The Role of Time in Learning

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ABSTRACT

This literature review paper examined the role of time in students learning. It was comprehensive in nature, investigating time and its direct effect on learning as well as indirect relationships with factors including teacher use of time, student use of time, the effect of aptitude or intelligence on time and learning, the role of time on cognition, and the economics of time use according to models of economics. It was intended to determine to what extent time plays a role in learning and suggest possible ways to improve teaching practices based on findings. This paper reviewed 27 quantitative, two conceptual, and one qualitative study. The conclusion drawn from this review was that while time was demonstrated to be a factor in learning, its role was not major. There are other factors, such as the nature of the time used, the cognitive demand of classroom lessons, and the aptitude and interests of students, that play a more significant role in student learning.

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

What is the role of time in learning and teaching? That is the question this paper will address. To be more specific, what does research say about the relationships between time, learning, and teaching, that I can use to be a more effective teacher?

As a teacher, I will likely face a room full of students from a diversity of backgrounds. Supporting this likelihood is an understanding that people are uniquely individual based on their prior experiences. Dewey (1938) and Zull (2002) supported this idea of student uniqueness in their works. With this diversity of experiences comes a diversity of interests, knowledge, and skills which places students in a range of starting points which vary with each lesson. Since not all students will have a similar starting point it might be reasonable to say that some students will need more scaffolding to help them learn the lesson. The cost of this scaffolding is time. But one question that seems to spring from this line of reasoning has to do with the nature of time. Is the time spent scaffolding those students that need the extra help going to pay off more in the long run, at the immediate cost of loss of time to learn more lessons? This paper will investigate whether or not time is a factor in a student's learning of a lesson. If time is a factor, to what extent does it play a role, and what is the nature of that time? Is time akin to investing capital into a growing market, almost guaranteed to return on the investment, or is it a fixed value mattering little when or how you use it?

To answer these questions I will examine the nature of time in learning on several levels in an attempt to gain an overall impression of how time interacts with learning. I'll start by looking at classroom practices from the perspectives of both the students and the teachers. Are the ways time is used by students and teachers, and the interactions of those ways, a factor in learning? From there I will investigate the effect of time in terms of aptitude. Does the ability of a student to learn a lesson have any effect on the amount of time needed to learn the lesson? Following that investigation I will attempt to determine if there is a relationship between time and student cognition. Does more time to learn lead to learning the lesson on a deeper level? Finally, I will explore the cost-benefit analysis of time spent on learning and the degree to which the lesson was learned. Is the extra time spent learning worth the outcomes?

Rationale

With recent legislation such as the Elementary and Secondary Education Act of 2001, also known as no child left behind, educators, school administrators, and governments on all levels are becoming increasingly accountable for students meeting certain standards of education. Through my broad experience going through multiple schools in a variety of states, and one other country, one thing that stood out was the use of time. When looking back at the three different high schools I attended, each school had a different length of school year, each school had a different length of the school day, and each school had a different length of class periods. This lead to the question: is the amount of time and the way it is used a factor in learning, and if so can time use be maximized to improve learning so that educators, school administrators, and governments can provide the best learning opportunities for their students to meet the standards of education demanded by society As a teacher, if I know the answer to the questions listed in the previous section, I will be in a better position to plan more effective lesson based on the presence or absence of time as a factor. If time is a factor, I can adjust my teaching practices to maximize the efficiency of my teaching so that students learn in a way that maximizes their use of time. If time is not a factor, I can focus my energy on using teaching practices that place emphasis on non-temporal factors that might affect my ability to teach effectively.

Statement of Purpose

This paper will answer questions I have in reference to the existence or non-existence of relationships between time, learning, and teaching so that I can more effectively develop teaching practices that are more efficient in affecting student learning.   I plan to investigate whether a relationship exists between time, learning, and teaching by first examining general research on time and learning. Next, I will examine the role of teacher influence on time allocations followed by the choices students make in reference to the use of time. Then, I discuss the relationship between time, aptitude, and achievement. I will also briefly explore the effect of time on cognition.   Finally, I will discuss time as a resource and how economic principles are used to justify time use.

Terms

In order to achieve this purpose, several terms, used throughout this paper will need to be clarified so that the intended meaning is taken form this paper. Achievement, as used in this paper is the degree to which a topic is learned. Aptitude is the ability of a student to learn a topic based on intrinsic factors such as prior knowledge, interest, and naturals talent. This word is interchangeably used with intelligence, though it should be noted that intelligence is sometimes seen as a controversial concept, thought to be based on social and racial/ethnic ideals more than on a universally accepted principle. In the case where intelligence is used, it is not meant to imply acceptance of the concept, instead it is meant to convey the ideas of the studies' authors in the words they used. Finally, a lesson is any learning experience and all of the activities required to accomplish or support the accomplishment of the goals of the experience.

Some of the studies used specific types of time to differentiate how it was used. In this case the terms used by the author(s) were used in the analysis as well to maintain continuity of understanding. Engaged time is the amount of time students display activities, postures, attitudes, or behaviors associated with attending to the lesson being taught as it is taught. Time on task is the amount of time a student spends performing a task associated with the lesson. Time available is the total amount of time possible for the teacher to use for the lesson. Time allotted/allocated is the total amount of time scheduled for the lesson. And time to learn/needed is the amount of time required by a student to learn the lesson.

Limits

While there are several ways time is viewed culturally, the focus of this paper will be limited to a western European perspective of time for two reasons. The first reason is that most of the research on the topic is done primarily by education researchers of western European origins. The second reason is that the school systems I foresee myself teaching in are western European in origin and thus are based on western European concepts of time. It should be noted that while the focus is limited to a western European perspective of time, many of the studies' participants came from other than western European cultures. I have interpreted this to mean that the studies have differences of the nature of time and its use, with respect to cultural identity, as a factor which may or may not have been addressed.

Summary

This paper will explore the relationship between time, learning, and teaching. In the next chapter, the role of time in schools will be discussed to provide a historical perspective to the research question. It will begin by discussing how school was historically organized with respect to time. Then it will move on to how the role of time in schools has evolved through history before coming to a discussion of what lead to the beginning of research on the topic of time, learning, and teaching in the early 1960s.

CHAPTER TWO: HISTORICAL BACKGROUND

In the previous chapter I introduced the question this paper will attempt to answer: what is the role of time in learning and teaching? I explained the relevance of this question to my future practice as a teacher. I then went on to provide a rationale for examining this question. Finally, I defined the terms I will use, and set the limits of scope of this paper. In this chapter I will provide an historical backdrop to provide context to the question. I will begin with a discussion about the initial development of organization in schools' daily schedules. Then, I will focus the discussion on the origin of research in education relating to time, Carroll's (1963) paper on school learning and time.

The Beginning of Organized School and Schedules

Much of early education was run by religious organizations (Bowen, 1981). Here education was a way to train young people in the traditions of the what ever form of clergy that particular religion had. Later this education would broaden out to different subject areas for people to be trained in administration of various government offices. In the late 1400s European schools began to change and several institutions began to appear that were supported by wealthy patrons. These schools were a result of the growing number of independent thinkers who challenged long held beliefs about the nature of the universe and man's place in it. Some of the early subjects to be taught in these academies were math, astronomy, biology, chemistry, mechanics, hydrology, psychology, and philosophy. Later, literature and writing classes would be added to schools. With this ever increasing diversity of subjects a system for scheduling the study of these subjects seemed inevitable.

This idea of teaching various subjects was eventually picked up by schools supported by religious organizations, though religious values still had a heavy influence on the subjects taught and how they were taught (Bowen, 1981). In 1698 in France, a royal edict mandated that all children had to go to Catholic school from age seven to fourteen (Bowen, 1981). In the protestant countries of northern Europe, schools became more secular (Bowen, 1981). Around this time, in the pre-revolution United States (U.S.), schools were mainly grammar schools focusing on literacy skills. In the town of Northampton, Massachusetts, school was in session for six months of the year teaching children to read, write, and “cipher.” In 1682 in the town of Flatbush, New York, school went from 8 AM to 11 AM, let out for lunch, and began again from 1 PM to 4 PM (Bowen, 1981).

In the 1800s in Prussia, schools were further organized into elementary and secondary levels under a nationally controlled system (Bowen, 1981). Elementary school was for the first three years of school followed by Gymnasium, which was another nine years. Boys from privileged, middle-class families attended Gymnasium. Students who could not afford to go to Gymnasium went to either the Progymnasium or the Realschule. These schools were less rigorous, focusing on language, science, and social science. Realschule also had a technical aspect to its curriculum (Bowen, 1981). This organization established Prussia as a leader in the field of education with the U.S. sending students to Prussian universities for more advanced schooling (Bowen, 1981). In the early 1900s in the U.S., schools were further divided and in 1940 the junior high school was developed (Bowen, 1981).

Research in Education Relating to Time and Contemporary Thoughts on Time

When Carroll (1963) wrote his paper describing a model of learning, he started a debate over the relationship between time and learning that would span several decades. From his model that stated that learning was a function of time spent learning divided by the time needed for learning, numerous researchers, discussed later in chapter three, sought to show the relationship through experimentation. Currently, no major research or experimentation is being conducted on the matter.

Though not much current research appears to be done on the subject of time, it is still a subject of much interest. Discussions about time revolve around such topics as year-round schooling (Orellana & Thorne, 1998), the need for a new perspective of time (Slattery, 1995), modifying class scheduling in the form of block schedules (Veal, 2001), and changing the pacing of classroom instruction (Wood, 1999). With the introduction of the Elementary and Secondary Education Act of 2001 and its increased emphasis on accountability, the topic of time in education and, by proxy learning, will likely continue to be part of the discussion of education reform.

Summary

In this chapter I provided a historical background for the development of time use in schools and a brief history of the origin of the research to be discussed in the next chapter. In chapter three I will discuss general studies of time and learning. Following this, I will examine how both teachers and students use time. Next, I will focus on the relationship between aptitude, achievement, and time. Afterwards, I will briefly explore the effect of time on cognition. Finally, I will investigate the application of economic principles on time allocation in learning.

CHAPTER THREE: INTEGRATIVE, CRITICAL REVIEW OF THE LITERATURE

In the previous chapter I provided an historical background to the research this paper addresses. I introduced the initial development of organization in schools' daily schedules. Then, I detailed the origin of research in education relating to time, which began with Carroll's (1963) paper on learning models**.** In this chapter, I will discuss general studies of time and learning. Following this, I will examine how both teachers and students use time. Next, I will focus on the relationship between aptitude, achievement, and time. Afterwards, I will briefly explore the effect of time on cognition. Finally, I will investigate the application of economic principles on time allocation in learning.

General Studies of Learning and Time

Most investigations into the nature of learning with regards to time can be traced back to Carroll's (1963) conceptual work describing learning as a function of time. His paper considered five factors of learning subdivided into two categories; factors affecting time needed for learning and factors affecting time spent in learning. The factors falling under the former category were aptitude, ability to understand instruction, and quality of instruction. Under the latter category he listed time allowed for learning and perseverance, the time a student is willing to spend learning.

Under the category of time needed, aptitude is that quality that takes into account any prior learning or experience in similar or relevant tasks. Carroll (1963) reasoned that a student with more progress towards mastering the learning objective will need less time to reach the objective, while students without as much progress will need more time. In mathematical terms, he described this idea in the formula, $a_t = f(\alpha_1, \alpha_2, \ldots, \alpha_n) - s_t$, where a_t, the student's time needed for an objective, is a function of the time needed to learn prior skills, α, minus the time saved, s_t, by knowing those aptitudes. This factor lies solely within the realm of the student, the student brings this with it to the learning experience.

Carroll (1963) continued with ability to understand instruction. Here, the student's innate intelligence and verbal ability factor in. A student with a higher intelligence may be able to figure out what is required for the learning task with less elaboration than a less intelligent student. The student's ability to actually understand the language in which the instructions are given is the student's verbal ability. Carroll did not go into great detail as to what he defined as verbal ability other than to say that it was the student's ability to grasp the language being used. Grasp of the language could be expanded to mean actual language, French, Japanese, Swahili, etc. It could also mean the level of vocabulary, the syntactical structure of the instructions, the semantics of the words used, or the pragmatic meaning of the instructions. Ability to understand instruction is a factor falling under the influence of both the student and the teacher; the student utilizes their intelligence and verbal skills to understand instructions and the teacher uses the same capabilities to create instructions.

Quality of instruction, is the third factor Carroll (1963) described under the time needed category. This factor is the teacher's ability to create a learning experience that allows the student to learn the objective in the most efficient manner possible. The teacher has sloe responsibility for this factor since the student has not yet attained the objective and therefore does not have the full information required to determine the most efficient manner of learning the material.

