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Differentiation and the Brain

Differentiation is the use of time, planning, and instructional practices to meet the different needs of diverse learners. Tomlinson (1999) says, "In differentiated classrooms, teachers begin where students are, not the front of a curriculum guide." The classroom teacher has the task of differentiating curriculum every day in order to meet the needs of all of the learners. Special populations, which include at-risk students, special education students, and gifted students, all need that differentiation if they are to be successful.

Some of the special populations that we will discuss in this chapter and the chapters to follow include those students—

1. Identified as needing the services of a program for academically gifted
2. Identified as having Attention Deficiency Disorder (ADD) or Attention Deficiency Hyperactive Disorder (ADHD)
3. Identified for services under the guidelines of special education

4. Identified for services under at-risk guidelines including guidelines for English language and second language learners, compensatory education, Section 504, and Title I
5. Identified for services under emotional and behavioral services

The Brain in Action

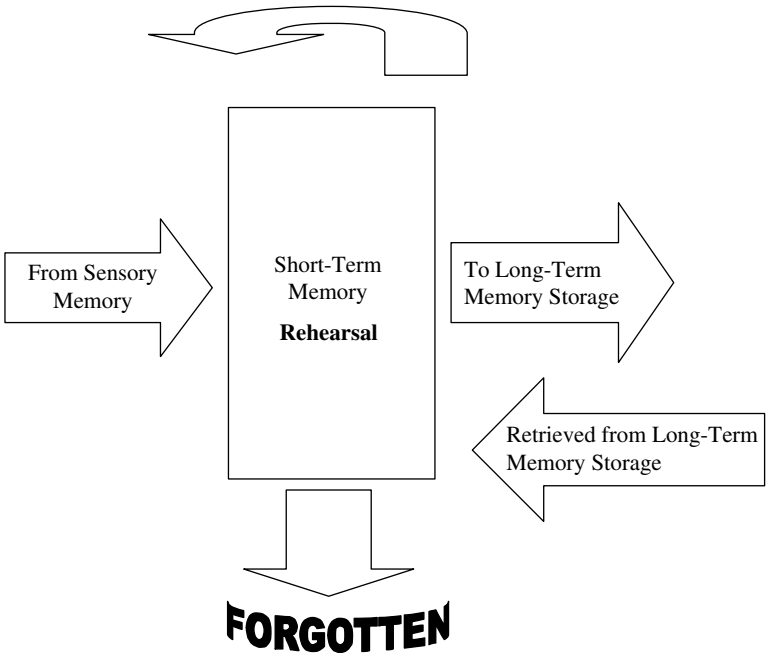
In order to understand the needs of these students and how the classroom teacher can modify and differentiate for those differences, it is necessary to look at how the brain learns, processes, and retrieves information under most circumstances. According to Sprenger (2002), we identify as "smart" those students who can take in information efficiently and quickly, process it, and then retrieve it quickly when it is needed. Gifted students tend to process more efficiently and quickly, and thus they need modifications so that they are challenged sufficiently and can reach their potential. Students with learning or behavioral problems may not be able to carry out one or more of these functions (taking in information, processing it, and retrieving it) without difficulty.

Incoming Information

It has been said that smart people are those who can quickly store and retrieve information. Underachievers are those who process information quickly but retrieve it from storage slowly; overachievers are those who process information slowly but retrieve it from storage quickly. How, then, can we help students process information in a faster and more efficient way so that when they need to use the information they can retrieve it quickly?

Our rate of learning is the amount of time it takes to acquire information. Using the graphic in Figure 1.1, let's look at how the brain takes in information, how it decides what to keep and what to discard, and how it retrieves information from long-term memory.

Figure 1.1 A Summary View of the Learning Process, From the Senses to Retrieval



Most brain researchers say that 99% of what we learn comes to us through our senses—vision, hearing, smelling, tasting, and feeling. That means that the classroom environment is important and that the way teachers teach students is important in getting information processing in the brain. For students experiencing difficulty with the learning, the classroom environment is a critical part of the learning process for them. How can we help these students to use their senses to take in information at a more efficient rate and to move the information to the processing center of the brain?

