clear. The website lists several statewide, as well as national, standards which it helps to fulfill. One such standard is the K-2 inquiry and experimentation skill standard. This standard states that children should know to ask questions about objects and topics of interest in their surroundings (BMOS, 2008).

The Ecotarium of Worcester also offers programs aligned with the Massachusetts Framework. The programs are varied between nature and astronomy experiences. Each program advertised on the Ecotarium website presents a brief description accompanied by the frameworks to which they are aligned (Ecotarium, 2008).

One program from the Ecotarium, Reptile Adaptations, states this for its description, "While observing live reptiles, students learn all about these animals' strategies for evolutionary success and their prospects for the future" (Ecotarium, 2008). This sentence is worded in such a way that it could be interpreted as a learning objective. It clearly defines what the visitors are supposed to learn. It also describes a small piece of the learning environment (Ecotarium, 2008). Over 30 individual standards are cited as being met by the Reptile Adaptations program. The Ecotarium website, unlike the BMOS website, does not give definitions of each standard it meets. The Ecotarium indicates the standards by subject, topic, grade level and number. The Ecotarium programs, due to

their alignment with state objectives, appear to be at the second level of Bloom's taxonomy (Ecotarium, 2008).

The Ecotarium also offers an array of exhibits. Unlike the BMOS, however, they do not have state standards listed for their exhibits. The descriptions of the Ecotarium's exhibits are not accompanied by state standards. Because of the lack of cited standards and stated learning objectives, information on the intentions of the informal educator can only be speculated. For example, the MicroDiner exhibit allows people to use microscopes to examine objects. This could be interpreted to mean that the educator wants the visitors to learn how to use a microscope, or that they want to encourage inquiry (Ecotarium, 2008).

The "Squid: Inside and Out" program at the New England Aquarium (NEAQ) involves the dissection of a squid. The description describes the program's activity, the dissection, and its goals; teaching students how to dissect things and giving them a greater appreciation for the squid's anatomy (NEAQ, 2008). Like all the other informal educational programs, the "Squid: Inside and Out" program has an accompanying set of relations to government standards. The standards listed are in a different format than those of the Ecotarium or BMOS. For the "Squid: Inside and Out" program, the standards covered are in the "Skills of Inquiry" section of the Massachusetts frameworks (NEAQ, 2008). This NEAQ program, despite not formally stating the aims of the program in an independent handout, states its objectives well. The accompanying state standards enhance the description and make the aims clear. The goal of the program is to teach students about dissection. The additional goal of educating the students about the internal workings of squid appears to be secondary (NEAQ, 2008). By demonstrating the inner workings of a squids anatomy, the "Squid: Inside and Out" program achieves the second level of Bloom's Taxonomy, Comprehension.

While the other educators had clearly defined relations to various government standards and learning objectives, the Discovery Museum did not. While they had several programs and events available to the public and to educators, the descriptions proved to be of little help in finding learning objectives. Because of the lack of state standards or extensive descriptions, an analysis could not be conducted on the Discovery Museum's programs (Discovery Museum, 2008).

The majority of programs above met the second level of Bloom's Taxonomy. Because the majority of applicable state standards also met with Bloom's Comprehension level, a correlation was found. The comparison between Bloom's levels was done to compare the learning objectives of informal and formal education together. What was found was that informal education catered to formal education. Various elements on informal educator websites indicated that this was true.

Informal education is also shown by the analysis conducted above to be useful to formal education. If informal education could only teach to the lowest single level of the taxonomy, then its use would be diminished. Because informal education can teach at higher levels, it is of extreme use to formal educators for motivating their students, and stimulating learning.

4.1.3 Field Trips

School excursions to informal education providers, such as science museums, are commonly referred to as field trips. The goal of informal educators is to enhance student learning by providing opportunities that are unavailable in the classroom (Krishna-Pillay). These trips are usually less than one full school day in length and are organized through collaboration between a school and an informal educator (Informal Educators).

Connection to Curriculum

An important consideration for informal educators and formal educators that go on field trips is the connection of the informal education programs or exhibits to the school curriculum. All the educators that are involved in organizing student field trips noted that field trips must be connected to schoolwork to be approved. Because of the schools' concern with meeting state framework standards, it is important for informal education programs to align with state educational frameworks. One method of doing this is to design the programs based on the framework (Dowd). Another method is to create the program and then look for and make apparent the connections between a program and state frameworks (Poldowsky). Also, working with a state department of education during program development to create programs that meet educational curricula makes a

program more likely to be useful to formal education teachers as an extension of classroom learning (Krishna-Pillay).

Goals of Formal and Informal Educators

One question that came to mind during the interview process was 'What are the goals of formal educators when they take their students on a field trip, and what are the goals of informal educators when students come to visit their location?'

Mainstream and special educators gave a mixed response to this question, however, mainstream teachers at the middle school level, or special education teachers that work at mainstream schools, account for only 3 of the total interviews. Al Dilley, formerly of the Lyndon Town School, told the group that the field trips are used as a way to supplement their curriculum, and stimulate the students to think, inquire, and investigate the three areas of science; life science, physical science and earth science. Beth Bohn of John Rogers Middle School concurred with this statement. Bernadette Goudey, a paraeducator at Billerica High School, added that the field trips were used as part of a reward system in which students accrue points based on behavioral and academic goals, and the point total is used to determine whether or not a student gets to participate in the field trip.

Special education schools such as the School House and the North River Collaborative indicated that the goals of the field trip were centered more on developing social skills and practicing good behavior outside of the classroom. Stefani Waterman of the Beverly School added that faculty at their school research the informal education site before visiting with students and that their students are placed into grade-level programs for field trips. Maria Cashdollar stated specifically that the field trips done with the Riverview School are part of the curriculum, promote active learning and are not merely an opportunity to get out of class for a day. Not all, but a majority of these special educators reported that their field trips are in some way tied into the curriculum of their school and agreed that field trips and hands-on learning are a great way to stimulate interest in science and that the students benefit greatly from the multi-sensory experience.

The informal educators interviewed by the group provided the other half of the perspective needed to analyze the field trip experience. Melissa Dowd, Planetarium and

Program Educator of the Ecotarium, aims to provide a free choice environment in which students can choose the things they wish to learn about. Dowd states that in developing her programs, she starts with the MSF and 'works backwards' to make these programs accessible to SWD. Alexander Poldowsky, also of the Ecotarium, concluded that the Ecotarium hopes to provide an informal environment to appeal to students that are not classroom learners, but added that their programs have more in common with a classroom environment than the exhibits. Chris KP of Commonwealth Scientific and Industrial Research Organisation (CSIRO) stated that 'Informal educators need to realize that you're not going to achieve deep learning in the one hour time', and followed that with the message that informal educators need to 'Provide an experience that will be useful for teachers and students' in the allotted time". Chris KP also responded by saying that CSIRO aims to make it more likely that students and teachers will be successful in the classroom after what they learn at the CSIRO education center. At the Discovery Museum in Acton, Massachusetts, Denise LeBlanc informs the group that they design exhibits to be hands-on with very little text, and these exhibits are designed in such a way that informal educators will have an easy time getting a response from the students as feedback. The Discovery Museum, according to LeBlanc, encourages observation, critical thinking and investigation, and adds that if possible, schools should bring their own chaperones in addition to the teachers that normally attend field trips. This puts the responsibility of keeping track of students on the chaperones, while teachers are then able to do observational studies. Several teachers said that evaluating students during a trip would be too difficult because simply keeping an eye on everyone can be a struggle. Freeing teachers of this task leaves them available to observe their students in the informal environment and get a more clear view of what programs or exhibits are the most interesting, engaging and effective. To quote LeBlanc 'People don't flunk museums. Leaving with a positive attitude is just as big a success'. Christine Reich of the BMOS noted that first and foremost the museum experience should be fun. The visit should also help students to enjoy science and think of science as a technical process, not simply the acquisition of knowledge. She continued by stating that the informal learning environment should be one of no stress and no pressure, and it should be up to the

students what they want to learn. Finally, all of these interviewees indicated that their programs and exhibits are aligned with the MSF.

In summary, formal educators are interested in supplementing the curriculum with hands-on activities that engage their students in science, as well as developing social skills and preparing their students to be productive members of the community. Informal educators are also concerned with supplementing the curricula of the schools statewide, as well as alignment with the state framework. Further, informal educators aim to create a fun, low stress, interactive environment in which students are free to choose what they wish to learn about.

Student Preparation

The findings presented in this section are intended to provide information on factors before a trip that can enhance student learning. Because of the limited time that students have at informal education providers, the project group sought to investigate what is being and can be done outside of the field trip timeframe. To determine this knowledge, informal educators were asked what materials they provide prior to a program. Also, formal teachers were asked what they do to prepare their students for a program.

Pre-trip information is an available resource from all informal science education providers interviewed. This information can be found on a museum website (Reich), sent out in a packet (Leblanc), or be provided by a visitation of museum staff to the school (Poldowsky). Though these services are made available it is the booking teacher's responsibility to request additional information and convey any sent information to the students (Poldowsky). The purpose of pre-visit material in informal education is to familiarize the teachers and students with museum programs and exhibits prior to visitation (Krishna-Pillay).