Under the category of time spent in learning, time allowed for learning is the actual time set aside by the teacher or schedule to learn the objective. Carroll (1963) said schools fall on a spectrum where students are given as much time as needed on one end, to all students are given the same fixed amount of time at the other. Realizing that most schools took a middle ground approach which involved ability grouping, Carroll discussed the problem with setting the time allowed based on ability groups. If the higher ability groups are favored, it is possible that the lower ability groups will not have enough time to learn the objective and fall behind. If lower ability groups are the determinant factor in time allotment, then it is possible that higher ability groups will become bored and/or unmotivated without some form of enrichment. In this factor the student has no control over the time allowed for learning and must adapt to it as best as possible.

Carroll's (1963) last factor was perseverance, the time the student was willing to spent learning the objective. This factor is affected by the student's motivation and emotional variables. Carroll took into account the possibility that a student may be so motivated that he or she is willing to spent more time than is needed to reach the objective and beyond. In response he narrowed the definition to perseverance in learning to criterion to avoid the complication of over-learning. Perseverance is likely affected by both the student and the teacher; the student provides a certain level of intrinsic motivation, and the teacher, as well as parents, society, etc., provides extrinsic motivation.

With these factors identified Carroll (1963) went on to create the model where degree of learning = f(time spent/time needed). For the values of time spent and time needed Carroll said that the value for time spent is the smallest value of either time allowed, perseverance in learning to criterion, or aptitude. Here It may be easy to ask, why is aptitude a possible value for both the numerator and the denominator? Carroll cited a previous work for the detailed answer, but the answer becomes apparent if it is considered that it is possible that the time allowed or the perseverance in learning to criterion values are greater than the time needed. At this point aptitude is all that is left to determine the amount of time spent learning. It should also be noted that in the denominator, Carroll also included the values for ability to understand and quality of instruction. In less than ideal conditions these two factors add to the denominator, reducing the overall degree of learning.

Carroll's (1963) model has had an impact on subsequent research, spawning numerous investigations into the relationship between learning and time. Though not supported by empirical data, the reasoning behind Carroll's work followed the tenets of deductive logic. This was facilitated by Carroll's careful use of words to explain what he meant. Furthermore, the seemingly general definitions aided in creating a model that is simple in its nature, but has room for expansion based on other methods of learning used in schools.

One researcher influenced by Carroll's (1963) work was Gettinger (1985). In her research comparing time spent, allocated, and needed to achievement, Gettinger (1985) hoped to determine what relationship exists between each type of time addressed in Carroll's paper to achievement. Specifically she sought to evaluate how the change in time spent or allocated from the time needed affected learning and retention. She also examined the relationship of the ratios of change to learning and achievement.

In this study, Gettinger (1985) used a sample of 171 fourth and fifth grade students from a Midwestern community of lower middle class to upper middle class socioeconomic status. The sample included 87 girls and 84 boys of which 81% were white, 13% black, 3% Asian, and 3% other. The sample had a median reading achievement score of 73.03 on the STEP test (Series II, form 4A).

The students in the sample were given a total of 3 grade level appropriate tasks consisting of a passage that students read along and listened to on an audio tape, and a 10-question multiple choice test (Gettinger, 1985). Each test had three versions, one each for use on the three trials with reliability ranging from .75 to .89. In addition to tests, Gettinger also collected teacher ratings of each student’s rate of learning and motivation to learn.

The three trials were designed to measure time versus achievement (Gettinger, 1985). The first measured time needed. Here students were given the task until they achieved 100% on the test. A maximum of six attempts was given based on prior research though not all students met criteria by the sixth attempt. For students not meeting criteria, time needed was extrapolated. In the second trial students were allowed to determine how much time they would spend learning the material. For both of these trials motivation was held constant by keeping each trial session as short as possible. They also gave students a star on a tracking chart for each time they improved their score from the previous attempt or achieved 100%. The third trial measured time allotted versus achievement. In this trial each student was given a third to half the time needed, as determined by the first trial. For all three trails, the test was given again a week later to test retention.

The timeline for this study was 2 months (Gettinger, 1985). The 171 students were in 8 separate classes of 18 to 23 students per class. Each class was seen for one week with the each trial given in random order typically administered on Monday, Wednesday, and Friday. Each trial session took 20 to 30 minutes.

Gettinger's (1985) results showed that time needed for the students averaged 4 trials to get 100% on the test. The estimated range was 1 to 8 attempts. Time needed correlated highly to teacher ratings ($r=.798$, $p<.01$). For time spent, students spent an average of 68% of the time needed on the tasks. This reduced time yielded 88% of their achievement in the time needed trial and 83% of the retention. When the time allotted was 58% of the time needed, students' learning was 83% of that achieved in the time needed trial and 80% of the retention.

Gettinger (1985) also found significant overall differences between the degree of learning ($F[2, 340]=33.47$, $p<.01$) as determined by test scores and retention scores ($F[2, 340]=24.75$, $p<.01$). Post hoc Newman-Keuls analysis demonstrated a significant decline ($p<.01$) in degree of learning from time needed to time spent to time allotted. Spending an average 2 less attempts decreased learning and retention (11% and 16% respectively, $p<.01$) significantly as well as significantly decreasing learning and retention (15.5% and 18.5% respectively, $p<.01$) when an average of two attempts were allotted.

When she examine the ratio data, Gettinger (1985) found that the time spent to time needed ratio correlated to learning and retention significantly ($r=.513$ and .597 respectively, $p<.01$) as did time allotted to time needed ($r=. 448$ and.549 respectively,

$p<.01$). This means that the closer time spent and time allotted were to time needed, the greater the learning. When Gettinger compared the time spent to time needed ratio scores to teacher estimates, she found a significant correlation ($r=.603$, $p<.01$) interpreted to show that higher motivated students showed less of a change between time spent and time needed than lower motivated students.

Based on the data Gettinger (1985) concluded that spending or allocating enough time is important based on short-term learning, but these results also have implications for long-term learning. While Gettinger did find significant variation in the amount learned with relation to time, the variation might not seem significant if cost benefit analysis were applied to these data. Student learning dropped by an average of 14.5% and retention by 18.5%, this for an average drop in learning time of 60.2%. Gettinger did not address the implications of this data on classroom time management given that the average classroom has only one teacher for, in her study, 18 to 23 students. Her study also showed a wide range of time needed, 1 to 8 attempts. This has implications for using results of this study to determine which students will need more or less time, but she failed to consider cost-benefit analysis for this also. How many students needing more or less time should be considered before changing the amount of time needed, and still maintain an efficient learning environment?

In a previous study Gettinger worked with Lyon to find what factors could be used to predict the differences in time spent and time needed (Gettinger & Lyon, 1983). They found several factors that might be used as predictors, and used some of this data to design the previously discussed study. In their work together Gettinger and Lyon experimented to see if they could determine what variables were associated with lower time spent learning (TSL) when compared to time to learn to criterion (TTL). They specifically wanted to examine locus of control, self reported interest in the material, and classroom behavior.

In their experiment, Gettinger and Lyon (1983) used a sample population of 96 boys recently done with third and fourth grade. The boys were all referred to a summer school/camp based on behavior problems. The experiment took place in southeastern Indiana in a mostly white, rural middle to lower middle class area. The boys exhibited on of four behavior patterns including attention deficit (42%), disruptive classroom behavior (14%), low frustration tolerance (18%), and low self-concept (27%). The sample had an average IQ of 98.82 using the Peabody Picture Vocabulary Test (PPTV, form A), and an average score of 90.30 on the Wide Range Achievement Test (WRAT).

Gettinger and Lyon (1983) measured five variables before the experiment began. Intelligence was measured using the PPTV and reading achievement using the WRAT. Interest level was gathered from the students with a five-point Likert scale on topics in the subject areas of science and social studies. The Intellectual Achievement Responsibility Questionnaire was used to gather locus of control data; a higher score indicated higher internal locus of control. Classroom teachers and school psychologists filled out a forced choice rating scale to gather the behavior description of each of the boys. These were cross-checked by two independent school psychologists, interrater agreement ranged from .79 to 1.00.

For each grade level, Gettinger and Lyon (1983) developed four learning tasks and corresponding tests. Criterion for each task was set at 100%. The tests for the tasks had reliabilities of .73 to .82 for fourth grade, and .69 to .79 for fifth grade. All of the boys participated in two learning sessions. In the first session students would read a passage along with a cassette recording of the passage and take a 10-question multiple-choice test. This process would be repeated for each boy until he got 100% on the test. The boys did not get feedback as to which questions were missed on the tests. This session was the TTL session and lasted 20-30 minutes. The second session, done the next day, was the TSL session. It also took 20-30 minutes and was similar to the TTL session with the major change being that the boys got to determine how many trials they would go through before taking the test. For both sessions Gettinger and Lyon administered a criterion test two days later for retention data. For each boy a TTL-TSL discrepancy score was calculated by subtracting the number of trials in the second session from the number of trials in the first.

Gettinger and Lyon (1983) analyzed the data to get results that showed that the average score for trial 1 in session 1 was 7.21 (SD= 2.21) and for session 2 it was 7.58 (SD=2.03). These scores showed no significant difference nor did the interest ratings for the tasks in the sessions. The mean number of trials to criterion in session 1 was 3.28 and the mean number of trials spent on the task in session 2 was 1.86. The differences between the number of trials in the two session was significant ($t[95]=7.43$, $p<.001$). The average retention test scores were 94.88% and 78.01% for session 1 and session 2, respectively. This difference was also significant ($t[95]=8.15$, $p<.001$). TTL-TSL trial score were found to be significantly correlated ($r=.58$, $p<.001$) with TTL-TSL retention scores. Gettinger and Lyon (1983) interpreted this to mean that the greater the discrepancy between them needed and time spent, the greater the discrepancy in learning.

Gettinger and Lyon (1983) further analyzed TSL/TTL ratios (M=.71, SD=.43) and TTL retention/TSL retention (M=.82, SD=.20) and found a significant correlation between the two ratios (r=.55, p<.001). This was interpreted to mean that retention dropped from 95% to 78% when the boys spent less time learning.

When correlation analysis was done on the rest of the variables, Gettinger and Lyon (1983) found that reading achievement (r=-.60, p<.001), locus of control (r=-.52, p<.001), IQ (r=-.29, p<.01), and interest (r=-.31, p<.01) had significant correlations with TTL-TSL discrepancy scores. The only behavior variable with a significant correlation was attention deficit (r=.22, p<.05). In the regression model, WRAT scores, attention deficit, interest, locus of control, low self-concept, and IQ were found to account for 63% of differences in TTL-TSL discrepancy (R=.794). The most variability came from WRAT test scores (56%), this was explained to come from the reading nature of the tasks. IQ had no significant amount of influence when factored in.

In their discussion of the results, Gettinger and Lyon (1983) found that spending 71% of the time needed yielded 81% of the retention of TTL. They failed though, to mention that the amount of time lost was greater than the amount of retention lost, showing there might be a pattern of diminishing returns. They also discussed the role of interest, locus of control, and self-concept as deserving of more research based on their significant contribution to the TTL-TSL discrepancy. Finally, Gettinger and Lyon discussed their finding that TTL-TSL discrepancy correlated to standardized achievement highly. Here though, the only standardized achievement data came from only one source, the WRAT. For such a statement to have weight, more achievement tests would be needed for analysis in this study.

Gettinger later went on to study how changing time spent and time needed affected student learning (1989). With predictive factors studied (Gettinger & Lyon, 1983) and relationships determined (Gettinger, 1985), Gettinger tested the effect of increasing the ratio between time spent learning (TSL) and time needed learning (TNL) (1989).

For this experiment, Gettinger (1989) used a sample population of 118 third grade students, 58 girls and 60 boys, from six classrooms. The experiment took place in three public schools in southern Wisconsin. Gettinger collected five extra sets of data for the sample. Each student was tested for locus of control using the Intellectual Achievement Responsibility Questionnaire (IAR) and intrinsic motivation using the Harter Scale. Teachers rated each student on motivation using a Likert scale, and 12 observers monitored and rated on task behavior. These data sets would be used later in the analysis to characterize two groups of students.

The experiment consisted of eight tasks consisting of a passage to be read by the students as they followed along with a cassette of the passage and followed by a 10-question multiple-choice test (reliability from .79 to .94) (Gettinger, 1989). For the TNL session, the students would read the passage and take the test. This would be repeated if the student did not reach 100% on the trial test. A maximum of six trials was set as a limit based on cited previous studies. For TSL, students would do as with TNL with the exception that the students could stop studying the passage when they felt they were ready. The goal was to reach 100% on the test. Gettinger also conducted an incentive version of the two sessions. Here students were shown a box of stickers and told they could choose one for each time they got 100% or improvement of test score from the previous trial for the incentive TNL session. For the incentive TSL session students could choose a sticker after each test they took. For all four session, a retention test was given the following day. Each session was 30 to 45 minutes in duration.