Using a Variety of Learning Modalities

Researchers have identified three learning modalities most often used by students to taking in information. Most of

us prefer one of these modalities to the others and are able to take in information faster and more efficiently if taught in our preferred modality. As a matter of fact, it is believed that students who have difficulty with the learning will not be successful unless they are re-taught in the modality in which they learn best. Following is a discussion of the three modalities and their characteristics (from Tileston, 2000).

Visual Learners. Visual learners make up the largest group in the classroom; perhaps as many as 87% of the students in any given classroom are visual learners. These students need to "see" the learning: Memorizing formulas in math is not enough for them. They need to know how the math works and they need to see it visually. Many of our at-risk students can be moved to higher levels of understanding simply by adding visual tools to the learning. Both linguistic and nonlinguistic tools are the keys to working with these learners.

Visual learners are those students who:

- Have difficulty remembering names but may remember details about a person
- Learn best when there are visual tools to help explain the learning
- Would rather read a story than have someone tell it to them
- Organize thoughts by writing them down
- Have difficulty remembering directions that are told to them
- Facial expressions often give away their emotions
- Like puzzles

As teachers, we can help these students to be more successful by using visual models. Visual models are usually either linguistic (i.e., use words to communicate the information) or nonlinguistic (i.e., use structure, symbols and fewer words to communicate the information). Form 1.1 is an example of a nonlinguistic organizer that helps students to organize the information in their notebooks.

Form 1.1 Linguistic Organizer

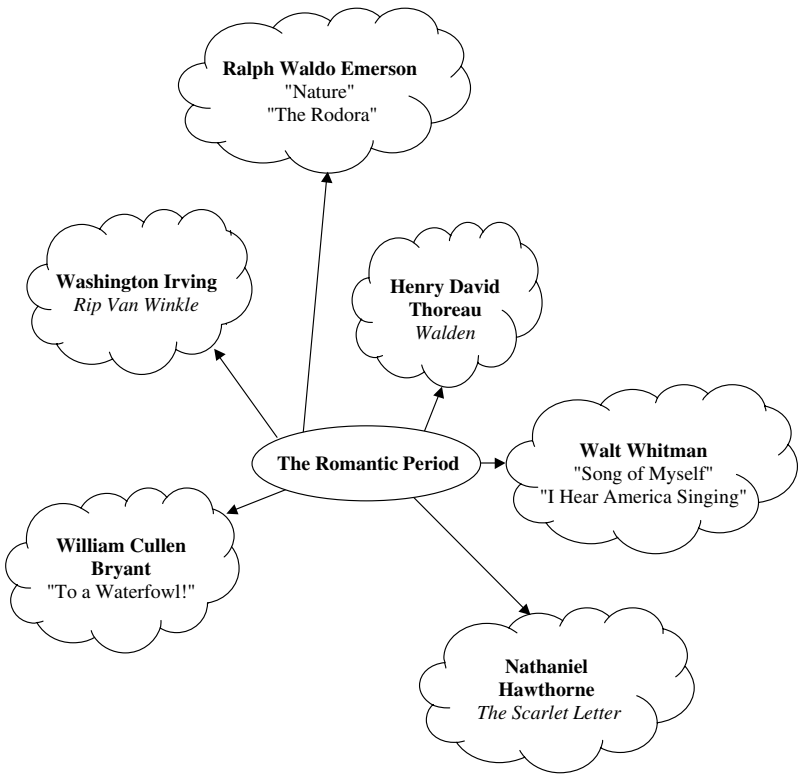
Mathematical Principle	*Example*	*Notes to Help Me Remember*

Students with learning problems are usually not very well organized, yet they need the structure to help them learn. For these students, it is essential that the classroom teacher set up structures to help these students organize their work. The structure in Form 1.1 is set up for a math notebook so that students can keep up with the different math concepts and formulas and how they are used. For language arts, a similar chart might be included for vocabulary words or parts of speech. For science, how to read the periodic table might be put into a graphic format.

An example of a nonlinguistic organizer is provided in Figure 1.2. A nonlinguistic organizer relies on structure and few words to help students learn.