Preparing for a field trip is an important matter for special education providers. Though it has been established that field trips are tied into classroom material, the differing abilities of students can produce different performance levels in certain areas. For this reason it is important to both prepare the students for the environment and prepare the environment for the students. Informal education material needs to be

reviewed and adapted to make it accessible to SWD (Cashdollar). Many students with significant hearing loss are well below grade level reading skills (Curran). In cases such as this it is important to familiarize the student with program relevant vocabulary prior to going on a field trip (Sullivan). Building familiarity with the museum programs and environment can make students with emotional and behavioral disabilities feel more comfortable with a trip to the museum because they tend to fear unfamiliar situations (Goudey). For students with behavioral disabilities preparation can include practicing good behavior for a trip (Marshall).

Post-Trip Activities

Another set of questions the group posed to interviewees inquired as to whether or not there were any activities or evaluations provided to formal educators by the informal educators as a follow up to the school's visit, and also, if the informal educators were not providing any material for the schools, were the formal educators doing any activities with their students to supplement the field trip. Finally, the group questioned all educators whether or not they would be willing to use a data acquisition tool or conduct a brief evaluation after the field trip as a means of gathering information regarding the students' impressions and reactions to the informal education experience.

The goal of these post-trip activities is to use the student responses to compare to the background knowledge gained earlier during pre-trip activities and provide feedback to informal educators. This feedback would then be analyzed by the informal educators to determine if their programs and exhibits are effective at conveying certain learning objectives. Another important aspect of this process is keeping the lines of communication open between the formal and informal educators for future visits.

When informal educators were asked whether or not they provided follow up materials to formal schools, Melissa Dowd indicated that the Ecotarium uses a 15 minute question and answer session after each program to interact with the students, but they currently have no formal evaluation in place at this time due to lack of staff. Alexander Poldowsky, also of the Ecotarium, said that a survey is occasionally used in the testing stages of a new program, but that more could be done to improve upon existing programs. He also cited a lack of staff as the cause. Chris KP told us that while their site

offers questions and answer sessions, CSIRO very rarely does direct assessment, but would be happy to supply formal educators with a simple follow up assessment if it was provided to CSIRO, so long as it asked questions that could be answered objectively. He also expressed a willingness to perform data analysis of the results. Denise LeBlanc stated that the Discovery Museum does conduct some formal assessment with students after a program to see what they have remembered and to observe the reactions of students. This is done in conjunction with their pre-program questionnaire, and in fact, may pose the exact same set of questions to students. LeBlanc also pointed out that the Discovery Museum looks at the post-trip information and tries to improve based upon what they learn. Additionally, the person that analyzes this information is the same person that speaks with the students after educational programs. Kristin Gibbs at the NEAQ informed us that the aquarium also makes use of a question and answer session after programs, and told the group that the aquarium would participate in a post-trip evaluation if it were provided to them to give to formal teachers. Christine Reich at BMOS told the group that the museum uses a combination of conversation, interviews, surveys, focus groups and observational studies to acquire data on their programs. BMOS also offers online survey software. One interesting fact she pointed out was that approximately 85% of teachers did not know what their students did during the trip, and that teachers need to know more about what happens on field trips, and what their students saw while they were at the museum. Christine is also heading an access inquiry group which is documenting all knowledge on accessibility in informal learning.

Formal educators were also questioned on the same topics. Of the nine formal educators that responded to these questions, three informed the team that they have follow up activities. John Rogers middle school uses papers and discussions 'sometimes' (Bohn), The Willow Hill School conducts post-trip discussions with students (Veroude), and the Lyndon Town School does projects, group work, and class reports as follow up activities for field trips (Dilley). When asked about conducting post-trip evaluations, eight out of nine educators showed a willingness to participate, and Ann Buckley added that she would prefer any evaluation to be done electronically. Mic Sandage also suggested that the follow up should contain easy language and be interactive. Stefani Waterman agreed that the any post-trip evaluation should be simple and easy to

understand. Finally, eight out of nine formal educators told the group that their school would be willing to provide feedback to the informal educators to help improve programs and exhibits. Maria Cashdollar cautioned that feedback should be done anonymously.

The overall response from informal educators is that they already do follow up studies and evaluation or would be willing to use an evaluation if it was carefully created and provided to them. A majority of formal educators do not do any type of activities after a field trip, but expressed an interest in using some sort of brief post-trip evaluation, and, in most cases, a willingness to provide feedback to the informal educators.
This interest was based on the assumption that the tool to be used for evaluation would be created by a future project group and supplied to the schools by that group or by electronic means.

4.2 Learning and Assessment in Formal and Informal Educational Settings

All interviews were conducted to obtain an understanding of the best method of assessing the learning outcomes of all students in an informal setting. It should be noted that the interviewee sampling does not represent a statistically significant sampling of formal, informal and special educators. Validity in the information provided is derived from the experience of the various professionals interviewed and also from the similar nature of responses within the three groups of interviewees. Contact information for all interviewees can be found in Appendix D. Transcribed notes from the interviews with mainstream, special and informal educators can be found in Appendices E, F, and G respectively.

4.2.1 Assessment in Formal Education

As described in the literature review, assessment in formal education can be either formative or summative in nature. Post-program formative assessments could be used to create a program improvement feedback loop if the programs are short duration, daily programs that see many visitors each day (Demetry). A classroom assessment technique (CAT) seminar held by Professor Demetry on Nov. 3rd, 2008 led the project group to look into the potential use of CATs, an important part of formal assessment.

Assessment in special education, another branch of formal education, and assessment technology are also discussed in this section.

Classroom Assessment Techniques

The findings in this section are a summary of relevant material from Cross and Angelo's book, *Classroom Assessment Techniques*, which was one of the books that Professor Demetry's CAT seminar was based on. Cross and Angelo identify classroom assessment techniques, CATs, as "instruments and methods designed to inform teachers *what* students are learning and *how well* they are learning it." (Cross & Angelo, 1988, p.2) These CATs bear relevance to informal education programs due to the presence of instruction based learning which is similar to classroom learning. CATs are meant to build understanding of a group of students' learning and allow for changes to be made to teaching methods to improve students' learning (Cross & Angelo). This means that CATs are formative in nature. It is also important to recognize that CATs are designed to provide information on groups of students rather than individual students. Methods for determining individual student data will also be explored as it is important to address the needs of all students.

One form of CAT, called *focused listing*, works to assess learning at the knowledge level of Bloom's Taxonomy. Focused listing is designed to quickly determine what students remember as the most important information related to the material that was taught. This technique is performed by having the instructor summarize a topic in a word or phrase and then list terms related to that topic. This is done prior to class. During class the instructor gives the students the topic heading and requests that they list terms related to the topic on a piece of paper. This paper is then collected and the data may be compared with the instructor's list to determine if the students' knowledge meets the instructor's expectations (Cross & Angelo, 1988).

The *memory matrix* is a spreadsheet-like table in which the instructor defines the column and row headings and the students write information in the empty cells. This method also assesses learning at the first level of Bloom's Taxonomy (Cross & Angelo, 1988). The memory matrix and focused listing both have potential for application in an

informal education setting because they require little time to prepare, apply and analyze the resulting data.

Directed paraphrasing begins to assess the comprehension level of learning by requiring the students to describe, in their own words, the material that they learned to an audience designated by the instructor (Cross & Angelo, 1988). Though this assessment technique is more time consuming than focused listing and the memory matrix, it provides data that will show if the students have a basic understanding of a topic and are not merely recalling relevant subtopics. This data can provide a clearer understanding of whether students are having difficulty as well as the areas where the students are having difficulty. For instance, if a program on the earth's seasons was assessed using focused listing to describe winter, responses might be: cold, snow, shorter days. Suppose the student paraphrased: during the winter season, the earth's axial angle relative to the sun decreases sunlight exposure thereby shortening daylight and while increased distance from the sun reduces the ambient temperature which may cause snow instead of rain. There is a great deal more information for an instructor to identify understanding or misconceptions by using directed paraphrasing.

Documented problem-set solutions assess students' application level of learning. This method is essentially asking students to show how they arrived at an answer. The data obtained from this type of assessment is used to identify students' methods of problem solving (Cross & Angelo, 1988). This information is useful not only to assess students' understanding of different problem solving methods but can also be used to identify whether insufficient problem solving skills are preventing students' from obtaining correct answers.

The *defining feature matrix* is a matrix used to compare closely related topics. An instructor can choose two or more topics to be compared and put them as column titles. A list of features that are either clearly present in or absent from the topics are placed into the row titles. The student must then indicate whether each feature is present in or absent from the different topics being compared. This technique is easy to analyze but requires significant preparatory time to ensure that it is requiring the students to recognize defining features rather than just testing basic-knowledge, factual recall (Cross & Angelo, 1988).