Gettinger's (1989) results showed that the baseline TNL mean was 4.91 trials and the baseline TSL mean was 3.99. Based on this the students were split into two groups, one group of students where TNL>TSL (63 students) and one where TSL≥TNL (55 students). T-tests comparing the means between the groups showed significant differences in teacher motivation ratings ($t=3.50$, $p<.01$), teacher task persistence ratings ($t=4.50$, $p<.01$), internal locus of control ($t=7.23$, $p<.01$), and intrinsic motivation ($t=12.21$, $p<.01$). Gettinger also did a one way, repeated-measures ANOVA on total sample TNL baseline and TNL score from each incentive condition and found significant differences ($F[2, 234]=10.61$, $p<.01$). A post hoc Newman-Keuls test also showed that baseline TNL scores were significantly different from incentive TNL scores ($p<.01$). Gettinger interpreted this to show evidence that incentives can improve accuracy and thus reduce time needed. Doing the same ANOVA test for TSL revealed significant differences again ($F[2, 234]=19.82$, $p<.01$). Another post hoc Newman-Keuls test showed TSL scores under both incentive conditions were greater than the baseline TSL ($p<.01$). Gettinger interpreted this to mean that incentives increased student perseverance.

Gettinger (1989) analyzed retention scores and got results showing significant effects. A 2X4 ANOVA revealed that there was a significant effect for both groups ($F[1, 116]=36.84$, $p<.01$) and all four task presentations ($F[3, 348]=13.93$, $p<.01$). An interaction between groups and presentations was also significant ($F[3, 348]=20.33$, $p<.01$). This was interpreted to mean that task presentations that minimized TNL and maximized TSL had the greatest degree of learning. Another result was that for students where TSL>TNL there was no significant benefit to learning, perseverance past time needed was wasted time.

In the discussion of the results, Gettinger (1989) conceded that one limitation of this experiment was the generalizability of the learning task to other types of learning. She mentioned previous research criticizing the creator's learning task model for being too narrow and mechanistic and based on this criticism recommended that more research be conducted on other types of learning. She also mentioned two other areas of future research. The first was relating to how time was used, the second to identifying factors that might increase TNL.

Gettinger's (1989) methods could have been made less mechanistic in light of criticism of the method used, but she did acknowledge this showing that she was aware of this aspect of the experiment. The methods used do draw questions as to the validity of the results with respect to actual classroom learning tasks and conditions.

Seifert and Beck (1984) were also studying the same relationships studied by Gettinger in her three studies (1983, 1985, 1989), but specifically examined time-on-task. They also added a variable Gettinger didn't study, that being student attitude. Seifert and Beck sought to answer two questions with their study. The first, is there a relationship between student achievement and time? The second, is there a relationship between student attitude changes and time? They focused these questions on the secondary education level due to the perception of less success at improving school effectiveness at that level.

For this study, Seifert and Beck (1984) chose five central Texas high schools based on accessibility and size. In each school they chose two sections of first-year algebra to be observed. Seifert and Beck decided to observe algebra based on the assumption that learning objectives would be less varied between the schools. Students were given a pretest (reliability coefficient=.80) and in each section six students were selected based on their pretest scores' closeness to their respective section's mean score. Neither the teachers nor the students knew which students were to be observed. Each student would be observed for one 55-minute period each week for ten weeks. Each period was divided into ten cycles lasting five and a half minutes each. In each cycle the observer would observe each of the selected students for a period of 55 seconds. The observations were coded on a student observation form (SOF) (reliability coefficient=.78). At the end of the ten-week period, all students in each section took a posttest.

For analysis of the data, Seifert and Beck (1984) used student achievement as the independent variable. Achievement was the difference between the posttest and pretest scores. The dependent variables were the five observed variables; setting, objective, learner moves, general moves, and interruptions. These data were compared on scatter plots and used Pearson's correlations and t-tests for statistical analysis.

In looking at the overall classroom strategy versus achievement, Seifert and Beck (1984) found that student achievement had a positive correlation with on objective oriented tasks ($R=.465$, $p<.05$) and a negative correlation with off objective oriented tasks ($R=-.50$, $p<.05$). Seatwork also had a negative correlation to achievement ($R=-.50$, $p<.05$) while lecture and discussion had a positive correlation ($R=.460$, $p<.05$).

For those events that were coded as engaged learning events, the only significant correlation came from covert engaged activities described as listening and/or thinking (R=.452, p<.05) (Seifert and Beck, 1984). This coincided with the correlation of total engaged time to achievement (R=.452, p<.05). Unengaged events displayed a trend of negative correlations. The two specific events that had significant negative correlations were off task (R=-.347, p<.05) and waiting for help (R=-.367, p<.05). Seifert and Beck suggested that waiting for help led to off task behavior, compounding that correlation. There was a significant negative correlation between total unengaged time and achievement (R=-.40, p<.05).

When they compared data from the setting variable to on-task time, Seifert and Beck found a positive correlation between lecture/discussion and on-task time (R=.286, p<.05) and negative correlations between seatwork and on-task time and no setting and on-task time, but the negative correlations were not statistically significant. When achievement was compared to off-task time, seatwork had a positive correlation (R=.157, p<.05) while lecture/discussion (R=-.10, p<.05) and no setting (R=-.115, p<.05) had a negative correlations with off-task time.

Seifert and Beck (1984) also did an analysis of the mean on-task time and achievement in all classrooms. They found that a mean on task time of 28 minutes (17-34 minutes) and an average achievement gain of +4.49 (-1.3-+9.0). When analyzed per classroom, a strong relationship existed between amount of time spent on-task and achievement gain (p>.95).

From the results, Seifert and Beck (1984) concluded that when the teacher exerted direct control over the class, there was more time spent on-task. Seatwork data indicated that students accomplished little suggesting that allowing students unsupervised time to work on homework appears to be a waste of time. Another conclusion, supported by the data was that students waiting for help are likely to lose interest during that time and shift to off-task behaviors. Finally, they concluded that secondary school instruction is more apt to suffer from off-task influences than elementary school instruction. They based this conclusion on comparisons of this study's average on-task time (28 minutes, 54.2% of total class time) to that of many others (sources not cited).

This study takes care in setting up a method of observation that attempts to record student behavior at various points of time during the class (Seifert & Beck, 1984). The category of covert engaged behavior left room for more subjective interpretation than others. It seems possible that a student may look like they are listening or thinking about the lesson, but are actually thinking about something else. This could have an impact on the correlations between covert engaged activity and achievement. Also, the inclusion of student absences as unengaged time might have had a biasing effect on the data. The student may have been engaged, just not in the classroom. The data might have shown different result had absences been treated as missing data as opposed to being counted as unengaged.

This study also had a narrow range of settings, group settings were initially listed as one of the codes under settings, but either it was not observed, or not observed at a significant level (Seifert & Beck, 1984). This deficiency in settings allows for the conclusion that lectures/discussions have a positive effect on achievement gain, where it might have the opposite effect in the company of other settings.

Finally, the conclusion that secondary school instruction is more likely to suffer from off-task influences, based on the amount of on-task time spent, than other instruction is not supported by any data in this study (Seifert & Beck, 1984). The findings only support the need for research in this area.

Another study researching general time relationships with learning achievement was Wayne, Walberg, and Rasher's (1979) study of high school students in Chicago. Like Seifert and Beck (1984), they also examined an extra variable. With Gettinger's (1985) and Seifert and Beck's factors added to the Carroll's (1963) model, it would appear that another variable would only act to complicate Carroll's model, making it less likely to be an all encompassing model of student learning. Nonetheless, in their study, Wayne et al. attempted to link in-class learning time to school learning achievement as well the effects of positive and negative teacher comments on achievement.

The sample for this study was 175 classrooms in 26 high schools in Chicago (Wayne et al., 1979). The observation order as well as the day of the week, time of day, and subject areas were chosen at random or counter-balanced to get as wide a representation of the classrooms as possible. One thing the researches noted that might have influenced the reliability of the results is that specific classrooms for observation were being chosen by the school administration. Wayne et al. (1979) recognized that they were likely being placed in classrooms where their presence was unlikely to interrupt activities or classes that were better than others.

Each classroom was observed for two class periods (Wayne et al., 1979). The observers recorded six variables, number of students present, proportion of students not involved in the lesson, a log of when students entered and left during the lesson, interruptions to the lesson, and running logs of both positive and negative comments from the teacher. The first two variables were recorded in five-minute intervals. For the first three variables there was an interrater reliability of .98, .88, and .98 respectively in a later study, similar reliabilities were assumed for this study.

Achievement was measured using the median reading scores for eleventh grade students taking the Iowa Test of Basic Skills for 1973 and 1975 (Wayne et al., 1979). The 1973 scores were used for regression analysis and control. Time was measured as Actual Student Time (AST). AST was measured in student-minutes. Since they could only get scores by school, the observations for each observed class in a school was pooled to represent school data.

The results of their study showed Wayne et al. (1979) that there was a significant correlation between AST and both tests ($r=.54$ and $.46$, $p<.01$ for 1975 and 1973 respectively). When a partial correlation factoring out the influence of the 1973 scores was examined AST correlated with the 1975 reading scores ($r=.35$, $p<.05$) as did positive comments ($r=.39$, $p<.05$). Average AST was 525 student-minutes, 46.5% of the maximum possible AST of 981 student-minutes. The greatest factor contributing to this difference was absences.

For the regression analysis Wayne et al. (1979) found that each standard deviation in AST equated to a .14 increase in standard deviation of achievement. In their model this represented two more students attending each day, a 50% reduction of interruptions, or 10% increase in attention level.

From these results Wayne et al. (1979) concluded that higher achieving schools had lower time loss and higher positive comments. Based on this they suggested that lowering student absences and increasing the quality of classroom interaction.

In their study Wayne et al. (1979) state that no causal relationships can be found in the data. Along with this statement and the fact that they had an outside factor influencing their observations, it is difficult to place any conclusivity in the results of this study. Furthermore the inclusion of teacher comments did not appear to shed light on the possible effect of time on achievement.

While the afore mentioned researchers all conducted their own experiments, two sets of researchers sought to determine the relationship between time and learning through the use of data collected from large survey studies. Brown and Saks (1986), and Aksoy and Link (2000) analyzed the data from these studies to come to more generalized conclusions about the relationship in question.

Brown and Saks (1986) analyzed data from the Beginning Teacher Evaluation Study (BTES) to ascertain if learning rates change across students, teachers, and subject matter as a function of instruction time. They were also paying close attention to the effect of a student's initial achievement on learning rate as a function of time.

The sample for the study was 25 second grade and 21 fifth grade classes (Brown and Saks, 1986). For one year, an average of six students per class was observed. Observers monitored time allocations in reading and math. Students were given tests in both subjects at three different times of the year; October, pre-holiday December, and May. Time allocation data was collected in the interim periods. Subset scores of the reading and math tests were collected, but whole subject scores were used for analysis in this study.

Brown and Saks (1986) collected time measurement data from teacher time logs and observer records. The teacher logs were eventually not used to prevent teacher bias. Also, observer recorded times of students activity were more consistent. Observers measured time use in seven categories; proportion engaged, proportion self-paced, proportion easy work, proportion hard work, proportion substantive, proportion grouped, and proportion tutored.

The results of the observations and test scores displayed a positive effect on achievement in both subjects in both grades for allotted time (Brown & Saks, 1986). Further examination for variation across teachers yielded a significant variation in the elasticity, or variation in the use, of time in math (second grade: .41 SD .065; fifth grade: .18 SD .073), but not in reading. After adjusting for this variation, Brown and Saks found that the elasticity of score with respect to allotted time was .45 and .13 in second and fifth grade reading, respectively, and .13 and .09 in second and fifth grade math, respectively. Brown and Saks suggested that the reason for the elasticity of time in math might come from the widely accepted feeling that teachers in elementary grades are poorly skilled in teaching math and dislike it.

Another result Brown and Saks (1986) found was that there was a significant effect of starting achievement and allotted time in both subjects in both grades. For students of lower initial achievement, time allotted had a greater effect than for students with higher initial achievement. When they investigated whether this effect varied across classes they found no significant variation, thus supporting the idea that the technology on instruction has an equalizing effect on achievement. Brown and Saks also suggested that this says that the effect on scores with change in time diminishes with both time and initial achievement.

The last result Brown and Saks (1986) examined was the finding that how the time was used did not significantly relate to achievement. They noticed that their results were frequently opposite of those predicted by theory. The reason for this was estimated to come from significant errors made by observers in determining the time use being observed and in what category it fell.

Overall conclusions from Brown and Saks (1986) stated that time had significant effect on achievement for subject and grade level, but varied significantly by teacher. Also noted was the significant interaction between time allocated and student achievement; increased time benefits students with lower initial achievement than it does students with higher initial achievement.

In this study, Brown and Saks (1986) were careful to mathematically justify their data calculations, especially in relating time allocation changes to initial achievement. Previous reports of the findings by other researchers were unable to determine this effect because of the use of a linear function for learning curve. Brown and Saks used a non-linear function to show this relationship. Also the conclusions are closely supported by the data without the interference of unobserved factors through careful use of mathematical principles.