The brain likes structure. As a matter of fact, the brain builds new learning by attaching it to old learning or experiences. When we can put information into a structure, we help all learners, but especially at-risk learners, to understand the information. In studies conducted by Mid-continent Regional Educational Laboratory and written by Marzano (1998), the effect size of using graphic models to help learners was significant. This means that students working at the 50th percentile range who receive instruction that includes visual

Figure 1.2 Nonlinguistic Organizer



graphic models can make as much as 39 percentile points progress when the instructional strategy is used properly. In other words, a student at the 50th percentile range can be moved to the 89th percentile range through the appropriate use of visual models. While this information comes from studies with regular education students, the studies conducted under the auspices of the U.S. Department of Education (2002) conclude that practices that make a significant difference in the learning of regular education students will probably make a significant difference for all students.

For students with visual perception problems or poor experiences with the learning, visuals will only be helpful if they are discussed in detail by the teacher or by others. Guenther (1998) says that what we see is really not a direct

representation of reality but one based on inferences within our brains based on past experience and perceptions. Given (2002) provides the following example:

> Two students may react quite differently to a poster showing various brain lobes and an announcement that the next thematic science unit will focus on the nervous system. A student with low reading skills and limited success in science may perceive only portions of the poster that accentuate his weaknesses. He immediately believes that his skills are inadequate to the task, fails to see any positive aspects of the project, and responds with worry. By contrast, another student, whose background is richly endowed, may perceive abundant detail and look forward to the experience as an exciting new learning opportunity.

Auditory Learners. Auditory learners make up the smallest number of the learners in the classroom. Many veteran teachers are auditory learners and were taught in classrooms that relied on lecture and discussion for learning. Few of today's students learn that way, which explains why many students struggle in a classroom based solely on lecture for disseminating information. It is not unusual to find in these classrooms that only a small percentage of the students are successful—usually those students who are auditory and those students that are good at adapting to the mode of teaching being used at any time. Most at-risk students are not good at adapting to the teaching style of the classroom.

Students who are auditory learners:

- Remember names better than faces
- Forget what is read unless it is discussed
- Would rather be in a group discussion about a topic than to read about it
- Are easily distracted by sounds
- Are good storytellers

For these students it is important that they hear the learning. Information does not have meaning to them until they hear the words and repeat them. Peer tutoring, discussions, and oral lessons are good tools for these students.

According to Given (2002), "Children with auditory processing deficit may have adequate hearing but have a great difficulty distinguishing the differences between sounds such as /b/, /d/, /g/, /p/, /t/, or /v/ and /f/." This may be the result of frequent ear infections from birth to three years of age. Given says that these children need intervention as soon as possible in phonemic awareness, "before a single collective neural net becomes firmly entrenched and similar sounds are perceived as one. The child must be aware that fine discriminations are necessary to grasp the appropriate meaning of language heard." She suggests using preschool alphabet books and playing "I see something you don't see and it begins with a B" as ideas for helping these students make the discriminations in sounds.

Kinesthetic Learners. Kinesthetic learners are those students who need movement and tactile approaches to the learning. They learn best when they can touch the information. Models and manipulatives are good tools for these learners. Many ADD and ADHD students come under this classification. By providing opportunities for these students to move and to experience the learning, the classroom teacher will assist these learners to understand the learning.

Some characteristics of kinesthetic learners include the following:

- They remember best what was done, rather than what is seen or talked about.
- When faced with a problem, they will often choose the solution that involves the greatest activity.
- They would rather participate in an event than to watch it.
- Their body language is a good indicator of their emotions.

- They like to build models.
- They like simulations, drama, and outdoor activities.
- They need movement or they may become a discipline problem.

Once information enters the brain through the senses, about 98% is discarded by the brain as not relevant. There are, however, some things that we can do as teachers to assist the brain to make good choices.

Processing Information

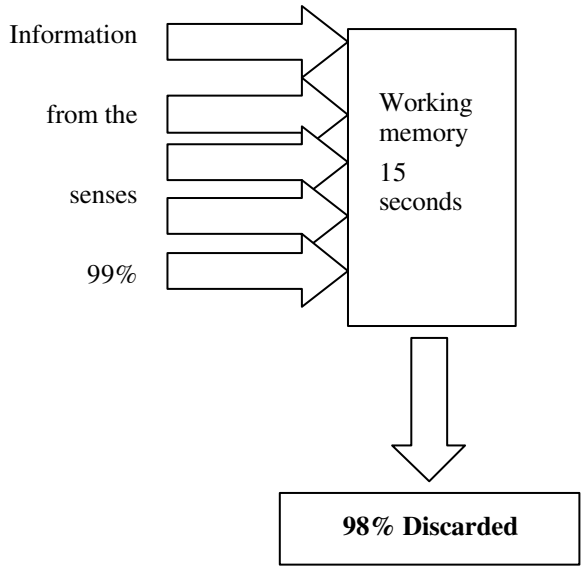
On test day students will often come into the classroom and say, "Hurry, hurry and give me the test before I forget the information." Those students do not know the material; they are merely saying it over and over (about every 15 seconds) so that they can hold it in working memory long enough to write it on the test. Ask them the same question next week and they will not remember the information. Once information enters the working memory (sometimes called *short-term memory*), we have about 15 seconds while the brain decides to process the information or to discard it: About 98% is discarded.