Well written *one sentence summaries* have the potential to assess learning at the synthesis level of Bloom's Taxonomy. However, at the primary and secondary school levels, summaries are more likely to assess understanding at the first to levels of Bloom's which is not necessarily problematic given that both formal and informal education programs are typically in the range of knowledge to application. A one sentence summary is supposed to answer the question, "Who Does/Did What to Whom, How, When, Where, and Why," (Cross & Angelo, 1998, p. 62) all in one sentence. To do this a student must synthesize all aspects of a topic and determine the appropriate information that will allow them to summarize the topic in as concise a form as possible (Angelo & Cross, 1988). This method provides a quick way for instructors to test students' learning and identify what part of a process a student does not understand.

The *one-minute paper* is a CAT that investigates students' responses to course material covered in the classroom. To use this method, an instructor asks his or her students to briefly write down what they think the most important thing they learned during the class was or what questions they have at the end of the class. These responses are short and easily tabulated by an instructor as responses should be very similar which means analysis should not take too much of an instructor's time (Cross & Angelo, 1988).

If an educational program is not meeting desired outcomes, it may be worthwhile to assess the impact that the classroom experience has on the students. Cross and Angelo conjecture that this assessment can be used to provide the students' thoughts on the teaching methods of the instructor and the students' opinions on the usefulness and effectiveness of educational material (Cross & Angelo, 1988). This material is concerned with determining why students are not learning rather than what they are learning. Discussion in this area is brief as this project focuses on what informal education visitors are learning. However, the group felt it was important note a couple methods of assessing why students are not learning because it may be useful information for future project group research.

Chain notes and *teacher-designated evaluation mini-forms* are two methods of determining the effects of a teacher's instruction on the students' learning. A chain note refers to a technique where each student is given an index card and an envelope is passed around during the class that has a specific question written on it. When the envelope gets

to a student they take a minute or two to write a short response to the question on his or her index card which is then placed into the envelope and passed to another student. By reviewing the index cards, an instructor can get moment-specific data on how the instruction affected the learning of the group of students. The biggest problem this method presents is that it requires students to divide their attention between performing the assessment and following the material being presented at that time (Cross & Angelo, 1988).

Teacher-designated evaluation mini-forms are questionnaires comprised of short questions of the teacher's choosing that pertain to teaching evaluation that are handed out at the conclusion of a program to be completed and returned. The questions are typically answered by multiple choice or short answer. With well constructed mini-forms, teachers can obtain useful feedback on student opinions of how teaching methods are affecting learning (Cross & Angelo, 1988). The drawback to this method is that like other questionnaires, creating a mini-form that will provide useful data will require a lot of time and consideration.

Learning in Special Education Schools

Of the three groups of educators we spoke with via interview- formal, special, and informal educators- nine interviews out of a total of 21 were done with special education professionals. Of these nine individuals, one teacher, Bernadette Goudey, is a special education teacher at a mainstream school, and Mic Sandage of the Carroll School indicated that 70% of their students are already or will be attending mainstream schools. These two individuals provided us with some information that gave us better perspective on the similarities and differences between mainstream and special education schools.

Interviews with special educators showed that all of these schools take their students on field trips, and that they also do some sort of preparation before taking their students to the various informal education sites. Additionally, five out of nine special educators say that their field trips are tied directly into the school curriculum or MSF.

Similarities & Differences to Mainstream Schools

While special education schools may have to provide increased accessibility for their buildings and programs, in some cases, they use similar assessment methods. Joan Curran from the Horace Mann School for the Deaf and Hard of Hearing, as well as Mic Sandage from the Carroll School said that they administer the MCAS to some of the students at their respective schools. Kathy Veroude at the Willow Hill School informed us that the Willow Hill School uses some formal assessment methods such as quizzes, tests, and long term assignments. These are just a few examples of how special education schools are similar to mainstream schools.

On the other hand, there are some differences in the programs at special education schools. Two educators, Mic Sandage and Stefani Waterman, report using IEPs in favor of standardized assessment methods. In cases where IEPs are being used, the assessments are usually adapted to correspond with the IEP goals and meet the needs of each individual student. Kathy Veroude and Joan Curran told us that their schools also make use of portfolios, with Curran stating that portfolios are utilized due to the fact that standardized testing, such as the MCAS, can be unfair to students. In cases where a certain school has students with severe emotional or behavioral issues, such as the School House, the curriculum can also have a focus on increasing social skills and correcting behavior that could be seen as inappropriate. Laurie Marshall refers to this as 'adapted learning'. The use of adapted learning, as well as IEPs and portfolios, demonstrates some of the differences in evaluation procedures at the various schools that were represented by the team's interviewees.

Accommodations for Students with Disabilities

When special educators were asked about the accommodations used for students with disabilities, their responses were varied. Some schools dealt with only one type of disability, and hence had become very specialized in accommodating it. Other schools were more generalized, and were capable of providing more information on general accommodations.

The special educators gave several common accommodations. More time on tests, simpler wording of materials, rigid scheduling, and smaller class sizes were common.

Smaller classes allow more individual attention. Rigid scheduling is a common accommodation for autistic students, giving them a routine they can follow, as well as giving all students an idea of what is coming next. Simpler wording is useful for those who have lower reading levels, such as deaf or learning disabled students (Waterman, LeBlanc, Sandage, Cashdollar, 2008).

There were also more esoteric accommodations available. For example, one informal educator stated that her institution had used a Velcro based navigation system for the blind. The idea was that certain sides of an exhibit were marked with Velcro pads in such a manner that it did not detract from visual appeal. These pads, however, were oriented in such a way that people with profound blindness could use their placement to orient themselves and find their way to exhibits. The need to update the museum, as a change in available accommodations, led to its disuse (LeBlanc, 2008).

Specialist schools often reported having programs specifically designed to help their students with both informal education and regular social interaction. These programs addressed the various social and behavioral difficulties of the students. One school's curriculum required that students take a theatre course. This course, however, focused more on the various social cues that most people take for granted. Sarcasm, for instance, was a topic of discussion in said course (Waterman, Cashdollar, Sandage, Veroude, 2008).

Another accommodation which was mentioned was the use of interpreters for the deaf. That service, along with others, was available at informal education sites. However, special educators often brought their own staff, not knowing about the availability of these accommodations. The informal educators did have these services advertised, but special educators were not able to find them. This led the team to believe that better communication would be of great help to both the formal and informal education providers (Reich, LeBlanc, 2008).

Informal sites also accommodated students in various ways. For example, the BMOS extensively practiced UD in the design of its exhibits. The museum also made it a point to include input from visitors with disabilities in its planning. Another site used extra floor staff to ensure that students were safe and enjoying themselves. This same site

also made use of staff to free up instructor time to observe students (Reich, LeBlanc, 2008).

Informal and special education staff provided several opportunities to their students, as well as accommodations for their needs. Admissions, medical assessments, and the items listed above were among them. One additional item, worthy of note, is the growing use of technology in these programs. This technology is the next topic of discussion.

Technology of Assessment

The team found that, in assessment, there is a growing trend to use electronic aids for students, both mainstream and with disabilities. One special education institution makes educational material more accessible through the use of laptops with their students, allowing the option of using various computer programs in assessment. Other educators used items such as answer clickers or online tutoring programs. The group was able to conduct interviews with various personnel and create a rough picture of how technology is affecting assessment and education.

Word processing, small packaging, and the access to various educational software, are all benefits of the modern computer. The institution that uses the laptops, the Carroll School, asked that any assessments from informal educators be accessible in an electronic and interactive format for their students. When asked about the idea of mainstream schools using this accommodation, the interviewee from that site mentioned that the students' laptops are paid for by their tuition, and that the cost could be prohibitive for mainstream educators (Sandage, 2008).

The laptop is not, by any means, the only technological assistant available for a class room. "Answer Clickers" are another tool available to the educator. These devices allow students to anonymously transmit answers to multiple choice questions, typically projected using a computer and some form of screen-projection media. The "clickers" are not the only means by which an educator can anonymously assess students (Demetry, 2008).

The ASSISTments program, created with help from WPI students and faculty, is a program currently used in Worcester city schools. The program is an internet based

assessment system. The system can be customized by educators using it. The questions, as well as feedback for students, can be tailored by educators. The students' complete exercises created by the instructor and the results are available for the instructor to see. What makes the program useful is that it can be set to not give the answer if a student is wrong, but rather challenge them to work out the solution by providing the students clues to the right answer (Heffernan, 2008).

Another accommodation, offered by the Discovery Museum was a virtual tour CD. The virtual tour would enable educators to see the exhibits and their layout without having to travel to the site. They could also use this instrument to familiarize students with the layout, and reduce anxiety that unfamiliarity might cause. It could also be used by educators to plan a trip, along with communication with the informal educators (LeBlanc, 2008).