The conclusions of Brown and Saks' (1986) study and the study by Aksoy and Link (2000) were in agreement that increased time led to increased achievement. The differences lie in what type of achievement. Aksoy and Link, in their analysis of data gathered in the National Education Longitudinal Study of1998 (NELS), wanted to find out if increasing learning time increases math achievement.

For this analysis, Aksoy and Link (2000) used NELS data. NELS collected data from 1,052 schools. In each school, 24 eligible 8th grade students were selected to participate, for schools with fewer than 24, all eligible 8th graders were used. Follow-up data was taken in 1990 and 1992 with augmentation of the sample to maintain roughly equivalent numbers of students. The data was broken down into panels of students, one with data for all three years (1/2/3), one for students with data from the first two years (1/2), and one for students with data from year 1 and 3 (1/3). These panels were further divided into a group considering all races and a group considering only white students.

The dependent variable for this study was test scores from mathematics item response theory tests gathered by the National Center for Education Statistics (NCES) (Aksoy & Link, 2000). This variable was measured against 17 independent variables; minutes per class, hours of homework, hours of TV, legal days per year, class hours per week, class size, beginning teacher salary, teacher experience, Hispanic teacher, black teacher, female teacher, private school, urban, rural, income, parents divorced, and hours worked. The panels were then balanced panel, all of the students included had data for all of the variables for the panel they were included in. This format allowed for a total of 2,756 students to be considered.

The results that Aksoy and Link (2000) got showed that an increase in class length by ten minutes yielded a significant achievement gain of 5.4%-6.2% ($p<.05$) for panel (1/2). For every additional hour of homework there would be a gain of .67, .36, and .81 point for panels (1/2/3), (1/2), and (1/3) respectively for the all race samples. For the (1/2/3) and (1/3) panels, TV lowered achievement scores by .55 and 1.31 point per hour viewed, respectively, for whites, and .84 and 1.59 points per hour viewed, respectively, for all races. This was significant ($p<.05$). There were no significant results for increased number of hours per week. For the panel (1/2) for whites, increasing the length of the school year by 5 days would increase achievement scores by 5.4% ($p<.05$).

Aksoy and Link (2000) also got significant results in the non-time related areas, but their conclusions do not match the purpose of this study so they will be ignored. In their conclusions they consistently suggest adding more time to learning where it was found to have a significant impact, but they did not consider the costs of those increases. In the case of homework they said that increasing the amount of homework appeared to be a low cost way of improving achievement, but what of motivation. They claimed that panel estimation allowed them to control for this and other unobserved variables, but how can something be suggested without observing the impact of those suggestions on the unobserved variables? They did concede that the data might represent more college bound students since they are the ones most likely to take two or more years of math. If this concession is taken into account, it makes the idea of motivation being a cost of more time more likely if non-college bound students are included. Aksoy and Link suggested three areas of further investigation. The first was the rate of absenteeism with respect to the number of school days per year. The second was getting more data by race. Since whites were the majority in the data collected they were easy to separate out, but minority groups were not represented in large enough sample populations to get significant data. The third suggestion was investigation into the impact of gifted students on this analysis.

In summary, all but one of the studies (Brown & Saks, 1986) showed some degree of an effect where more time to learn lead to an increase in achievement. The main critique of these studies is that while they claimed to show an effect of time on learning, the methods used were not congruent to an everyday classroom environment.

Teachers' Use of Time and its Effect on Learning

In the previous section, it was shown that there is some relationship with time and learning, but that there are also several confounding factors that might diminish the directness of that relationship. This section will address one of those factors, that being the role of the teacher in controlling time. Two studies were examined. Specifically, these studies addressed the question of how a teacher's use of class time influenced students' achievement. The first was an experiment performed by Sanford and Evertson (1983). They studied the use of time in junior high schools to answer two questions. The first question addressed how class time was used in the classes observed and how it varied between the classes. The relationship between the way time was spent and student achievement gains were addressed in the second question.

To answer these questions, Sanford and Evertson (1983) used a sample of 52 math classes and 50 English classes from 11 different junior high schools. A total of 51 teachers each teaching two classes participated in the study. Data was collected between the third week and the last week of the school year resulting in eight or nine observations of one hour each for all 102 classes. The observations were divided into three categories of student behavior, on-task, off-task/unsanctioned, and disruptive. These observations were taken every 15 minutes by counting how many students were exhibiting behaviors for each category. The observers also recorded how many minutes of time were spent in the following nine categories: administrative and procedural routines, transitions, grading, whole-class instruction, seatwork, tests, dead time, small-group instruction, and other.

Along with classroom observations, Sanford and Evertson (1983) gathered data of each student's achievement before the study. This was assessed using the California Achievement Tests (CAT). Students were also asked to rate each teacher and subject to measure student attitudes, this was done at the end of the year in May.

The results of this study were broken down by subject area. Since all teachers taught 2 classes in one of the two subjects, a correlation analysis was done to measure the stability between the two classes taught by each teacher. The results showed high stability ($r=.64$ to $.99$, $p<.01$).

In the math classes the average majority of time was spent on seatwork (19.81 min, SD 7.37 min) and whole-class instruction (15.33 min, SD 6.94 min) (Sanford & Evertson, 1983). English classes had similar results with seatwork (19.61 min, SD 5.15 min) and whole-class instruction (15.57 min, SD 6.02 min) again taking up a majority of time spent. Both math and English classes were, on average, 55 minutes long. The other categories each had values less than five minutes for math and less than six minutes for English.

When looking at the relationship between how time was spent and achievement, Sanford and Evertson (1983) found that in math the only significant correlations were found with whole-class instruction ($r=.4252$, $p<.05$) and seatwork ($r=-.4160$, $p<.05$). No significant correlations were found for English classes.

The relationship between student behavior and how time was spent showed some significant correlations also (Sanford and Evertson, 1983). For total academic time in math classes there was a significant correlation with on-task behavior ($r=.5411$, $p<.05$) and with disruptions ($r=-.3870$, $p<.05$). For English classes there was a significant correlation with total academic time and disruptions ($r=-.4406$, $p<.05$).

Further investigation in the time use of four selected teachers showed that the teacher with the highest average class achievement gain (.9786) also had the highest amount of whole class instruction (33.25 min), the lowest amount of dead time (0.00 min), and the lowest amount of non academic activities (7.63 min) (Sanford and Evertson, 1983). The teacher with the lowest average class achievement gain (-.4223) had the highest amount of seatwork time (29.56 min). These data supported Sanford's and Evertson's results showing correlations between how time was spent and achievement.

For math, Sanford and Evertson (1983) hypothesized that the reason that teachers with great amounts of whole-class instruction time had higher achievement gains might be due to the idea that more material is covered in that time. This hypothesis was supported by another study that they cited. Since they did not examine the material taught in the math classes, Sanford and Evertson also entertained the possibility that whole class time may allow for more thorough discussion and practice of the material.

From the results, Sanford and Evertson (1983) concluded that teachers do vary how they use their time, although for the two subjects the mean time usage appears very similar. They surmised that the reason for insufficient significant data from English classrooms may have to do with the variable nature of the curricula. From this they also suggested that classroom management, instructional, and curriculum variables be taken into account in future studies.

Wang and Walberg (1983) found somewhat similar results for teachers' effect on time and learning. The greatest difference between their study and that of Sanford and Evertson (1983) was the focus of the time management of the teachers. In Sanford and Evertson's study, the teachers studied exercised the same method of management for all students while in Wang and Walberg's study, the teachers were using flexible adaptive learning method of classroom time management. In more exact terms Wang and Walberg sought to determine the level of implementation of the Adaptive Learning Environments Model (ALEM) and to determine whether adaptive instruction is useful in increasing time-on-task, reducing the amount of time needed for learning academic basics, and increasing the amount of time for teacher instruction and student learning activities. Adaptive instruction models, cited by previous work by the lead author, assessed student learning based on the rate of objective attainment. This is contrary to programs where time is held at a constant and the level of mastery is assessed.

The study took place during the 1980-81 school year. 156 classrooms ranging from kindergarten through third grade participated in the study. The schools were located in 10 school districts of varying socioeconomic, ethnocultural, and geographic characteristics. All 156 classrooms were using the ALEM program.

Wang and Walberg (1983) took three measurements in the course of their study. They measured degree of ALEM implementation, classroom processes, and student learning outcome measures. For ALEM implementation they looked at 96 performance indicators for 12 critical dimensions. Observers recorded these indicators using the

Implementation Assessment Battery for Adaptive Instruction at three separate occasions during the school year. The observations generally took two hours with an inter-observer reliability coefficient for the 12 dimensions ranging from .48 to .91 with a median of .74.

The results of this data show significant variation of implementation ($F=3.15$, $P<.01$) with a mean of 92% implementation across the 12 dimensions (Wang and Walberg, 1983). Of these 12 dimensions those with the highest percentage of implementation were record keeping, prescribing, diagnostic testing, and managing aides. These were implemented above 85 %. The lowest percentages of implementation were found in creating and maintaining instructional materials, interactive teaching, and developing student self responsibility. Here, only 55 classrooms implemented these dimensions above 85%.

Classroom processes were recorded using the Student Behavior Observation Schedule (SBOS) (Wang and Walberg, 1983). This data was collected during the first two weeks of May 1981. Due to cost and time constraints third grade classrooms were excluded leaving 72 classrooms to participate in this process of the study. Students in each classroom were observed for 5 consecutive 1-minute intervals. Students were randomly assigned to an observer who observed the students in an order shown on their respective lists. All observations for a given class were completed in one day and the time at which the observations occurred were determined to be insignificant. Observations had an average of 95.5% inter-rater agreement.

When analyzed in relation to ALEM implementation, classroom process showed a statistically significant correlation ($r=.36$, $p<.01$) (Wang and Walberg, 1983). Schools with higher rates of ALEM implementation had higher percentages of processes including on-task interaction, exploratory activity, self-initiation of activity, and sharing of ideas and materials. They also had lower percentages of process such as disruptive interactions and individual work settings.

Another analysis was made between classroom processes and on-task time (Wang and Walberg, 1983). Though there was a relatively small observation period for each student (5 minutes total), there were some significant correlations between on-task time and classroom process. The greatest correlation was a negative correlation between disruptive interactions and on-task time ($r=.23$, $p<.01$) followed by a negative correlation between individual group work settings and on-task time ($r=-.10$, $p<.01$). The greatest positive correlation was between group interactive settings and on-task time ($r-.09$, $p<.01$) followed by teacher initiated reaction and on-task time ($r=.08$, $p<.01$).

Student learning outcome measurements were primarily determined from teacher records of student progress, but for four school districts standardized test scores were available (Wang and Walberg, 1983). The results of these measurements when compared to ALEM implementation show a trend of more progress in the number of math and reading objectives mastered as well as an increase in standardized test scores, but neither of the trends was statistically significant.

While this study includes a large, diverse sample of students, there was not a diverse sample of school types or programs. Including more schools that did not use the ALEM program method might have yielded more significant results as pertaining to the effectiveness of the ALEM program in increasing student learning outcome. Comparing implementation rates within a program, though useful in determining the effectiveness of a program in various stages of implementation, does not give perspective of the program’s effectiveness in the greater realm of education. If previous comparisons were made, mention of the results would have helped to put the results of this paper into perspective.

Another shortcoming that might have been addressed by including other programs is the appearance of bias in this study. The lead author of this study appears to be one of the architects of the ALEM program. Furthermore, the lead author devised many of the measuring tools also. The use of measuring systems developed by another researcher would have helped to corroborate the results of the lead author’s tools.

Finally, the method used for observing the students could have been modified to allow for a greater amount of observed time. The author did note some attenuation of the correlations between classroom processes and on-task time. Had the observation format been modified to reduce this attenuation, the results may have shown higher correlations.

This study does address the idea that time and learning might be reconciled by more effective classroom management practices. More efficient methods of managing a group of students of varied aptitudes might reduce the amount of time needed to attain learning objectives at the same time increasing the amount of time available to attain those objectives.

In summary, the two studies in this section, Sanford and Evertson (1983) and Wang and Walberg (1983), suggested that in classrooms where the teacher minimized non-learning tasks, achievement was higher than in classrooms with higher incidences of non-learning tasks. In effect, in classrooms where more time is spent on learning, more learning will generally occur than in classrooms where less time is spent on learning.

Students’ Use of Time and its Effect on Learning

Students as well as teachers have an input to how time is used in classrooms. As evidenced in the previous two studies, this influence is sometimes antagonistic to the influence of teachers in terms of time use that has been shown to increase achievement. In the following two studies, student time outside the classroom was examined. The reason for this focus was that student time inside the classroom was measured in several previously discussed studies, but student learning sometimes is extended outside the classroom in the form of homework. In the first study Smith (1990) investigated this time use and even suggested which uses of time might be more beneficial to achievement. He hypothesized that homework, leisure reading, and parent time would relate positively, and television, friends, and radio/record listening would relate negatively.