How, then, do we ever move information into long-term memory? The key to getting information into long-term memory is rehearsal (see Figure 1.3).

Rehearsal refers to what we do with the information once it has been introduced into working memory through the senses. Rehearsal performs two functions: it maintains information in short-term memory and it is the mechanism by which we transfer information to long-term memory. Both the amount of time devoted to the rehearsal and the type of rehearsal are important. Rehearsal may be rote or elaborate.

Rote rehearsal is deliberate, continuous repetition of material in the same form in which it entered short-term memory. Rote rehearsal is used when the learner needs to remember

Figure 1.3 The Road From Input to Discard



and store information exactly as it is entered into working memory. Examples of material learned by rote include math facts, spelling, and state capitals.

Elaborative rehearsal involves elaborating on or integrating information, giving it some kind of sense or meaning. In elaborative rehearsal, the learner does something with the information. Elaborative rehearsal is used when it is not necessary to store information exactly as learned, but when it is more important to associate the new learnings with prior learnings to detect relationships. Examples of material learned by elaborative rehearsal include problem solving, vocabulary in context, and reading comprehension.

Think about your classroom: What do you have students *do* with new information? We cannot create meaning for our students, but we can facilitate the process through good instructional practices. Most researchers agree that there are three basic ways that we make meaning:

- *Through relevance*—Jensen (1997) says, "In order for learning to be considered relevant, it must relate to something the learner already knows. It must activate a learner's existing neural networks. The more relevance, the greater the meaning."
- *Through emotion*—Emotion is the strongest force for embedding information into long-term memory; it has the power to shut down our thinking or to strengthen an experience so that we remember it for life. We add emotion to the learning through music (try adding sounds of the times to lessons), celebrations of the learning, adding visuals and simulations, and real-world applications.
- *Through patterns or connections*—The brain is a seeker of connections; it is constantly asking, "What do I already know about this subject that can be connected?"

Storing and Retrieving Information

Although there is controversy over the number of memory pathways that we have, most researchers agree that there are three primary memory pathways. Let's review them in terms of how to help students to use them more effectively.

Semantic Memory

The semantic memory (also known as *taxon, declarative, categorical*, or *linguistic memory*) is the system most often used in education. It is the area that stores words and facts—and it is the least brain-compatible of the three memory systems. That is one of the reasons our students cannot remember the learning. Sprenger (1999) says,

> New information enters the brain through the brain stem, goes to the thalamus, and is then sent to the hippocampus, which is the file cabinet for factual memories. If incoming sensory information is factual, it will use the

> hippocampus to search its files for matching information. The brain will look for prior learning or experiences with which to connect the new learning. It may take several tries for the brain to do this. Anything that we can do as teachers to facilitate this process will help our students to make sense of the information.

We can lead our students to the connections or, if there is not prior learning, provide a connector for our students. For example, for a lesson on the Romantic period, I may have students who are not familiar with the works of Emerson, Irving, Thoreau, and Whitman, but they are probably familiar with the idea of romance. I might start the unit by asking my students to list for me the characteristics of romance. From that list, I might lead my students to the understanding that in romance, we tend to have a preference for emotion over reason or logic. That, of course, is one of the characteristics of the literature of the Romantic Period.

When facts and words are taught in isolation without any context or connection, they are lost unless rehearsed, reviewed, or relearned. Teaching English language learners using the semantic memory system is unproductive, because these students lack the language to be able to make meaning of the learning. The same is true of students from poverty, since most of their learning outside of school and prior to entering school has been contextual and has involved the semantic memory system in only a very limited way.