While RFID transmitters can help the hard of hearing to listen to what an educator is presenting, the Museum of Science is experimenting with another electronic device to help the blind. The "talking sign" provides the same information as a sign, but in a format that the blind can utilize. The system uses a hand held unit to receive signals from transmitters, and give information that a vision impaired user will find useful. They are using this to help the blind find their way around and to use a small sample of exhibits (Reich, BMOS Website UD page 2008).

As has been shown, there is a great deal of support available to educators today. There is also research being done to create more useful technology for education. While the future is uncertain, it is a common opinion that as technology advances, so will the quality of life for everyone. As quality of life increases, so will quality of education.

4.2.2 Evaluation in Informal Education

The interviews conducted by the project team throughout the course of the semester yielded valuable information about the museum experience from the perspectives of both the formal and the informal educator. Since most of the informal education facilities are at least a one hour driving distance from Worcester, the team was not able to do any direct observational studies of the programs or exhibits. Therefore, interviews were conducted with various formal, special, and informal educators as the

primary means of data acquisition. After speaking with these educators, many of them referred us to various websites, articles, research papers, and books to augment our knowledge on the subject, as well as to corroborate information that they had provided. Analysis of these documents and records supplemented the interviews as our secondary means of gathering information.

Data Acquisition Methods

The November 10th, 2008 interview with Professor Demetry produced a wealth of information about data acquisition through a book, *Evaluating Intervention Programs*, which was lent to the project group by Demetry. In their book *Evaluating Intervention Programs*, Barbara Davis and Sheila Humphreys identify the five major methods of gathering data for informal education programs as questionnaires, interviews, observation, tests and documents, records and materials (Davis & Humphreys, 1985). The book goes into great detail on each of these areas of data collection and should be referenced if the key points provided in this section do not provide enough information.

"A questionnaire is a set of written questions, typed or printed, from which you can collect personal information, opinions, and reactions." (Davis & Humphreys, 1985, p.26) Davis and Humphreys note that questionnaires can be distributed directly to people or via the mail. Questions may be either open-ended or forced-choice. The former gives more freedom in response where as the latter restricts responses to only the options that are provided. An example of an open-ended question is a short answer question such as the *muddiest point* CAT. "The technique consists of asking students to jot down a quick response to one question: 'What was the muddiest point in _____?'" (Angelo & Cross, 1993, p.154) This question can easily be applied to any subject or activity. The wording can be simplified for younger age groups or ESL students, who may misunderstand the question, by explaining that "muddiest" means least clear or by rephrasing the question (Angelo & Cross, 1993). Basic principles of UD would suggest that rephrasing the question to be more accessible to all students is preferable to asking a question that may be misunderstood by some students and require subsequent clarification.

Forced-choice questions are also referred to as closed-ended questions which may be of many different varieties including multiple choice, true-false, yes-no, and ratings or

rankings questions. Skill and knowledge rating or ranking questions are scales which present a question that asks a person what his or her level of skill or knowledge in an area is. Answers are given on a fill-in-the-dot scale which typically has either three, five or seven dots representing a range of no knowledge or skill to in-depth knowledge or skill. Closed-ended questions are easier to analyze but do not have the ability to collect unexpected answers like open-ended questions do (Davis & Humphreys, 1985).

In creating a questionnaire it is important to consider the reliability and validity of the questions. A reliable question has the same meaning to different people and retains the same meaning at different times. A valid question provides data relevant to the question asked by ensuring that the students understand what instructor is asking. By these definitions a valid question must also be reliable but a reliable question is not necessarily valid (Davis & Humphreys, 1985). The "muddiest point" technique would not be valid because younger children and ESL students may misinterpret the question. Creating reliable and valid questionnaires can be time consuming but worthwhile because they produce large amounts of data over a short period of time. Using existing questions saves time in creating questionnaires and can help ensure reliability and validity depending on the source. Also, it is a good idea to limit the number of open-ended questions to three or less to save time in analyzing questionnaire data (Davis & Humphreys, 1985).

Interviews allow for more in-depth responses to questions but require time and skilled interviewers (Davis & Humphreys, 1985). Since this project focuses on short duration trips lasting less than one day, we will not focus on interview data acquisition because the time spend interviewing and analyzing data would greatly exceed the time a student spends at the informal education program. It may be worth considering interviews for programs of extended duration where informal educators have more time in which to conduct interviews.

Observation is able to gather data that questionnaires may be unable to produce. Observation allows for assessment of student and instructor behavior that does not rely on the accuracy of the students' responses that may be inaccurate and decrease the reliability of the assessment. Of the three observation formats described by Davis and Humphreys, structured observation appears to be the best method for assessment of short

duration informal education programs. A structured observation can be performed by creating a list of detailed descriptions of behavior to be observed and using a checklist to tally the frequency that the observed behavior occurs (Davis & Humphreys, 1985). A benefit to this type of assessment is that observation does not take valuable instruction time. A third party could observe a program thereby providing assessment data without cutting a program short to allow time for student completed evaluations. Also, analyzing a checklist does not take much time which will offset the time it takes to create the observation checklist (Davis & Humphreys, 1985). Different assessment methods, such as questionnaires, may be desired if an evaluator is interested in the opinions of the participants of the program being evaluated.

"A test is typically a paper-and-pencil measure of a program participant's knowledge, understanding, or cognitive skills in a particular subject area or topic." (Davis & Humphreys, 1985, p.62) This description of tests aligns test-based assessment with summative assessment. Tests are not well suited to short term programs. Because of the varied nature of informal education programs, finding existing, applicable tests may be difficult. Informal educators may need to create their own tests, which can be very time consuming if valid and reliable data are desired (Davis & Humphreys, 1985). The fact that formative and summative assessment is not mutually exclusive means that it is possible to use formative assessments to also provide a summative assessment; thus, it may be possible to forego the use of tests in assessing student knowledge in an informal setting.

Documents, records, and materials can provide a wealth of information including information about program goals, past programs, participant information and more (Davis & Humphreys, 1985). The data gathered from searching recorded information can provide a control from which assessment can be related. For educators interested in determining if changes made to a program have affected learning outcomes, not only will they need to assess the current outcome but also they will need documentation of prior outcomes to view the effects of the changes.

Current Practice

Prior to conducting the interviews, there was a surprising lack of information available regarding the assessment of students in informal education. Christine Reich from the BMOS gave us some great insight into why the team was unable to find relevant information. As soon as she heard the title of the project she stopped immediately and asked the group if we talking about assessment or evaluation. We explained to her that we had been using these words interchangeably. Reich then proceeded to explain to the difference between assessment and evaluation.

Assessment, according to Reich, is the act of measuring individual performance, and is not generally used in the informal environment. Part of the informal education experience is actually the lack of formalized assessment methods, in favor of more hands-on learning activities. A visit to an informal education center should be low stress, low pressure, and it should be up to students to decide what they want to learn. Several educators indicated that most importantly, the experience should be fun, and that students may feel as though they are being tested if you hand them a questionnaire to fill out during a field trip, or if you ask them to recall certain facts.

However, even though individual assessments are not performed, informal educators are still interested in evaluating the programs and exhibits, and improving those programs based on information that they receive from visitors. Therefore, evaluation, says Reich, refers to looking at the museum exhibits and programs as a whole, and using different methods of data acquisition to alter the aspects of the museum that they determine need improvement.

The BMOS uses several techniques to evaluate and determine the effectiveness of their programs and exhibits. For example, when a new program or exhibit is introduced, staff from the museum will conduct a study on the product that is in development. This may be something as simple as speaking with visitors on the museum floor and questioning them about their interests. Additionally, the museum conducts focus groups with SWD as a formative assessment to find out what they are thinking, what they know, and what they would like to know. Informal educators will also contact scientists and people with related research interests to provide the exhibit designers with extra information when developing a new exhibit or program. This demonstrates the main

difference between assessment and evaluation. Assessment is a test of individual performance, whereas evaluation is a means of gathering a more broad range of data concerning the effectiveness of programs and exhibits. Despite the fact that some informal learning centers focus more on evaluation of exhibits and programs, our group is interested in introducing a method of individual student assessment as a means of comparing the learning progress of students with and without disabilities.

Reich did indicate that during their evaluation process, a survey is used when conducting focus groups. In general, informal educators try to avoid assessments like this, but when done quickly and in small groups, while asking open-ended questions, these surveys can be extremely valuable feedback and students in the focus groups are cooperative. Reich also stated that most informal educators prefer surveys for ease of analysis, but noted that developing a reliable survey can be difficult. Other than a survey, the museum uses conversations, interviews, focus groups and observational studies to evaluate their programs and exhibits and make necessary changes, which further illustrates the museums' extensive use of evaluation, rather than assessment. Reich finally informed us that interviews are easy to understand because they are written, while analysis of observational studies can be extremely challenging. The group suggested the use of a checklist in favor of observational notes, and Reich agreed that a well prepared checklist could be useful for informal educators and would be easier to analyze than written notes. Of all informal educators, Reich provided the most comprehensive and in-depth overview of evaluation methods used at informal learning centers.