For this study, Smith (1990) collected data from a sample of 1,584 seventh and ninth grade students attending 14 public schools in a southeastern city. The sample was racially mixed (41% black, 59% white), and represented a diverse socioeconomic status. Asian and Latino students were eliminated because they were too small of a potion of the original sample population of 2,236.

Smith (1990) measured student achievement by using test scores from the Comprehensive Test of Basic Skills (form U, levels H and J). The school administered the test about a month after the students filled out the questionnaire used by Smith. The questionnaire was used to measure time spent by the student on homework, leisure reading, household chores, parent interaction, TV viewing, being with friends, and listening to radio or records. These were independent variables as were race, gender, grade level, family type, parental occupation, and parental education.

The data was analyzed with multiple regression with effects being considered significant if they were seen with at least two of the four dependent variables of reading, language, math, and overall achievement (Smith, 1990). Of the hypothesized positive relationships, significant data was only found for leisure reading when compared with overall achievement ($p<.05$) and reading achievement ($p<.001$), though the relationship with reading achievement was determined to be weak (beta=.082). For the negative effects, listening to radio or records had a significant relationship to all four categories of achievement ($p<.01$). Time spent with friends was the other significant negative effect, but only for ninth grade students ($p<.05$ for math, $p<.01$ for overall, reading, and language).

Smith (1990) found significant results for household chores and TV viewing. For TV viewing, there was a significant relationship with parental occupation and overall and reading achievement ($p<.001$), language ($p<.01$), and math ($p<.05$). There was also a significant relationship between TV viewing and parental education and overall and reading achievement ($p<.01$), and language and math ($p<.05$). The direct effects were positive for time spent viewing TV, but negative for parental occupation suggesting that TV viewing appeared to help students whose parents had a lower socioeconomic status. Smith said that this was also supported by data found in another study that showed the same result with the addition that students whose parents had higher socioeconomic status had achievement negatively affected by TV viewing. Smith suggested that TV might act as a leveler.

Household chores showed significant relationships with race and overall achievement and math ($p<.01$), and reading and language ($p<.05$). Direct effect showed negative effects for chore time and all four categories of achievement ($p<.001$), though these relationships were weaker among black students than for white students even though blacks were found to spend more hours per week doing chores ($M=11.43$, $SD=7.86$) than whites ($M=7.45$, $SD=5.97$). Smith hypothesized that this might be that more chore time for blacks reduced the amount of time with friends and listening to radio or records they could participate in. Smith found no significant relationship and suggested more research as to why this effect works as it does.

In his discussion of the results, Smith (1990) concluded that the prevalence of non-academic fun and non-academic work such as chores appear to be associated with lower academic achievement. He cited the lack of positive parental encouragement of education as another factor leading to lower achievement. The conclusions seem contrary to some of the results of the study. His data showed that increased time with parents did not necessarily increase achievement, it did not address the nature of that time. It may have been that that time was devoted to academics, it may not have had an effect. This also holds true for interactions with friends. While more time with friends equated to less achievement for ninth grade, the results did not make any indications as to the nature of those interactions. Smith did go back to conduct a special analysis on the type of friends through the activities students reported doing, but found no significant results. This might have been because the activity may not necessarily be an indicator of the type of friends in it. It is possible to be in a non-academically related activity with friends that support academic achievement and vice versa.

A final note is that Smith (1990) could have sought more diversity in the sample population by using fewer schools from the city and adding schools from nearby rural communities with different racial make-ups.

In the second study in this area, Bruno (1995) took this analysis further by comparing traditional students to those labeled as at-risk. At-risk students are students defined as having low achievement levels for reasons other than mental disability or learning disability. Similar to Smith's (1990) results, Bruno found a link between the types of activities students spent their time on and academic achievement. Bruno also examined the temporal dominance, the sense of the past, present, and future, of students.

Using a sample of 205 normal and 308 at-risk students, Bruno (1995) obtained self-reported time allocated data through use of a survey. The types of time were separated into four categories, outer directed time (reliability=.77), other directed time (reliability=.73), inner directed time (reliability=.80), and non-directed time (reliability=.86). These types of time correspond to the following emphases respectively; achievement, relationships, personal development, and passing time. The students attended the same inner-city high school. The designation of at-risk or normal was made based on teacher input. Bruno also used a circle test cited as being developed by Cottle. This test was used to measure the temporal dominance of both groups of students.

The results of Bruno's (1995) study showed that in a ratio of directed time to non-directed time, the normal achievement group had a ratio of 12.6:1 while the at-risk group had a ratio of 4.4:1. This signified that the at-risk group spent more time than normal achievement group on non-directed time. Non-directed time was defined as time spent on such activities as TV viewing, hanging out and other passive entertainment experiences. A regression analysis further yielded that allocation of non-directed time is related to male gender (R^2=-.061, p<.0017), at-risk designation (R^2=-.03, p<.0011), and temporal dominance patterns (R^2=.055, p<.0010). The model had an overall R^2 value of .27 (F[4, 507]=35.7, p<.001).

For temporal dominance, Bruno (1995) found that the at-risk group (8%) displayed small future circles more often than normal achievement group (4%). The at-risk group (35%) also displayed large future circles less often than the normal achievement group (58%). Some of the students' explanations of their circle test supported Bruno's observation that students designated as at-risk had a lower temporal dominance than did those in the normal achievement group.

Bruno (1995) suggested that for at-risk designated students, teachers should work to demonstrate the importance in time sense. One way Bruno said teachers could do this is by increasing the ratio of satisfaction to time expenditure. Bruno supported this idea with his data that showed that at-risk designated students showed a trend towards allocating more time to non-directed time allotments. The reason for this, Bruno asserted, was that activities under this category had higher satisfaction rates and low time expenditure requirements.

While Bruno (1995) researched time allotment from the student perspective, he did not adequately support it with more quantitative measurements. He relied on student self-reporting, which in itself presents the possibility of bias. To mitigate this, he had a large sample size (N=513). For the designation of achievement, if Bruno used achievement tests and other quantitative measurements to determine achievement category, he may have divided achievement categories even further to get better data resolution allowing for more precise analysis of the results. As it is, the use of teacher designations of the students' achievement may have also biased the results based on each teacher's own bias. It is also possible that achievement test scores, themselves not being the most reliable indicator of achievement, might have been used to verify teacher assessments of achievement.

For the two studies in this section, Smith (1990) and Bruno (1995) found that students who spent more time on activities associated with learning such as homework had higher achievement than those who spent more time on activities such as socializing with friends. One of Smith's findings showed that students whose parents were of a lower socioeconomic status benefited from TV viewing. This one result may point to several underlying social aspects to the use of time by students.

Time Versus Aptitude as Determinant of Successful Learning

The studies in the previous section all addressed the idea of a relationship between time and achievement, but a few of the studies hinted at the possibility that students' aptitudes play a role. Investigating the possibility that time does not play a significant role in achievement, this section will examine studies that have evaluated the relationships between time, achievement, and aptitude.

The first of theses studies was a study by Gettinger and White (1979). This study explicitly asked which factor, time or intelligence, related more with achievement. Gettinger and White (1979) performed this study using two samples. The first sample had a total of 71 students; 20 fourth graders, 28 fifth graders, and 23 sixth graders. These students went to a predominantly middle class school in Indiana. The second sample had a total of 82 students; 32 fourth graders, 28 fifth graders, and 22 sixth graders. These students attended a parochial school in New York City with mostly Latino, lower middle class students. For each sample, a mean IQ was tested for. In the first sample mean IQ was 107 with a standard deviation of 14.23 and a range from 82 to 139, in the second sample, the mean was 98 with a standard deviation of 12.33 and a range from 65 to 135. Gettinger and White also measured achievement. For the first sample the median score was 59.6% on the Stanford Achievement Test (Form A, 1973 edition, Intermediate levels I and II). For the second sample the median was 38.6% on the SRA Achievement Test (Form C, grade 3 and Multilevel editions).

Each sample was given six different types of grade level appropriate learning tasks; vocabulary, spelling, math concepts, math computation, reading comprehension, and reading for the facts (Gettinger & White, 1979). Each task had an accompanying criterion test of 10 or 12 questions. Each task was given according to the same procedure whereby each task was given and then immediately afterwards a test was administered. Then, the task would be repeated seven more times with tests administered after each task repetition/trial. This was done in a time period of 45 minutes. Each task was given on a separate day. Prior to this study, Gettinger and White conducted a pilot study to determine the criterion for each task.

Gettinger and White (1979) attempted to keep motivation constant by marking a star on a chart for each repetition the student met the criterion. This also served to as a visual display of student performance on the various tasks.

The results of the study showed no significant differences in the time to learn based on gender and grade level so each sample was analyzed as a whole (Gettinger &

White, 1979). When correlated with achievement and IQ, time to learn was shown to have a higher composite correlation with achievement (sample 1: $r=.87$, $p<.05$; sample 2: $r=.85$, $p<.05$) than with IQ (sample 1: $r=.72$, $p<.05$; sample 2: $r=.72$, $p<.05$). Gettinger and White (1979) further looked at correlations for each task for each trial and noted that as the number of trials increased so did the number of students reaching criterion. The standard deviation in performance decreased as the number of trials increased also. This supported the idea that as time increased, so did the success rate of meeting criterion. Not only did the success rate increase, but the difference in scores decreased.

Gettinger and White (1979) argued that the results display a predictive quality. The results based on individual trial correlations showed that by the fifth repetition, correlation results were almost as high as the results for all eight trials. With this knowledge, if a student has not reached criterion by the fifth trial, it is possible to estimate how much more time the student will need to reach criterion.

In the discussion of their results, Gettinger and White (1979) examined implications of their findings. They contend that if mastery level is fixed, then achievement can be predicted based on the amount of time needed to reach mastery. This would also make it possible in a classroom where time is the fixed value to determine which students need more time allocated for a certain task.

Time to learn, as argued by Gettinger and White (1979), measured performance against time and not IQ, making it less likely that inferences of intelligence would lead to group discrimination. But here, Gettinger and White appear to discount that while time to learn does have a stronger correlation to achievement than IQ, IQ still has a significant correlation. Furthermore, they calculated a correlation between IQ and time to learn (sample 1: $r=.60$, $p<.05$; sample 2: $r=.60$, $p<.05$). Although the correlation is not as strong as the others, it does suggest a more complex relationship between the three factors. It could be argued that discrimination by proxy might still occur; students who require too much time might not be seen as capable of performing, especially in a fixed time setting.

Spiegel and Bryant (1978) did similar work in their study of processing speed, intelligence and achievement. Their conclusions were supportive of those of Gettinger and White (1979), but their interpretations of the discriminatory effects of the findings differ. In their study of processing speed, Spiegel and Bryant (1978) set out to determine to what extent response time and change in response time with change in difficulty related to intelligence and achievement.

The subjects of this research were 51 male and 43 female (N=94) sixth grade students from four parochial schools in a large urban city (Spiegel & Bryant, 1978). All students spoke English as a first language and had a mean composite IQ score (Lorge-Thorndike Intelligence Test, multilevel edition) of 116.7 (SD=14.16) ranging from 80 to 148. The scores displayed a normal distribution curve. Along with the Lorge –Thorndike test, the students were also given the Stanford Achievement Test to measure achievement.

Spiegel and Bryant (1978) developed three tasks each with four levels of difficulty. The tasks were pre tested in both timed and untimed settings on 2 separate samples of 20 sixth grade students to evaluate grade-level appropriateness of the tasks. The three tasks were sentence picture comparison, pictorial similarities and differences, and matrix analysis. In each task the challenges were displayed in a screen. In front of the screen were four buttons labeled A through D. A large X was marked equidistant from all four buttons to indicate starting hand position. Spiegel and Bryant measured response time with an electronic stop clock accurate to 1/100th of a second. For each task, incorrect responses were thrown out.

The results of this study were limited to those data gathered from the sentence picture comparison task because the lowest two difficulty levels of the other two tasks were too close to yield reliable data (Spiegel & Bryant, 1978). They found that mean response time correlated to the composite IQ scores (r=-.6). For achievement they found lower correlations with reading comprehension (r=-.5), math concepts (r=-.4), and math computation(r=-.4). The change in response time with change in difficulty correlated to response time also (r=-.5) as did it with achievement (r=-.4 to -.3). When Spiegel and Bryant did a partial correlation between response time and achievement, controlling for IQ, they found no correlation indicating an influence of IQ on the correlation between response time and achievement. To support this, they controlled for time and found a partial correlation between IQ score and achievement scores (r=.4 to .5).

Spiegel and Bryant (1978) also looked at data relating to the number of incorrect responses and found there was little change in the number of wrong answers with a change in difficulty. Also, no significant differences were found with respect to gender.