Jensen (1998) says,

> The exact location of the semantic memory function has not been pinpointed, though we know it operates out of the cerebral cortex. The brain is poorly designed for remembering print and text copy. Information embedded in content is usually learned, or attempted to be learned, through rote tactics and by following list-like formats. Semantic memory is the type of list-oriented, sometimes rote, memory which requires rehearsal; it is resistant to

change, is isolated from context, has strict limits, lacks meaning and is linked to extrinsic motivation.

In other words, if students are to learn facts and words, they must have something with which to connect that information, otherwise it is useless to the brain and discarded. Some ideas that help students to remember facts or words include mnemonics (e.g., Please Excuse My Dear Aunt Sally for mathematical operations), rhymes (e.g., the alphabet with a song), peg words, or with similar content (e.g., "Last week we learned X. This week we will add to that by learning . . ."). As Jensen (1997) says, "This type of learning is typified by seated classroom work and homework, e.g., 'Study for Friday's test by reading Chapter Six.'"

Semantic memory is related to chunks of information. We can only handle a few chunks at one time. The number of chunks of information that we can process at one time is age dependent and fixed (i.e., we cannot change the number of chunks, although we can change how much we put into a chunk). LeDoux (1996) says that adults—those with a mental age of 15 and up—can hold up to seven items in short term memory at one time. Sprenger (1999) says, "Beginning at age three a child has one memory space. Every other year this increases by one space until the capacity of seven is reached. Then two spaces can be either added or subtracted, depending on interest level and prior knowledge." Form 1.2 shows the chunks by age.

The more that we can put information into manageable chunks or categories for our students, the more information they can deal with at one time. I can teach 20 items to my students at one time if I can find a way to put that information into chunks. For example, instead of having students memorize a list of reasons for World War II, a teacher is more likely to help students remember if the reasons are put into categories, such as economic reasons, legal reasons, and social reasons. Random lists of vocabulary are easier to learn if the information is put into categories. Prior to a lesson, provide a

Form 1.2 Chunking

Memory Space (+/– 2)

Age	*Number of Chunks*
15–adult	7
13	6
11	5
9	4
7	3
5	2
3	1

list of vocabulary and possible categories for students to determine the categories based on what they already know about the vocabulary (see Form 1.3). Provide opportunities throughout the learning for students to revise their list.

Episodic Memory

The episodic memory system (also known as *contextual, loci,* or *spatial memory*) is based on context and location (i.e., where you were when you learned the material or in what context you learned the information). While this memory system is used in the early elementary years, its use diminishes each year as the student moves through the education system, until it is rarely used in secondary school except in the arts or vocational classes.

This memory system, located in the hippocampus, is highly brain-compatible and can be remembered for years (although details may become distorted unless they are reviewed from time to time). Sprenger (1999) says, "The

Form 1.3 Teaching Students to Develop Categories (i.e., "Chunks")

Directions: Cut out the list of words below and decide which are categories. Place the vocabulary words under the appropriate categories. You may make your own categories as well.

Adrenaline	Automatic memory	Frontal lobe
Midbrain	Neocortex	Peptide
Structure of the brain	Memory pathways	Stress chemicals
Types of memory	Semantic	Cell membrane
Procedural	Contextual	Amygdala

important link for this memory lane is that you are always somewhere when you learn something so you can easily associate the learning with the location."

This is the memory pathway that stores information taught from the bulletin board, the chalkboard, or a color-coded sheet of paper—anything that gives the information context. During a test, you may see students look at the covered-up bulletin board in an attempt to recall the information that was there. If you ask a student a question for which they do not know the answer, sometimes just saying, "Remember, it was on the blue vocabulary sheet" can help trigger this memory lane. We tend to do better on tests when we take the test in the same room that we learned the information. Think about how we often conduct national or state tests by taking students to the lunchroom or some other general place. Try putting the students back into the classrooms for standardized tests. If your students

are typical of those in studies conducted by Jensen (1998), your students will do better on the test. Using visuals can help students to use this memory system more effectively. Remember that at least 87% of learners need visuals.

It is this memory system that allows us to remember where we were when significant events in history took place, such as the death of Dr. Martin Luther King or President Kennedy, or the explosion of the space shuttle. The episodic memory is also why this generation will remember 50 years from now where they were on September 11, 2001. Contextual learning is essential as we work with students from poverty. These students often lack the vocabulary skills to learn in the semantic system but have experience in learning through story telling, which is a part of the episodic memory system.