Chris KP from CSIRO also added several pieces of information that the team found to be useful. Chris informed the group that CSIRO provides evaluation forms for schools to fill out during a visit, while also performing yearly program evaluations to find out the best and worst aspects of the programs. According to Chris, the majority of available funds are allotted for new program evaluation. Chris also pointed out that CSIRO occasionally uses observation to gather data. He continued on to tell the group that he personally enters evaluation data into a spreadsheet and performs data analysis.

The group also learned from Denise LeBlanc that the Discovery Museum meets four times per year with an advisory board composed of teachers, administrators and

scientists to facilitate conversation and develop new programs based on feedback gathered through post-trip evaluations.

Although the group gathered some very valuable information from the informal educators when asking them about current practice in informal evaluation, not all interviewees were presented with this same line of questioning due to the direction and flow of the individual interviews, as well as our fundamental lack of understanding of the difference between evaluation and assessment. The final two interviews with Christine Reich and Chris KP proved to be the most beneficial as the group had gained a much better idea of what questions should be posed to informal educators.

Accommodations for Students with Disabilities

Previously, IQP groups from WPI have addressed the issue of making science education and informal education programs accessible to SWD. In these reports entitled *Adapting Hands-On Science Programs for Students with Disabilities* and *Adapting Zoos Victoria Educational Programs for Students with Disabilities*, the project teams developed the framework for a specific set of accommodations that can be made for students with mobility, sensory and cognitive disabilities. Each category of disability is then broken down into a matrix which addresses the type of difficulty a given student might have while performing certain tasks, and then uses a code number to direct the reader to a list of accommodations that can be made for that student. Refer to Appendix H and I for detailed descriptions of the Program Accessibility Reference (PAR) and the Student Accessibility Matrix (SAM) (Simone et al., 2007; Gilde et al., 2008).

These teams laid valuable groundwork for following projects as any future teams, including ours, have this information at their disposal for easy reference. However, during the course of our interviews, we asked informal educators as well as some formal educators to provide some information about the general accommodations they make to create an inclusive learning environment and provide the best experience possible for their visitors.

During the interviews with the Ecotarium staff, the group found that most students with hearing impairments provide their own equipment. Assisted hearing systems are available, but rarely needed, as most instructors make use of a wireless

microphone for presentations, which alleviates most issues. The staff also has limited or no experience working with vision impaired students. It was noted that certain 'allowances' are made for students with ASD, but no specific accommodations were mentioned. A final note informed the group that the Ecotarium occasionally complies with teachers' requests for accommodations prior to visit, but the Program Director feels as though the instructors are 'properly trained' and do a good job of making accommodations for SWD 'on the fly'(Dowd, 2008).

CSIRO staff will make reasonable accommodations for SWD, but usually schools help accommodate for SWD. Schools participating in programs do sometimes address accommodations that need to be made prior to their visit, but should do this in all cases to allow the staff prepare appropriately. The group also learned that it is most difficult to make accommodations in cases involving mainstreamed SWD due to the fact that schools may not have the additional help needed to assist students (Krishna-Pillay, 2008). For more information on accommodations that CSIRO makes for SWD, refer to *Adapting Hands-On Science Programs for Students with Disabilities.*

At the Discovery Museums, facilities meet ADA accessibility guidelines, but not all floors are wheelchair accessible. For those floors that are wheelchair accessible, the museum designs new exhibits so that they *are* accessible to the mobility impaired. The museum also has interpreters available for non-English speaking students and signers available for students with hearing impairments and non-verbal disabilities. Advanced notice is needed to setup these services. This facility also gives students the option of writing or drawing to alleviate issues for students with writing difficulties. Previously, the museum has used a CD tour of the buildings as well as a system of Velcro boards that served as a trail-marker for students with vision impairments, although these accommodations are no longer in place. One room in the building is used as a 'retreat room'. This room is typically used for students that are overwhelmed with the environment and need a quiet place to relax. Finally, the group learned that unlike some locations, staff members are always on the museum floor to ensure that children are learning and having fun (LeBlanc, 2008).

The final location, the BMOS, has information for teachers to read on their website prior to a visit regarding accommodations that can be made in site. The BMOS

representative indicated that not all teachers make use of this info prior to visiting, and it would be useful to hear from these teachers ahead of time. Also, the BMOS aims to include visitors with disabilities, not just students, in as many activities as possible, if not all of them. The museum has assorted personnel available, such as ASL interpreters for non-verbal and hearing impaired visitors, as well as sighted guides for blind or vision impaired visitors. Staff members are also available to assist deaf students or hearing impaired students and students that do not speak English as their first language. Braille, large print documents and tactile displays are on hand for students with vision impairments, blindness, or print-based difficulties. A Velcro board with pictures can be used for non-verbal visitors to show assistants what they would like to see. By rearranging pictures on the board, these visitors can communicate their interests to staff without speaking (Reich, 2008).

The previous section shows general accommodations made at each informal education center, as stated by interviewees. These lists do not represent the full extent of accommodations made at each location, but served as a brief overview for the group to consider. Kristin Gibbs is a new employee was not able to provide any information regarding accommodations made at the NEAQ. The remaining informal educator, Alexander Poldowsky, referred the group to Melissa Dowd to answer accommodation questions at the Ecotarium.

5. Results

The material presented in this section incorporates the information gathered by the literature review and the findings sections into a series of recommendations for educators that will allow them to assess student learning and evaluate informal education program outcomes. Therefore, the goal of this section is to synthesize the data gathered in previous sections of this report and formulate the best possible suggestions for a method of student assessment and program evaluation. The symbiotic nature of such a collaboration means that the success or failure of the conclusions made in this chapter are dependent on the accomplishment of certain tasks by both groups of educators. The objective of this section is also to describe the responsibilities of formal and informal educators that have been distilled from various interviews and literary sources. This will allow informal educators to better serve their visitors and provide teachers with a more enriching experience for their students. The recommendations presented represent both formal and informal education tactics that have been determined to be the most appropriate for applications regarding informal learning. It should be noted that while these techniques have all been used individually, in their respective settings, the combination of techniques presented in this section has not yet been evaluated and is merely theory from which future project groups may produce more defined assessment tools and assess the validity of the conclusions drawn in this paper.

5.1 Field Trip Preparation

The nature of the information desired by informal educators necessitates some degree of preparation prior to schools' involvement in informal programs. A pre-trip baseline of student knowledge needs to be established to gauge the effect of a program because this project focuses on determining the how an educational program has affected a student, which cannot necessarily be understood simply by means of a summative assessment. A combination of formative assessment surveys and pre-visit information packets can be used to determine and enhance the level of student understanding prior a field trip. The implementation of a system that prepares students for a field trip and sets

the foundation for a beneficial formative assessment requires collaboration between formal and informal educators.

5.1.1 Pre-Trip Materials and the Background Knowledge Probe

Evaluating programs puts many responsibilities on informal educators. Establishing the level of understanding of visitors before a program experience will provide program developers with useful information for understanding informal program outcomes. With known levels of student understanding, an assessment of program outcomes can be made by comparing pre- and post-trip data. Many of the pre-visit responsibilities lay with the informal educator.

To deal with the differences in student ability, informal educators need to determine what abilities their programs require and try to ensure that visitors are given a fair opportunity to participate by attempting to provide necessary information. Consideration must be given to what knowledge and skills an informal education visitor must have to participate in a program. Some science museums list grade levels for their programs which have been shown to indicate a connection with state framework goals for the noted grade level. It should not however be assumed that a student at a certain grade level possesses all necessary knowledge and skills from previous grade levels. Many students with learning disabilities or hearing impairment have below grade level reading skills. Also, there are variations in performance between mainstream students that would indicate different levels of knowledge and skill on a student by student basis.

Informal educators can establish student knowledge and skills by either surveying the participants or providing information that will ensure that visitors have certain skills and knowledge prior to a trip. A background knowledge probe could be prepared by an informal educator and given to students prior to a trip to elicit data on the students' level of understanding. Currently, informal educators distribute pre-visit information packets rather than background knowledge probes. Providing pre-trip information to visiting schools is another way to establish visitor knowledge. An informal learning center can attempt to ensure that all students are provided with program relevant knowledge by providing material to teachers to share with their students. Formal educators are encouraged to return this material in a timely manner to the informal learning center. This

will help informal educators prepare for a group visit, thus aiding all educators involved in the experience. Pre-visit information also helps to provide students with necessary background information. This can build anticipation for a field trip and introduces an informal education program or exhibit.

There are benefits to using background knowledge probes. Informal educators can determine the state of student skills and knowledge by using a background knowledge probe prior to a field trip. Providing pre-visit information may seem like it can establish a certain level of knowledge but even if teachers share this material with their students, they may not absorb all of the information. This means that there can be fault in an assumption that providing pre-trip information will result in knowledge of all of the material provided. Because event-influenced knowledge assessment is a measure of the relative change in knowledge of a person, it is important to have a clear measure of student knowledge before a program. Background knowledge probes will provide a more accurate student by student representation of knowledge and skill set levels than simply providing pre-trip information for a teacher to review with students.