The conclusions that Spiegel and Bryant (1978) came to were that response time and achievement relationships can be attributed to intelligence. They also concluded that the relationship between processing speed and intelligence is independent of difficulty of the task. Tied in with the idea that students with faster processing speeds are capable of learning more information in the same amount of time as students with slower processing speeds, this would make it appear that intelligence is the factor driving the relationship between time and learning. The idea that processing speed can be used as a potential determinant of intellectual ability was also seen as a more acceptable form of measuring intelligence than conventional methods due to the influence of cultural bias.

Though they did have several strong correlations for the one task they were able to get data on, Spiegel and Bryant (1978) failed to list the level of significance for these data, thus leaving them suspect. Also the fact that they had to throw out the data from two tasks limits their findings to sentence-picture comparisons that drew more on verbal coding skills than did the other two tests.

Another study closely related to Spiegel and Bryant's (1978) was one on an experiment designed to test error-based intelligence measurements with a newly created time-based measurement. Like Spiegel and Bryant's, and Gettinger and White's (1979) studies, Hughes (1983) experiment also showed an influence of intelligence on time with reference to achievement. He suggested that by not keeping time fixed, time could be used as a determinant of intelligence.

Hughes' (1983) subjects were 80 undergraduate college students of which 34 were male and 46 were female. Race and socioeconomic status data were not given for the subjects. He divided them into two groups matched for IQ using the Standard Progressive Matrices. One group got strategy instructions for the experiment task, the other did not.

The task was a paired associates learning task (Hughes, 1983). In this task, the digits 0 through 9 were paired with three letter nonsense syllables. The subjects would sit at a computer and learn the pairings in 10 blocks of 10 presentations. For each presentation a nonsense syllable would appear on the screen and the subjects had to enter the corresponding number on a keyboard. They would get feedback for each response, incorrect responses would include the correct answer. The instructions for this task were the same for both groups with the exception of the extra strategy instruction that was given to the strategy group. The task took less than 30 minutes for most subjects.

The data was entered into one of six methods for calculating learning rate. These methods were used for descriptive analysis using t-tests and F-tests, correlation analysis, and regression analysis.

The results showed that the strategy group fared better on the task with significant means for two measurement tools ($p<.001$) (Hughes, 1983). Five measures showed significant variances between the two groups ($p<.001$). For the correlation data, the scores for the group not receiving strategy were not significantly correlated to IQ scores. Further analysis using the strategy group revealed the one time based measure to have the highest correlation ($r=-.594$, $p<.001$). The next highest correlation was at $r=.465$ ($p<.01$). In the regression analysis, none of the error-based measurements had any significant F values. The time-based measurement accounted for 35% of the total 42% of variance.

Based on the data Hughes (1983) concluded that based on observation of the subjects, not all seemed to respond at the same rate, justifying the use of time-based measurements. This was supported by the data showing the time-based measurement to have the highest correlation to IQ. Further correlations of the error-based measurement tools also yielded very high, significant correlations ($p<.001$) suggesting that they measured the same factor with similar efficiency. Hughes went on to cite supporting research to conclude that the data supported the relationship between learning time and general intelligence.

Hughes' (1983) study was simple in its goals and means of achieving them. He used mathematical and statistical principles to support his findings. The one possible area for improvement would be to test this measurement on other learning tasks that make use of different forms of learning as well as a larger sample population. This would help to establish the generality of Hughes' measurement tool.

Anderson (1976) wrote a report lending support to the argument for intelligence when she investigated the use of mastery learning and the difference of students' use of time. In mastery learning, the criterion determining mastery is fixed, whereas time is fixed in anon-mastery classroom.

In her study, Anderson (1976) tested the hypothesis that time-on-task to learn to criterion would be the similar to time-on-task in contemporary, non-mastery classrooms. She would achieve this by testing a mastery-learning classroom against two non-mastery learning classrooms.

For this experiment Anderson (1976) used a sample of three classrooms of thirty students. Later the number of students would be reduced to 26, 27, and 29 students. All students were tested using the Lorge-Thorndike Verbal Intelligence Test scoring from 87 to 135. Anderson also pre-tested the students on the subject of matrix arithmetic. The class means were 7.6%, 8.9%, and 7.9%, respectively. Students used a programmed textbook for the three units they would be going over. At the end of each unit they took a formative test. For each unit the students would write in their books, the time they began the unit and the time they stopped. When they took the test they would write the time they began and finished on the test. For the mastery-learning class the procedures were the same except that if students did not get 85% on the test they would be given review problems covering those areas they missed and be retested, again keeping track of time as they reviewed and retested only for those areas each student missed. This would repeat until the students got 85% on the test. All students in the mastery class needed only two review periods before meeting the 85% criterion. In all three classes, the units were limited to 80 minutes, each unit was covered in one day.

Anderson (1976) considered three variables in her analysis, elapsed time, time-on-task, and achievement. Elapsed time was measured by totaling the clock time the students spent on learning the units. Time-on-task was measured using observation notes and student written reports of thoughts taken at certain times during seatwork. Formative test (reliability=.62 to .82) scores were used to measure achievement.

To calculate her results, Anderson (1976) grouped the students into four groups for each unit. The criterion for the group scores was 80%. Group 1 was made up of students in the non-mastery classes that attained at or above 80% in the elapsed time. Students in the mastery class that scored to criterion without extra time or help were placed in Group 2. Group 3 was composed of students in the mastery class that needed extra time or help. Group 4 included those students that failed to meet criterion in the non-mastery classes. Across each unit, the orthogonal contrasts between the groups for the amount of time-on-task needed to reach 80% criterion decreased though significant contrasts were only noted for units 1 (-4.6, $p<.001$) and 2 (-2.5, $p<.001$). Orthogonal contrasts between groups for elapsed time needed also decreased, and again the only significant contrasts were noted for units 1 (7.7, $p<.001$) and 2 (4.1, $p<.001$). The result that there was no significant contrast between the groups for unit three show that the time required for those students in each group needed almost similar amount of time for that unit.

Anderson (1976) also considered prior achievement levels of the students and increased student involvement. For prior achievement levels she found that, based on scores obtained from the test prior to the experiment began, students in Groups 1 and 2 had stronger math achievement scores than those in Groups 3 and 4. There was a change when Anderson looked at the prior achievement and groups for units 2 and 3. For these last two units she considered unit 1 and 2 scores for prior achievement. Here the prior achievement for Group 3, the group needing extra time or help, was closer to Groups 1 and 2.

A similar pattern emerged in the data for student involvement as defined as the percentage of elapsed time on-task (Anderson, 1976). There was no significant difference in student involvement between Groups 1, 2, and 3 for units 2 and 3, but there was significant difference between Groups 3 and 4 for unit 2 ($p<.01$) and unit 3 ($p<.001$). These two considerations combined suggest that with the extra time or help, Group 3 students appear to display learning characteristics of students in Groups 1 and 2.

One of the implications of this experiment is that making up for learner inequality by exercising unequal instruction time in early units can help students with lower initial achievement levels reach criterion in later units at the same or similar amount of time as students with higher initial achievement levels.

This experiment was set well, but could have used a larger sample population with perhaps equal numbers of mastery and non-mastery groups. Also the use of other statistical tools on some of the data might have created a stronger picture of what the relationships are and their significance than the use of orthogonal contrasts alone.

With Anderson (1976), Hughes (1983), Spiegel and Bryant (1978), and Gettinger and White's (1979) having established an influence from intelligence, Smith (1979) wanted to delve further to determine just how much of an influence intelligence had. Her findings were at odds with those of Gettinger and White, who found time had a greater influence than intelligence.

She divided her investigation into two further questions; is there a relationship between the amount of time and elementary teacher allots to social studies and achievement, and if intelligence is considered equal, how much of an increase in achievement will result in increasing time spent on social studies?

Smith (1979) performed this study in the Tri-County area of southern Maryland. 92 fifth grade teachers were eligible to participate, but only 68 were included in the analysis. These classrooms also had mean IQ's falling within the normal range. She used three tools to measure three variables. A 1974 multilevel version of the Cognitive Abilities Test (reliability coefficient=.933) was administered to the classes to determine intelligence. The social studies battery of the STEP series II test was used to measure social studies achievement, and time log kept by teachers tracked of time. The study ran for a period of 101 days.

Results of the time logs showed that teachers spent an average of 27.5 minutes per day on social studies with a standard deviation of 8.7 minutes (Smith, 1979). This was found to fall below expectations of 35 minutes per day. When compared to achievement as measured by the STEP series II test, Smith found a positive correlation ($r=.23$, $p<.05$).

In addressing the second question, Smith (1979) obtained results that positively correlated IQ to allotted time ($r=.16$, $p<.05$) and IQ to achievement ($r=.69$, $p<.05$). To control the influence of IQ she performed a regression on the data ($R^2=.49$). It was determined that in the regression model, intelligence still accounted for much of the power in the model, allotted time was insignificant. Based on this model, Smith calculated that if the teachers had taught for the mandated time standard they would have added 760 minutes of social studies instruction at the benefit of approximately ¾ of a raw score point on the STEP series II test.

Additional results based on class involvement by students and class attendance were also analyzed (Smith, 1979). If attendance increased from 95% to 100%, the average class mean score would go up 2.5 points. If student involvement increased from 65% to 100% the increase would be 1.5 points.

Overall results for the regression system show that the correlation with achievement was highest for intelligence ($r=.69$, $p<.05$)), followed by class attendance ($r=.36$, $p<.05$), allotted time ($r=.23$, $p<.05$), and class involvement ($r=.13$, $p<.05$) (Smith, 1979).

In her discussion of the results, Smith (1979) went over four assumptions of the study. The first was that teachers kept accurate time logs. To help reduce errors, the logs were collected three times during the 101-day period and the results of the tabulations were sent to the teachers for verification. The second assumption was that the 24 teachers dropped from the study would not have biased the results. Scores for 10 of the 24 dropped classes were available for t-test analysis. These were the 10 classes dropped for other reasons than IQ. The t-tests did not show any significant variation between the dropped classes and the 68 used in the major analysis. The third assumption was that the STEP series II test provided reliable results when assessing Tri-County social studies programs. The STEP series II test was found to have a reliability coefficient of .90. When tested against the curriculum, two independent panels noted mixed results. The fourth assumption was that teachers would maintain normal teaching practices despite knowledge of the study. With times ranging from 700 to 400 minutes over the 101-day period, this assumption was accepted.

Smith (1979) concluded that the study does little to solidify a relationship between allotted time and achievement. It does however suggest that intelligence might be more effective in predicting achievement than time allotted. She did concede the limited significance of the study based on four factors; unreliable measures of achievement, criterion measures may not have matched implemented social studies program, sample size may have been too small reflecting Type II error, and there may not be a relationship between allotted time and achievement.

Smith (1979) went on to make three recommendations based on her experience in this study. The first was that teachers and administrators should take teacher's time logs seriously if there is a relationship between allotted time and achievement. The second was that research should be done to investigate the reasons for the large range of time spent on social studies. Finally, she recommended that research be conducted to determine which types of learning tasks, if any are more dependent on time allotted and which are more dependent on other factors.

In her research, Smith (1979) was careful to test most of her assumptions statistically. She also made several concessions as to the accuracy of her findings, though she did not offer any possible solutions for future attempts at replicating this experiment. One of the concessions was that the STEP series II test may not have reliably matched the objectives of the curriculum. This concession may have to do with the use of social studies as the subject of choice in this study, Smith might have done better to choose a more objective subject such as math. With math it might have been possible to more accurately and adequately assess student achievement with her sample size. With social studies, it is possible that teacher interest might influence the degree to which each objective is taught. The time spent covering one objective might vary among teachers more dramatically than it would with math. Another factor to consider is that in social studies it is possible to cover an objective using different topics. This leads to more possible variation between classrooms in what students learn. Though it is also possible in math, the objective nature of math might prevent some of this possible variation. Another possibility would be to create a small curriculum to use for the study and then use an assessment test that matched the curriculum. This would remove some of the variability in material taught.

Smith (1979) was not the only one to find a strong relationship between aptitude and achievement. Burkman, Tate, Snyder, and Beditz (1981) investigated aptitude, time allocated, and teacher directedness, though they found that in analyzing their data that the sample size was too small to give precise conclusions. This means that they were only able to make general statements. Their study differed form Smith's in that they studied high school where Smith studied Elementary school classrooms, this adds to further questions of the amount of support the data from the Burkman et al. report gave to Smith's findings.

Burkman et al. (1981) initially selected 83 classes taught by 26 teachers with a total student population of 1,847. This initial sample of students was 47% male and 53% female distributed in the following manner through 4 grade levels: 61% tenth grade, 18% ninth grade, 16% eleventh grade, and 5% twelfth grade. The final sample was 43 classes taught by 14 teachers with a student population of 912. The gender and grade level distributions were roughly similar.

The three variables measured in this study were academic ability, time allowed for study, and teaching methods (Burkman et al., 1981). Academic ability was measured using reading comprehension (reliability=.96) and math problem solving (reliability=.81) tests generated for this study. These tests were given at the beginning of the year. Time allowed was limited to three categories, low time (2750 minutes), medium time (3000 minutes), and high time (3250 minutes). Teaching methods were either teacher directed or student-directed.