Teachers who work with students from poverty will do well to explore this memory system and how to incorporate it into the classroom. Since students today are often not motivated intrinsically, this is a good memory system, because it requires little intrinsic motivation to be activated. By combining this memory system with the words and facts needed in the semantic memory system, teachers can help students not only to review information but also to remember it.

Finally, the episodic memory system has unlimited storage capacity. Where the semantic memory system is limited by chunks (7–10 for an adult), the episodic memory system requires little intrinsic motivation to remember and can remember large amounts of information for years—forever, if the information is rehearsed periodically.

Some examples of ways to use the episodic memory system include the following:

- Post information so that it is visually accessible to the learners who need visuals to learn. For English language learners, visuals are critical to their learning because they have limited semantic acquisition strategies.
- Color-code units, especially if there is a great deal of vocabulary involved.

- Use graphic (i.e., nonlinguistic) organizers to help students "see" the learning and teach students to develop graphic organizers of their own for learning.
- Change the room arrangement prior to a new unit. Doing so affects context ("Remember, we talked about that information when you were all seated facing the windows").
- Use symbols and/or costumes to help students separate the learning. I use picture frames (what I call "frames of reference") when studying the Romantic Period in literature. One group of students has a frame that says *Emerson*, another a frame that says *Hawthorne*, another one that says *Whitman*, and so forth. Each group must talk about their author in terms of how he or she used the characteristics of the Romantic Period in his or her writing. The frame serves as a context for the learning.

Procedural Memory

The procedural memory (also called *body, motor,* or *kinesthetic memory*) is powerful memory system stored in the cerebellum. It seems to have unlimited capacity (as opposed to the semantic memory, which is limited by chunks), and we tend to remember the information stored there for years. Jensen (1997) says, "Procedural memory, also known as motor memory, includes that which happens when one, for example, learns to ride a bicycle, remembers the melody of a favorite song (musical memory) and recalls the fragrance of a flower (sensory memory)."

Sprenger (1999) calls it muscle memory, because it has to do with what the body does and remembers. It is strongly brain-compatible. Material learned this way is highly likely to be recalled; in fact, this method is the most commonly used for early childhood learning. A child's life is full of actions, which require him or her to stand, ride, sit, try out, eat, move, play, build, and run. The learning is then embedded in the body, and therefore remembered.

Students from poverty have had many experiences learning this way. If they want to know something, they generally learn by doing it. Adding movement to the learning is a great way to reach these students, as well as ADD and ADHD students. As a matter of fact, teachers trying to work with students from poverty or students with ADD or ADHD by teaching through lecture (i.e., by accessing the semantic memory system) are setting themselves and the students up for failure.

You can add movement to the lessons through the following:

1. Role-playing
2. Drama
3. Choral reading
4. Projects
5. Hands-on activities
6. Manipulatives
7. Debates
8. Group activities

Other Memory Systems

Tileston (2000) and Sprenger (2002) say you will find two other memory systems listed. Some researchers, such as Jensen (1998), say that although we first thought there were five memory systems, two of those systems are probably part of the original three. The two memory systems sometimes mentioned are the automatic and emotional memory systems.

Automatic memory. Automatic memory is also found in the cerebellum and is sometimes called *conditioned–response memory* because the automaticity is a result of conditioning. Some examples of where this system is used include multiplication tables, the alphabet, and decoding skills. The use of

flashcards or songs in order to learn facts are ways of putting information into the automatic system. Researchers, such as Jensen (1998), say that the automatic memory is really a part of the procedural memory system.

Emotional Memory. Sprenger (2002) says,

> This memory lane begins with the amygdala, the limbic structure that sifts through all incoming information for emotional content. The amygdala is very powerful and can take control of the brain. For this reason, attaching emotional memories to learning can make a tremendous difference in how material is remembered. The primary emotions are joy, fear, surprise, sadness, disgust, acceptance, anticipation, and anger. Using these will help reinforce learning. Some researchers believe that emotion is not a separate pathway but a factor that can enhance or shut down the other memory systems.

The truth is that there are probably memory systems that have not been discovered as yet, but for now the information about these three (or five) systems is important to helping all students to be successful.