A combination of informal educator provided pre-trip information and background knowledge probe could be employed to enrich students' pre-visit experience and provide useful information to informal educators. Given that many informal educators currently have pre-visit information available to schools the only addition necessary on the part of informal educators is the development of a background knowledge probe. These probes can be as simple as skill or knowledge rating scales or as complex as a series of open-ended questions. Rating scales are the easiest to analyze as they simply ask for the students' perceived comfort or ability levels in areas which are important to informal education program related topics. Open-ended questions will allow student visitors more freedom in their answers but will require more time for an informal educator to create, to ensure valid responses, and to analyze because of the varied responses that will be returned. Rating scales would also seem to be more likely to be used by formal educators because they typically do not have much class time to dedicate to non-curriculum related assessments. However, as Professor Heffernan pointed out, formal educators would be more willing to use assessment techniques if they feel that the assessment does not detract from teaching time but instead assists in student learning.

This means that well formed, open-ended questions that cause curriculum-related student learning are likely to be used by formal educators thus increasing the likelihood of feedback. The use of pre-trip information should be continued as it serves to familiarize students with informal education programs and facilities that may increase learning at informal education facilities because the student has already seen some of the material and may be able to better understand material presented by making connections to pre-trip material. The added benefit of building familiarity with a program and its environment can also alleviate the stress of students with emotional and behavioral disabilities.

The differing abilities of all students should be considered by an informal educator and available accommodations should be made known. It was apparent during interviews with informal educators that there are systems in place to provide accommodations for SWD. When interviewing special educators that had visited certain informal educators who have disability accommodations, the group discovered that many specialist teachers were unaware that such accommodations were available to them. It would be beneficial for informal educators to more prominently place website links that provide accommodation information because many formal education teachers get pre-visit information from informal education websites. Also, it should be noted that many formal educators stated that they would prefer pre-visit information to be sent to them electronically.

5.1.2 Making Field Trip Material Accessible

Formal educators share the responsibility of making pre-trip arrangements with informal educators. Formal education encompasses both mainstream and special needs students and as such there are certain things to consider for both groups of students. As mentioned in the previous section, it is the responsibility of informal educators to provide pre-visit, supplementary material. Conveying this material to student visitors is the responsibility of formal educators. For mainstream students this means that teachers must present provided material to their students. Special educators must also take this into consideration but have the added responsibility of making sure informal education material is accessible to students of different abilities. Ideally, any material sent to a

formal educator by an informal educator would be universally designed so that it is accessible to all students but the time and planning for such an endeavor is beyond the scope of this project. Though informal educators may strive for universally accessible material, limited resources may preclude the development of such items. Thus, it becomes the work of special educators to use their skills to modify material to better suit the needs of SWD.

It is also the responsibility of formal educators to inform informal educators about the specific needs of students that will be going on a field trip. Providing information about the needs of certain students prior to a trip allows informal educators to make accommodations that will make program material more accessible during a field trip. It is important to make information accessible to all students to ensure that unfavorable program outcomes are not a result of students' inability to connect with what is being presented.

Formal educators should also take care to provide feedback to any informal education background knowledge probes. The information gathered by these probes is essential to assessing a student's change in knowledge and therefore integral in determining what outcome an educational program has had on a student. Formal educator opinions on the usefulness and student responses to pre-trip information may also prove valuable in improving pre-trip material to facilitate student learning.

5.2 Recommended Assessment Strategies & Tools for Field Trips

Based on the findings, there are many recommendations which can be made concerning the place of assessment in informal education. The overwhelming opinion of informal and formal educators is that they do not want the students to feel that they are being "tested". Informal educators use the motivation of students to help them learn what their formal counterparts are teaching. It is important that student assessment methods stress students as little as possible to avoid what students would consider a testing situation. Similarly, tests can cause anxiety for students, which may hamper their motivation and distract them from learning. In formal education, formative assessment has been used without the loss of student motivation for some time. The relatively

relaxed nature of formative assessments aligns well with the desire of informal educators to maintain a fun and engaging experience that does not make visitors draw parallels between their experience and classroom education.

Informal educators already evaluate their programs, and such evaluation is essential to the improvement of education as a whole. What informal educators may find useful is assessment's ability to augment and enhance evaluation. Informal educators agree that students do not like to be tested. Student motivation is a key factor in informal education that comprises a large amount the utility of informal education. Because of the need for student motivation, informal educators recommend avoiding tests. While tests are a form of assessment, they are not the only assessment option available. Several, far more fitting options exist for the consideration of informal educators.

The best type of assessment for informal education is formative assessment. Formative assessment is used to determine what a student learned, as well as to diagnose student misconceptions. Improving curricula is also an important use of formative assessment. Summative assessment, in contrast, merely tests mastery. Furthermore, summative assessment is the realm of tests such as MCAS and KIRIS. Students are typically deterred by tests which bear resemblance to those used to rank them. Because of its potential to prevent students from enjoying themselves, summative assessment dissuades students from engaging with exhibits, asking questions, and learning. Thus, summative assessment should not be used by informal educators.

Student motivation in informal education encourages students to examine new exhibits, follow their interests, and learn new things. Summative assessment, or improperly executed formative assessment, would put undue emphasis on certain material, negating the benefits of student exploration. To avoid restraining student curiosity, assessments should be as general and unobtrusive as possible. Assessments that do not deter students or constrain their curiosity are what informal educators would find the most useful.

5.2.1 Observation

One of the best assessment tools available to the informal educator is observation. Observation does not ask anything of the students, it merely makes judgments on student learning based on student behaviors. Structured observation, where specific actions or traits are examined would be the best type of observation for informal educators. Using checklists to record and guide observations, structured observation allows informal educators to quickly assess students while requiring minimal staff effort. The cost benefits of some observation techniques would allow many informal education sites with limited resources to gain important data on student learning.

5.2.2 Minute Papers

Another excellent option for informal educators is the minute paper. The questions on a minute paper do not need to be related to specific objectives, merely things that the students enjoyed or had trouble with. Asking both questions offers a brief, low-stress method for students as well as an excellent source of data for educators. To reduce student anxiety towards written assessments, the educators should inform the pupils that the assessment is being used to improve the program, not to grade the students performance.. The benefits of the minute paper are the lowered use of staff time and good data acquisition. The risk of using minute papers is that of any assessment tool which requires direct student input; it may deter student learning in an informal environment.

5.2.3 Questionnaires

The questionnaire is an assessment which possesses the potential for large information gains. The questionnaire is the least student friendly of the methods presented here, but has the capacity to collect very precise data on student learning. Questionnaires are similar to tests, consisting of several types of assessment tools, yet are very brief in length. Questionnaires merely resemble tests in that multiple choice questions, short answer questions, and other assessment methods can be combined into a single, compact assessment. The ability to use multiple choice questions allows various exhibits to be ranked by students based on any criteria the informal educator deems important. The minute paper questions above can be used to examine the entirety of the

students' experience instead of the impact of a single exhibit, and other questions can also be added.

The information that can be gained by a questionnaire is determined by the questions asked. If the questionnaire targeted a specific topic, then the students would only be giving information on their learning gains in that area. If the questionnaire targeted accessibility and how entertaining the exhibits were, then the questionnaire would return accessibility information, as well as information on student amusement. The information on student amusement could be used to make other exhibits more engaging and thus improve the value of the informal education site.

The main caveat of the questionnaire is that it must avoid stressing the students. If students are subjected to too much stress during their visit, it could detract from the informal learning experience. While such losses are preventable with forethought and careful consideration, the potential to stress students must be considered to ensure that a questionnaire does not impair student learning.

Informal educators are not limited to the use of the assessment techniques listed above. There are other assessment methods which can offer similar benefits, so long as student interests are carefully considered. Summative assessment should be avoided by informal educators, and left to their formal counterparts; the methods of formal educators, however, can be used to create new, better forms of informal educational assessment.

5.2.4 Suggestions for Formal Educators during Field Trips

The improvement and enhancement of informal education is not the sole responsibility of the informal educator. Formal educators who visit informal education sites can also contribute to assessment in informal education while also enhancing the benefits of informal education. Several things that can be done by formal educators to assist informal educators are summarized below.

Many special education personnel interviewed reported that they brought several chaperones on each trip. The benefits of chaperones include extra hands to help students who need assistance, as well as extra eyes and ears to watch over students and observe them. The use of extra chaperones is also supported by the NEAQ and its chaperone policy, which requires one chaperone per student at a minimum for SWD (NEAQ, 2008).

Formal educators, like informal educators, have the tool of assessment available to them. The same concerns for informal educators apply to formal educators if assessment is being used to evaluate student learning. If an assessment deters student motivation, then it negatively impacts informal education. Formal educators using assessment after the informal educational experience would benefit from fewer restrictions on what assessment could be used. While student motivation is important, so is informal educator time. Assessment after informal educational experiences is not the topic of this section, and will be examined in a subsequent section.