Student achievement was measured using 58-question multiple-choice test (reliability=.88) given at the end of the allotted time period for each group (Burkman et al., 1981). The teachers of the classes administered these tests. Student achievement was compared in six treatment groups were created by combining the two teaching method types with the three allotted time types.

Burkman et al. (1981) analyzed the data by classes and by students. When analyzing by class they found that their sample was too small for precisely describing relationships. To compensate for this they also analyzed by students, though they acknowledged the difficulty of using students as the unit of analysis due to the presence of confounding factors. Because of this, the results Burkman et al. reported were point estimates of relationships and confidence intervals of these estimated effects.

Results from the study by Burkman et al. (1981) indicated three things. The first is that the student directed method was better than the teacher directed method at low time allowances, but this trend reverses for medium and high time allowances. These trends remained consistent between ability groupings. The second is that low time conditions were better for the student directed method, medium time conditions were best for the teacher directed method. The third indication is that the effect of ability on achievement is positive and strong.

When looking at the time allowed, Burkman et al. (1981) found that their data contradicted mastery learning work as cited for the student-directed method. They explain that this may be a result of the pressure of having a deadline. Though they also suggest that there is a point where too short of a deadline has a detrimental effect on learning. They hypothesized that this point, for the teacher-directed method fell somewhere between the low time allotment and the medium time allotment. One reason Burkman et al. offered for the contradiction might be that the deadline may likely have the effect of suppressing disruptive or off-task behavior in the time allotted. If this is the case they said that their data would agree with the mastery learning theory.

Though their sample size was admittedly too small for significant analysis Burkman et al. (1981) did have initial access to a larger sample. During the course of their study they had to eliminate more than 50% of their classes due to non-compliance with the established procedures. While their adherence to their methods helped to eliminate bias, Burkman et al. may have been able to salvage some of the data through extrapolation for groups going over their allotted times. For other deviations, the data could have been compared to acceptable data to see if the deviations caused any significant variations.

In an effort to increase generalizability, Smith's (1979) results and the results from Burkman et al. (1981) were compared to those of Carver (1970) who conducted an experiment at the undergraduate level. Carver found a stronger correlation between aptitude and achievement than between time and achievement. This is similar to what Smith found and Burkman et al. generalized about.

Carver (1970) performed this study with two adult introductory psychology classes. He had a total of 48 students, 27 in the first group and 21 in the second. The study ran for 16 weeks with both groups meeting for 100 minutes each week. The students were given the Wonderlic Personnel Test at the beginning of the 16 weeks to determine each student's ability to understand instructions. Quality of instruction was assumed to be the same for both sections since they were exposed to the same lessons. To assess learning time, Carver had students self-report the number of hours they spent studying psychology each week. The students were informed that this information would not influence their grade. The amount learned was measured using two multiple-choice tests for each student.

Carver (1970) examined correlations between learning ability (the Wonderlic test results), learning time (student reports of study time), and amount learned (multiple choice test results). For learning time and amount learned, Carver found no significant correlation ($r=.07$). He did find significant correlations between learning time and learning ability ($r=-.42$, $p<.01$) and learning ability and amount learned ($r=.48$, $p<.01$).

Noting the tendency for higher ability students to have lower reported times, Carver performed a partial correlation between learning time and amount learned and found a significant correlation ($r=.30$, $p<.05$).

Some of the factors Carver (1970) attributed to the results were restriction of range, test unreliability, time report unreliability, and representation of the variables. The range restriction was due to failing students dropping out of the course before the 16-week period ended. Although Carver could have included the data for failing students to do a comparison with students who didn't drop out for the time at which they were present. Carver noted that both the Wonderlic test and the multiple-choice tests were unreliable, but failed to note why and to what degree they were unreliable. For the time reports, he cited the possibility of falsification or memory errors as sources of unreliability. He did appear to attempt to curb falsification by having students informed that the reported times would not affect their grades. The data collection tools used to represent ability to understand instruction, actual learning time, and degree of learning were described as imperfect. Again, Carver does not go into detail about the imperfections, but one might be the fact that the tools allow for the possibility for confounding factors to introduce variation to the data.

One implication Carver (1970) discussed was the problem with criterion. Put simply, Carver believed that grades and test scores would not make accurate indicators of learning if they were influenced by time. He proposed that self reports of time be used as a control for future investigations into learning and other possible independent variables.

Carver's (1970) lack of elaboration on certain points leaves large gaps in logic making it difficult to discover the root source of some of the problems noted in this experiment. This puts into question the reliability of the data and the results drawn from that data.

In contrast to the previous studies in this section that sought to define the relationship between aptitude, achievement, and time, Arlin's (1982) study examined how those relationships appeared in a classroom environment. His report was presented as a qualitative analysis of multiple classrooms. His analysis suggested an integrated approach to the subject of time, aptitude and achievement, something not done in the previously discussed studies.

Arlin (1982) analyzed how teachers manage time in a mastery-learning environment based on a model relating student aptitude, teacher time allocation, breadth, depth, and cooperation. He used an initial sample of 28 elementary level schoolteachers in two semi-rural school districts in British Columbia, Canada was narrowed down to 10 teachers and their classrooms in seven different schools (Arlin, 1982). The class breakdown by grade level included 3 first grade classrooms, 1 fourth grade classroom, 1 fourth-fifth grade combination, 2 fifth-sixth grade combinations, 1 sixth grade classroom, 1 sixth-seventh grade combination, and 1 seventh grade classroom.

To prepare for this study, the teachers read a book on implementation of mastery learning, and worked with the author of the study to create units, objectives, and quizzes for mastery learning (Arlin, 1982). The actual teaching of the unit was to take place over a three-week (10 school day) period in January. Students of the classes would take a pretest to assess the level of prerequisite knowledge they possessed one week before the period of mastery teaching. Students not attaining a 90% on the pretest were given remedial lessons to catch up. 92% of the students were caught up by the time the mastery-teaching period.

During the three-week mastery-teaching period, students would spend 15-30 minutes learning through lecture, demonstration or group activity directly from the teacher (Arlin, 1982). After the lesson, the students took a quiz taking 2-3 minutes, correcting it immediately afterwards. Once the quiz was corrected, students not getting 100% were given a form of remediation. The students would repeat this cycle of remediation and quiz taking until they reached criterion. On day 5 and 10 the students took longer tests covering all of the material learned up to that point. The criterion for these tests was 85%-90%.

During this time, Arlin (1982) and seven research assistants observed all 10 lessons of all 10 teachers recording the topic of the lesson and remediation tasks used. Arlin took observations of each teacher twice, keeping unstructured notes of classroom observation, the number of off-task students, and notes of the discussions with teachers after the lessons observed.

Arlin (1982) divided the result into four categories for discussion. In the first, Arlin analyzed the teachers' awareness of time differences. He noted that they had an increased awareness of not only which students were faster or slower, but also in how much time was needed by the students. Most of the comments the teachers made also compared their experiences with mastery teaching to previously used methods. The teachers, in general, felt that they were able to accommodate the various needs of their students better under mastery learning than in their previous methods. Most of the teachers were able to pace their lessons so that they had an average of about eight students needing remediation out of a class of about 25 students. This pacing was calculated to be at the 30th to 35th percentile students, greater than the pacing at the 25th percentile found in previous studies.

Next, Arlin (1982) analyzed how teachers allotted time for slower students. Here he noted that teachers felt frustrated when having to create remediation strategies for students that did not require too much explanation, creating rough spots in the flow of time. The teachers seemed frequently frustrated in trying to structure meaningful activities that were also less teacher-dependent. Most teachers used the strategy of small group remediation combined with peer tutoring. Here groups of students missing the same aspect of the lesson could work together. Arlin noted that this was more successful at the lower grade levels since the students seemed more apt to working quietly during group work. At the higher levels he noticed that off-task behavior jumped from 10%-40% during whole class lecture to 10%-80% during reteaching to small groups, most of this the result of those students not in remediation. Teacher preferred to use peer tutoring the least due to difficulty of impromptu assigning of tutors. Teachers also felt that they were more capable of reteaching than the peer tutors, but Arlin's observations showed that peer tutors were also effective, being able to explain the material in simpler language than the teacher.

Obtaining extra time was the next category Arlin (1982) discussed. Most teachers had difficulty getting extra time for remediation for those students needing it. Many times the teacher would make the lesson short to make time for remediation or have the students come to them during lunch, recess, or after school. Teachers wanted to avoid the latter practice because over time it would be less popular. For students missing classes, this was unavoidable because they would have to make up the missed lesson before they could go on to the current lesson. Another trend was teachers taking time from other subjects to make time to catch student up. Here teachers traded breadth for depth.

The final category Arlin (1982) analyzed was time allocation for fast learners. Teachers had difficulty in the area and often saw enrichment activities given to those students as nothing more that “high-powered busywork” designed to allow the teacher to work with students needed remediation. Many times the teachers would see this as holding the faster students back indicating that the teacher was aware that they were increasing depth at the cost of breadth. One phenomenon Arlin observed was that in one lesson taught immediately before the mastery lesson, that 92% of the students exhibited off-task behavior, once the mastery lesson started this number dropped to 24%. Arlin attributed this to the student attitude that if they pay attention and get it done the first time, they don’t have to do any extra work. This was seen as a motivating effect, but what was done with the extra time the students had needed to be worked on.

Arlin (1982) made four conclusions based on the results; (a) mastery teaching appeared to increase teacher awareness of time considerations, (b) providing various methods of remediation based on each student was not possible in this study, (c) time is not an unlimited resource and is problematic in obtaining, and (d) faster students finishing earlier is a problem that needs addressing. He also noted that these conclusions can only be generalized for teachers beginning to use mastery teaching, and that with time, teachers might gain experience to resolve these issues. It should also be noted that these results cannot be generalized to higher grade levels than those in this study based on observations Arlin made about the differences between the higher and lower grade levels in this study.

In Arlin's (1982) study there was an implicit suggestion that students varied in their use of aptitudes in learning. This was also suggested in Anderson's (1976) procedure for creating groups for analysis. Burns (1980) studied the idea of hanging aptitudes in his experiment. The results of his research supported the idea of shifting aptitudes, but did not make any suggestions as to how these shifts relate to time in reference to achievement.

In his aptitude treatment interaction (ATI) study, Burns (1980) investigated the possibility of varying aptitude-learning relationships over time. He cited that previous research examining ATI did not consider shifting in relation to the type of learning required in the course of schooling.

To answer his question, Burns (1980) had a sample of 101 students in four sections of a class called "Change in Society" offered in a California high school. The students represented 3 grade levels, 10^{th} (76 students), 11^{th} (19 students), and 12^{th} (6 students). Males and females were in almost equal ratios (51:50). Most of the students were white from lower middle class socioeconomic status families.

Burns (1980) utilized an imaginary science subject divided into four units of study. Each unit was done in one day consisting of a 15 to 25 minute lecture followed by individual reading time in the booklet for the unit. At the end of the unit the students took a test ranging from 14 to 18 multiple-choice questions. The reliability of these tests ranged from .59 to .74 and correlated from .55 to .77 ($p<.01$). Burns also obtained 19 aptitude measures using the Kit of Factor-Referenced Cognitive Tests, the Culture-Fair

Intelligence Tests (scale 2, form B), the Comprehensive Test of Basic Skills (CTBS, expanded edition, form 5, level 4), and one test he devised. He gave these tests, except for the CTBS, on the three days prior to the beginning of the unit teaching days. This experiment ran from a Thursday to the following Friday.

In his data analysis, Burns (1980) got complete unit test score data for 72 students. For the rest of the students he used the mean scores for that test for which the score was missing. Burns then analyzed these data against 4 aptitude components created from similar aptitude measures. In his correlations he found that component 1, covering numerical and verbal aptitudes correlated with all four units (r=.51, .46, .42, and .44, respectively, p<.01). Component 2, which dealt with spatial aptitude, correlated with the third and fourth unit tests (r=.41 and .35, respectively, p<.01). Component 3, dealing with flexibility of closure, correlated with unit test two (r=.42, p<.01). In a regression analysis of the four components with the unit test scores, Burns found that component 1 had a significant effect on unit test one (R=.51, p<.01), component 2 had an effect on test three (R=.33, p<.01), and component 3 had an effect on test 2 (R=.31, p<.01).

From the results, Burns (1980) concluded that there is a suggestion of aptitude shift and that this is possibly a result of differing aptitudes being needed at different times. If this ideas is to be accepted then it would seem to require that teachers be more cognizant of the cognitive demands and aptitude requirements of their of their lessons and how those might change with time. Burns did not say this nor did he say that this could arguably shift the focus from time to aptitude, but he did state that one could speculate that the changes in aptitude-learning relationships are a natural result of learning. This would seem to tie the factor of time in learning to aptitude.