Formal educators have the option of observation available for student assessment. Observation, as stated in a previous section, does not require anything from the students. While observation checklists can take an extended time to create, such lists offer the formal educator a method to quickly determine what students gain from an informal education experience. So long as staffing concerns can be dealt with, observation offers formal educators an excellent option for assessing students.

During an informal education experience, the responsibilities of the formal educator decrease, as the informal education realm is the territory of the informal educator. After the experience however, the formal educator can do a great deal to assist the informal educator. The suggestions for formal educator actions are discussed in the next section.

5.3 Suggested Post-Trip Activities for Educators

Another objective of this project was to determine what, if any, materials or information is given to students and educators to take back to their schools after their trip. Based on the information from interviews, coupled with the pre-trip activities and current practices in formal and informal evaluation, the team hoped to determine the most effective means of evaluating student learning gains and the most appropriate manner in which to conduct a post-trip evaluation. A close analysis of websites, documents and interviews allowed the group to make a number of recommendations for educators of all types.

Interviews with formal educators revealed that an overwhelming majority of teachers at mainstream and special education schools would be willing to make use of an

evaluation if it were provided by the informal educators. Based on the findings, it is strongly recommended that formal educators provide follow-up activities for students as a supplement to the pre-visit activities and the field trip experience as a whole. Comparing the results of student responses before and after the trip will help teachers understand what students knew, or thought they knew prior to the trip, and what was learned during the trip.

If an evaluation is to be done with a group of students following a field trip, the implementation and type of evaluation need to be carefully considered so as to be inclusive to the maximum number of students. When designing an evaluation tool, it is important to keep UD concepts in mind. More specifically, such a tool should be 'usable by all people, to the greatest extent possible, without the need for adaptation or specialized design' (NISE Network).

5.3.1 Questionnaire or Survey for Formal Educators

Our team recommends an evaluation in the form of a short survey or questionnaire to be conducted by formal educators at their respective schools. The group recommends formal educators perform the activity with their own students, as opposed to informal educators, as the formal educators are more familiar with the needs of specific students. This will help students feel more comfortable with the assessment process. A questionnaire or survey of short duration is recommended so students will not feel intimidated and also to avoid taking away valuable classroom instruction time.

The findings of our research suggest that if a survey or questionnaire is to be used, questions should be open-ended and contain easy-to-understand language. Closed ended questions can be answered with a simple yes or no, but open ended questions allow students to give meaningful descriptive answers based on their own individual experience. Some examples of open ended questions that were suggested to the group are; "What was your most or least favorite part of the field trip?", "Did anything surprise you?", "Did you see anything you hadn't seen before?" or "What did you learn about penguins that you didn't know before?" Denise LeBlanc suggested that the pre-trip and post-trip evaluations ask the same questions of the students. By using this method, teachers can gain an understanding of their students' background knowledge on a subject

prior to a field trip, and upon returning and asking similar questions, the teachers and informal educators can get a sense of what the students learned while on the trip. This information can be used to determine the effectiveness of programs and exhibits, as well as giving teachers some insight as to what students are actually learning during the course of a field trip.

Students should not be graded based on performance, but should be rewarded for participating in this program. This method of grading should encourage cooperation from students. Also, students should be informed before-hand that this evaluation is not a test, and that filling out this survey or questionnaire is beneficial to educators and students alike.

5.3.2 Suggestions for Informal Educators

After inquiring as to whether or not informal educators provide any follow-up material for students and teachers after a field trip, the findings indicated that three out of five locations indeed offer some sort of evaluation or additional information for groups to take back to their schools. The team urges informal educators that are currently using post-trip evaluations to continue in those efforts to gather information and stay in contact with schools following field trips. Other recommendations to informal educators include utilizing a post-trip survey or questionnaire, providing materials to formal educators personally before the group leaves the site, as well as requesting that the information get sent back at the earliest convenience. An alternative to handing out this information to school teachers before departure is making the information available and easy to find on the website and instructing teachers on how to navigate the website to find such material. Performing these tasks will keep communications open between educators, assure that formal educators understand the importance of this information, and will hopefully encourage expedited responses from the schools.

In a previous section of the report, several methods of data acquisition were described in detail. Of these methods, observation and interviews or conversation are recommended as the most convenient ways of gathering data. If possible, appointing a staff member to supervise and carry out these operations would be preferable. For informal learning centers that are under-staffed or lack funding to hire such staff

members, observation and interviews can be a cumbersome task. In this case, the team recommends the use of a post-trip survey or questionnaire that would be easier to perform, although at least one staff member would still be needed to analyze the results of such information.

Whichever methods are chosen for data acquisition and analysis, this information is extremely important and needs to be scrutinized by qualified staff of informal learning centers. As a final recommendation, the team suggests sending an email or making a phone call to thank those formal educators that responded with feedback, and to encourage future visits.

5.4 Maintaining Correspondence Before and After Field Trips

A key factor in any successful relationship is communication. This simple idea provided direction for the group while exploring the possibilities of ways to improve communication between formal and informal educators. Since informal educators use conversation or interviews to acquire data, maintaining correspondence can be beneficial to not only the educators involved with the field trip, but the students as well. In accordance with these thoughts, the group recommendations combine a post-trip assessment, provided by informal educators and given to students by formal educators, with continuous feedback given to informal educators by formal educators after assessing a class of students. The aim of this two-fold post-trip program is to keep students engaged in learning, help formal educators assess student learning that occurred during the trip, and to assist informal educators with program and exhibit evaluations and modifications.

Formal and informal educators are urged to communicate with each other prior to a visit at any informal learning center. This communication could take the form of pre-trip materials provided by the informal educators or it could be something as simple as a phone call to informal educators to let them know about any specific student needs that might need to be met during a field trip. Opening the lines of communication can make the visit much more effective for educators and students as well, because the educators have had time to prepare for the students' arrival and know what to expect.

The second part of the post-trip tasks to be completed involves formal educators sharing the results of student evaluations with informal educators. The formal educators that were interviewed expressed an overwhelming willingness to provide feedback to

informal educators, but several interviewees pointed out that this should be done anonymously. However, while the group agrees with formal educators in that this submission should be done anonymously, the overall goal is to compare individual students, so it is recommended that these evaluations be divided into categories using some type of coding system. A detailed description of one such possible system is described in Section 5.5. Informal educators also stated that post-trip feedback usually gets returned at a lower rate than pre-trip information. Therefore, the group recommends that formal educators remain diligent in collecting post-trip evaluations and returning them to the appropriate staff member at the informal learning site for analysis. Implementing electronic methods would alleviate the cost of paying for postage, as some educators suggested that adequate funding might not be available.

5.5 The SMIRF

To summarize the material presented in this chapter, a suggestions matrix was created for all educators. The Suggestions Matrix Incorporating Results from Findings (SMIRF) categorizes suggestions for formal, special and informal educators at different timeframes relating to an informal education trip. As previously stated in this paper, formal education encompasses both mainstream and special education therefore, special educators should also take note of the information listed under the "formal educators" column of the SMIRF. To use the SMIRF, an educator should identify the column that corresponds to their educational area and follow the suggestions listed that will allow for student assessment to occur.

Table 4: The SMIRF

Educators / Timeframe	Formal Educators	Special Educators	Informal Educators
Pre-Trip	- Use info from informal educators. - Establish knowledge level of students by either teaching or BKP/survey/questionnaire - Return pre-visit materials to informal educators - Check website for listing of accommodations - Utilize virtual tour - Notify informal educators about specific needs of students	- Contact informal educators regarding student needs - Familiarize students with informal education environment as much as possible - Make pre-trip material accessible to SWD	- Provide pre-visit materials to formal educators - Collect pre-visit materials from formal educators and enter into database for post-trip comparison - Consider differing student abilities and make accommodations accordingly - Provide easy to find information regarding accommodations on website
During Trip	- Bring extra chaperones so teachers can be free to do student observation - Record observations of student behavior	- Help informal educators in making necessary accommodations	- Do not overload teachers - Present any evaluation materials in a simple, quick, low-stress manner - Engage students in Question and Answer sessions - Involve students in conversation during their visit - Interview students and teachers if possible about their experiences during field trips - Provide staff for observation of students
Post-Trip	- Implement materials provided by informal educators - Provide students with inclusive follow-up activities/evaluations to keep them engaged in the informal learning experience - Provide feedback to informal educators - Maintain correspondence with informal learning centers	- Modify post-trip materials to accommodate students - Reward students for participating in evaluations	- Provide materials to formal educators and request timely response - Analyze feedback from formal educators to determine program effectiveness and make necessary changes - Examine observational data gathered by staff during trip - Maintain contact with formal educators - Follow-up call to thank educators for providing feedback

There are other considerations to be taken into account that are not listed in the SMIRF but should be considered by all educators. First, as was supported by the findings and emphasized in the earlier results, assessments should not remind students of being tested. Whether an assessment is put to use before, during or after a program, educators should inform students that any assessment is for program improvement rather than grading. Also, when possible, assessment methods should not only provide valuable data for informal educators but serve as a viable learning opportunity for the students that will be attending a field trip. Questions can be used to provide knowledge, build interest, and encourage students to develop their own ideas while simultaneously gathering data for student assessment.

Another consideration not addressed in the SMIRF due to spatial considerations is individual student assessment. Much of the material in this paper is concerned with providing feedback on students but not specifically individual students. One obstacle to individual assessment is the factor of anonymity. All formal educators indicated that while they would be willing to provide feedback to informal educators, it would have to be anonymous with respect to the students. To produce individual student assessments, pre-trip and post-trip assessments would have to be linked to each student. This can still be done while maintaining anonymity through the use of a numbering system. In this way, students' names can be omitted in favor of numbers that will allow informal educators to properly assess individual student learning without exposing student identity. There is one caveat to this method in that there would need to be some sort of identifying factor for SWD to determine whether different skill sets affect student learning outcomes. That is, in the number system, a notation would have to be made adjacent to the numbers of SWD. The notation should identify what disability a student has so that proper assessment comparisons can be made to determine if further program improvement is needed to better accommodate students with that disability. Again, this method is clandestine in regard to student identity and necessary for disability specific program improvement.

6. Conclusion

Forming the groundwork to assess the effect of informal education programs on student knowledge was the primary goal of this project. The Suggestions Matrix Incorporating Results from Findings was developed as a condensed summary of suggestions that would provide a base of assessment guidelines from which more specific assessment tools could be developed for individual informal education programs. The information used to develop the ideas presented in this paper was gathered through an extensive literature review, educational program documentation analysis and a series of interviews with educators.

To begin this project, research was conducted to provide the project group with strong background knowledge in assessing student learning. The literature review focused primarily on assessment but also included different educational settings, disability information, UD and educational legislation and reform. The research in these areas was used to identify characteristics of formal and informal education and assist in creating a method of assessing all students through a collaboration of formal and informal educators. Also, a distinction between formative and summative assessments was made in the literature review which allowed the project team to justify the use of formative assessment techniques in informal education settings.

Interviews were used as a continuation of the research begun in the literature review. Formal educators were questioned about formative assessment techniques they employ in teaching and what considerations need to be taken when putting these techniques to use. Similarly, informal educators were questioned as to what techniques they currently use for program and student assessment as well as what methods they would be willing to use that they are not currently practicing. Special educators were asked what effects certain disabilities have on students and how those effects can be circumvented.

Because assessment has to be relative to learning objectives, all educators were asked what their goals were for students that are visiting an informal education center. A common response of formal educators was that their goals for a field trip were directly related to educational curriculum goals. This information catalyzed document research

into the state frameworks educational goals as well as the program goals of informal educators in corresponding states. The results collected in these areas showed that there was significant overlap in state framework objectives and informal education program objectives. This information was further supported by interviewees that stated that informal education programs are supplementary to formal education curricula.

The general concern of all educators was that assessment of student learning in an informal setting should not be reminiscent of being tested. In that regard, informal educator provided assessments that are given to formal educators should maintain the same philosophy of being non-test-like when being administered to students. These assessments need to not only provide data for informal education providers but they also need to have potential to enhance student learning. An assessment that allows students to learn will not detract from formal educators' teaching time and will be more likely to be used. Also, any material that is to be seen by students should be made as accessible as possible to all students by the informal educator and if this is unable to occur, special educators should try to make this material accessible to the special skills of their students.

The project group achieved their goal of creating a practical set of guidelines for formal and informal educators to follow that will allow for a successful assessment of student learning that has occurred as a result of informal education programs. These guidelines, embodied in the SMIRF, will allow for more in depth research to be done to create specific assessment tools that combine the resources and abilities of informal and formal education to provide a thorough perspective on program-influenced learning. By following the suggestions presented in this paper, future research can be done that takes into account the thoughts and opinions of formal and informal educators and help avoid the creation of an assessment tool that is unlikely to be used by educators. Most importantly, utilizing the SMIRF to create a universally accessible assessment tool will allow informal educators to adjust their programs to maximize the learning and enjoyment of all students regardless of their disabilities.

*****NOTE TO READERS: This concludes the body of this report. Complete appendices can be found in a separate file which can be obtained by contacting Professor Holly Ault at hkault@wpi.edu.*****

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http://zoo.org.au/Learning/Programs/Early/Melbourne/All_But_Lost

Zoos Victoria. Eat Or Be Eaten. 02 December 2008.
http://zoo.org.au/Learning/Programs/Middle/Werribee/Eat_orbe_Eaten

Appendix A: Excerpts from State Learning Standards

Massachusetts Frameworks	http://www.doe.mass.edu/frameworks/current.html Excerpts taken from Mass. DOE, 2008
Victorian Essential Learning Standards	Excerpts taken from VCAA, 2007

http://vels.vcaa.vic.edu.au/essential/discipline/science/index.html#H2N100F1

Appendix B:
Informal Education Information

BMOS:
http://www.mos.org/educators/field_trip_resources/field_trip_activities/special_school_programs

CSIRO:
http://www.csiro.au/products/TheHelixTeachersGuides.html
http://www.csiro.au/resources/DIYScience.html

Ecotarium:
http://www.ecotariumorg/programs/schoolgroups/

Zoos Victoria
http://www.zoos.org.au/Learning/Programs/Early/Melbourne/All_But_Lost
http://www.zoos.org.au/Learning/Programs/Middle/Werribee/Eat_orbe_Eaten

Appendix C: Interview Questions

Appendix C: Interview Questions

The interview questions contained in this appendix were created prior to the completion of any interviews. Each question set is specific for the group of educators interviewed. The groups interviewed were mainstream, special and informal educators. These questions were part of a semi structured interview and are not representative of all questions asked but rather general questions which would provide information in areas of interest to the project group. These questions served as a base for interviews but questions were modified or adapted to fit the natural flow of interviews. The sets of questions are as follows:

Questions for Formal Educators (that go on field trips)

1. Are field trips scheduled to supplement your educational curricula?
2. Do you prepare your students for field trips to increase the educational value of the trip?
3. How do you do so?
4. Would you be willing to administer an informal educator supplied background knowledge probe prior to the students' field trip?
5. What do you do during the students' involvement in an informal education program?
6. Would you be willing to use that time to assist informal educators in assessing the learning of your students?
7. Do you perform any post-trip assessments on what your students have learned during their informal education experience?
8. Would you be willing/able to disclose the results from post-trip assessments to the informal educator?

Questions for Special Educators

1. What disabilities do you have experience working with?
2. How do you assess what a student with _____ has learned?
3. How long have you been using this technique?
4. Have you experienced any problems applying this method?

5. How did you overcome them?
6. How do students respond to the technique?
7. Do some students require more explanation to correctly perform the assessment?
8. Do you feel that this method would evoke similar results if applied to a student without _____?

Questions for Informal Educators

1. Are your programs designed to supplement formal education curricula?
2. How do you develop the learning goals for your programs?
3. What do you use to assess the learning of your program participants?
4. Have you run into any problems with this method of assessment?
5. Are there particular assessment methods which you currently do not employ but feel would be beneficial assessing the learning outcomes of students?
6. What is preventing you from using these methods?
7. Would you be willing to use brief formative assessments that can provide data to assist in program improvement?
8. Would you be willing to dedicate an employee to observation during the presentation of a program?
9. Do you have the resources to conduct exit interviews as a means of acquiring data on the relative success of your educational programs?
10. To what extent do you document the different aspects of your programs?

Appendix D: Interviewee Contact Information

Appendix E:
Mainstream Educator Interview Notes

List of interviewees by order of appearance

Beth Bohn
Chrysanthe Demetry
Al Dilley
Janice Gobert
Bernadette Goudey
Neil Heffernan
John Wilkes

Appendix F:
Special Educator Interview Results

List of Interviewees order of appearance

Ann Buckley
Maria Cashdollar
Joan Curran
Lauri Marshall
Mic Sandage
Joanne Haley Sullivan
Kathy Veroude
Stephani Waterman

Appendix G:
Informal Educator Interview Results

List of interviewees by order of appearance

Melissa Dowd
Kristin Gibbs
Chris Krishna-Pillay
Denise LeBlanc
Alexander Poldowsky
Christine Reich

Appendix H : Examples of PAR (Mobility Impairment Spectrum, Mobility Tasks & Barriers, Mobility PAR Matrix, Mobility Accommodations List and Mobility Checklist)

Taken from Gilde et al., 2008

http://www.wpi.edu/Pubs/E-project/Available/E-project-030908-120654/

Appendix I : Examples of SAM (Mobility Tasks & Barriers, Mobility SAM Matrix, Mobility SAM Matrix Solution Key and Mobility Barriers Checklist)

Taken from Simone et al., 2008

http://www.wpi.edu/Pubs/E-project/Available/E-project-042907-213933/

Appendix J: Eric Hansen Matrix

Eric Hansen Presentation, Delivered at WPI, 2008

Appendix K: Notes from Demetry Seminar

Excerpts from slides featured at a Seminar, conducted by C. Demetry at WPI, 2008