On a cautionary note, the replacement of incomplete data from 29 of the students with the means of the test scores was never verified for impact on the results (Burns, 1980). 13.7% of the data is statistically suspect. Burns might have allayed these concerns by running a second analysis using only the data from the 72 students with complete data to see if there was any statistically significant difference in mean scores. The 187 missing tests scores might have represented students missing school for one reason or another, including truancy, which might have a relationship with the aptitude of student in a school-learning environment.

The complex interactions between time, aptitude, and achievement have shown a trend towards a stronger influence from aptitude than time. Tate (1981) wanted to ensure that these interactions were being analyzed using the most accurate calculations possible, ones that reduce statistical error. Tate in his examination of multivariate analysis of aptitude treatment interaction (ATI) attempted to establish the benefits of using such analysis on controlling error and confidence levels.

In this study Tate (1981) analyzed data from a previous study of 413 high school science students. The students were placed in three controlled time classrooms of 55(LT), 60 (MT), and 65 (HT) minutes in length. The dependent variables were achievement on core material (ACHC), achievement on advanced material (ACHA), number of science courses planned to be taken before graduation (NCRSE), and interest in science (INTRST).

The data collected was processed using the Full Rank Multivariate Linear Model Program (Tate, 1981). The results of the calculations showed that for ACHA and ACHC there was a negative correlation to time allowed, meaning that as more time was allowed, achievement scores were lower. When reading ability was compared to achievement, there was found to be a positive correlation between the two, although there was an ordinal relationship between these correlations and time allowed. This meant that for all three class lengths as reading ability increased so did achievement, but classes with less time did better then classes with more time. The same correlation was found with reading ability and NCRSE and INTRST, but when the correlations were compared by class time there was a disordinal relationship showing that the relationship was more positive in HT classes than it did for MT classes. Displayed on a graph, this meant that while the correlations with respect to class time started out in the order where LT>MT>HT, the order changed to LT>HT>MT as reading ability increased.

Tate (1981) went on to discuss how multivariate analysis has the advantage of controlling Type I errors whereby the null hypothesis is rejected when it is in fact true. He also talked about Type IV error. These errors come about when hypotheses are tested that are not implied by the rejected global hypothesis.

Tate's (1981) study did not give the statistical significances of the data so it leaves the results as questionable at best. While he did use several statistical formulas in comparison to evaluate the data, he never listed actual values and significances for comparison or verification. If the data was shown to be significant it could have been used to suggest a trend of negative returns with time as opposed to diminishing returns.

To summarize the studies in this section, when compared to time, aptitude appeared to have a stronger effect on achievement than time and that the higher the aptitude of the student, the lower then amount of time needed in learning. It should be noted that in Anderson's (1979) study, students with lower aptitude that got more initial instruction time, eventually needed similar amounts of time to reach a set achievement level as higher aptitude students on later lessons. This result leads to a discussion of the cognitive functions of students that lead to differences in learning curves, especially when considering the cultural aspect of defining intelligence or having predispositions for certain aptitudes.

Time and Cognition

In the previous section studies on the relationship between time, aptitude, and achievement were discussed. This section will focus on two studies concerning cognition and its relationship with time. The first study specifically examined the differences between a classroom focusing on time and one with an emphasis on cognitive thinking skills. In this study, Swing , Stoiber, and Peterson (1988) had four questions they were attempting to answer. The questions were: what were the effects of the thinking skills and learning time interventions on teachers' instructional behavior and students' engagement? Were there significant effects of the thinking skills intervention on students' reported cognitive processes and thinking? What were the effects of the thinking skills and learning time interventions on students' achievement? How did teachers' instructional behavior, students' engagement, and students' reported cognitive processes mediate the effects of the interventions on students' mathematics achievement?

To answer these questions, Swing et al. (1988) used a sample of 24 female and 5 male fourth grade teachers and their classes (507 students). The study was done within 2 hours drive of Madison, Wisconsin. Most of the schools were in middle class small cities or towns adjoining larger cities. All 29 teachers volunteered, but were paid for their participation. The teachers were divided into two groups with 14 teachers in the thinking skills group, and 15 in the learning time group. The two teacher groups attended 2 two-hour workshops for their particular intervention method. In each class, the researchers randomly chose 6 boys and 6 girls for observation, this data was based on observations of 5 boys and 5 girls from each class due to some students moving during the school year.

In December, all students in the classes took a pretest consisting of 40 questions, 20 high level items and 20 low level items (Swing et al., 1988). High-level items focused on understanding and application, low level items on knowledge and skill. Reliability ratings for the subtests ranged from .67 to .73. Students also took a 30-question vocabulary test from the Science Research Associates (SRA) Achievement Test (form E/Green level, grades 6 and 7). Internal reliability was calculated at .46, the publishers calculated a .93 test-retest reliability.

In January the researchers had observers collect data for 5 days for baseline data (Swing et al., 1988). Teachers were observed in 90-second cycles; for 30 seconds the observers observed the teacher's actions and speech, the next 30 seconds were used to record the observation, and the final 30 seconds were used for tracking thinking skills and other instructional process use. Students were observed in a similar manner except they did not have the third 30-second period. Each of the 12 selected students was observed once in a randomly determined order. Once the order was finished the observer started another round of observations in the same order. In March, April, and May the observers took observations again for two sets of 4-day observations about three weeks apart. In May all of the students took a posttest similar to the pretest. The subtest reliabilities ranged from .67 to .78. 10 trained, female interviewers interviewed the students also.

The results of this study showed Swing et al. (1988) that for the learning time intervention, engagement increased, off-task behavior decreased significantly ($p<.05$). For the thinking skills group there was greater production of thinking skills instruction as well as high percentages of high-level understanding and application instruction. For achievement, Swing et al. found significant effects for both intervention methods ($p<.05$), but these were not independent of class or student ability levels. Across classes, high and medium ability classes achieved better high level scores with thinking skills instruction, but within classes low ability students gained more form thinking skill instruction than did their medium and high ability counterparts. Low ability classes were found to do better with the learning time intervention than with the thinking skills intervention, but again with high-level objectives. None of these effects showed with any significance with low level objectives. It was expected that learning time classes wouldn't outperform thinking skills classes because higher-level learning was cited as possibly having a positive effect on lower level learning. Based on pre and posttest scores, Swing et al. found that there was no significant difference in achievement between the intervention methods.

Swing et al. (1988) also examined the effect of ability level on the results and found that on the class level, the thinking skills classes' use of certain processes seemed more difficult to integrate into low ability classes than in high ability classes. They suggested that this might be because the teachers of low ability classes did not modify their application of the processes to meet student needs. On the level of the individual student, the increased positive effect of thinking skills methods by low-level students was probably a result of those students need for those methods. One reason suggested by

Swing et al., was that teachers in the thinking skills classrooms took more time for low ability students at the expense of the other students. Medium and high ability students could have used this extra time to learn more material.

Overall this study was very focused on fourth grade math classes (Swing et al., 1988). The large quantities of data collected were analyzed using a variety of statistical tools. This said, it initially seemed that Swing et al. were trying to answer too many questions at once. They mitigated this by linking the questions to one another in their discussions of the result. They also verified or explained their assumptions, when possible, with data collected from the study.

In contrast to the results found by Swing et al. (1988), Peterson, Swing, Stark, and Waas (1984) found results that appeared to be more consistent. Though, this is most likely due to the difference in analysis techniques. Peterson et al. (1984) had four questions they were attempting to answer. The first was what cognitive processes do students report using during math instruction? What affective thoughts do students have was the second followed by how are students' aptitudes related to their cognitions and affective thoughts? The last question was how are students' cognitions and affective thoughts related to future achievement and attitudes?

Peterson et al. (1984) chose a sample of fifth grade students from two classes in the same urban elementary school. There were 38 students total of which 29 were white and 9 were black. 32% of the students received free or reduced lunch and 41% got Title I benefits. Students were pretested with the Mathematics Concepts Subtest (form 4A, reliability=.87) from the STEP Test, the Reading Vocabulary Subtest (level 15c, reliability=.87) of the California Achievement Test, and a 15-item questionnaire (reliability=.93) about attitudes towards math. The students also took posttests. The Cognitive Processes Questionnaire (reliability=.81), Motivational Self-thoughts Questionnaire (reliabilities=.85 and .89), the attitude towards math questionnaire (reliability = .89), and an achievement test (reliability=.93).

The students studied a unit covering measurement broken into nine lessons, each consisting of a development segment where students practiced problems as the teacher explained the concepts followed by a 20-30 minute seatwork session (Peterson, 1984). During the lessons, 4-6 students were video taped each day. This tape was used for a stimulated recall interview session after the session. Of the students, ten were targeted each day for observation during the lesson with their behaviors coded by and observer in 20-second intervals.

The results Peterson et al. (1984) found were that students were off-task 5% of the time. Students mean attending level score from the stimulated recall interview showed that most of the students were paying attention (M=3.27, on a Likert scale of 4). The mean understanding score from the same interview was 3.48. Generalizability coefficients of 26 categories and subcategories from the stimulated interview showed no significance. The categories and subcategories that did show significance were analyzed using Kendall's Tau Coefficients.

Peterson et al. (1984) concluded that, based on the results, student ability and achievement had significant correlations ($p<.05$) with thoughts during the lesson, paying attention to the lesson, understanding the lesson, and using specific cognitive processes. They also found that observed engagement was not related to achievement, what was seen as paying attention or not paying attention was not related to how well the students did. From this Peterson concluded that the quality and not the quantity of on-task time was what mattered. They also found that students with negative self-thoughts were debilitated by them in reference to achievement and attitude. Peterson et al. suggested that future research be conducted in finding methods to train students to use those specific cognitive processes used in this study.

This study collected vast quantities of categorized data from a small sample population taught by the same teacher. This makes it difficult to generalize this data to most fifth grade classrooms, furthermore, the student demographics also acts as a limiting factor. Only 24 % of the students weren't white and then that 24% was black, ignoring other ethnicities.

In summary, both Swing et al. (1988) and Peterson et al. (1984) found that students thoughts during the lesson had a significant impact on the level of achievement. Furthermore, classrooms, focusing on depth of thinking or quality of learning attained higher achievement results for their students. This also points to an alternative approach to that of time in improving student learning. This might be a necessity if time is seen as a finite resource with costs for its use.

The Economics of Time with Respect to Learning

The studies in this section explore the concept of time as a limited resource. This consideration came from the idea that time is limited to the effect that both students and teachers have a finite amount of time when they are together to interact. Millot and Lane (2002) examined time as a global resource by investigating the use of time in Middle East/North African (MENA) countries. They paid particular attention to the amount of time spent in school and how time was used in the context of subjects, yearly scheduling, and cycle.

Millot and Lane (2002) suggested the use of typologies in an empirical method for their analysis of data. They used data collected from the TIMSS-R study, and questionnaires to MENA countries. The questionnaires were broken into four sections including basic background, student and school information, teacher information, and unscheduled time. Basic background was aimed at collecting data concerning the level of resources available to students in the country. Student and school information gathered data about how long students go to school and the amount of time allocated to each subject, to provide a more detailed picture of time allocation and level of resources. Teacher information also made this picture more clear by providing time spent teaching and doing administrative work. Unscheduled time got data about days missed by teachers and students.

From the data gathered from the questionnaire, Millot and Lane (2002) were able to make broad characterizations of MENA countries. Primary and secondary education patterns were similar, there was a broad difference in the length of the school year in total hours, there was a wide range of time allocation strategies, potential time and time-on-task data are similar to other parts of the world, most time loss came from holidays, student and teacher absences are similar between the primary and secondary levels.

The TIMMS-R study data showed that for math there was a significant positive relationship ($p<.05$) between instruction time and test scores (Millot & Lane, 2002). Also the data showed that for both math and science, class subjects most likely to be studied outside of school, there was a significant negative relationship ($p<.05$) between instruction time and test scores.

Using these data Millot and Lane (2002) concluded that increasing time in school to increase achievement is inefficient based on the wide variety of ways that time is spent in education. This is based on a broader view and can only be generalized in this scope.

While the time use data Millot and Lane (2002) collected most likely came from a large sample, making wild variations less likely, it is missing country specific achievement data to support their connection between time use and achievement. The TIMMS-R data included several countries from the MENA region, but this general data might be skewed away from the trends actually seen in the MENA region. This makes any connection suspect. They did attempt to mitigate this through use of time use data from other regions of the world for comparison, but this data was not well connected enough to MENA data to warrant the connection made to the TIMMS-R data.

Brown and Saks (1987) similarly, suggested the influence of economic principles in time management in their study of the economics of teacher time allocation. The use of time in an efficient manner was the most noteworthy similarity, suggesting that time is perceived similarly on both a macro and micro economic level. Where Millot and Lane used a region of the world as their scope of analysis, Brown and Saks attempted to understand how these allocations affected the productivity of teachers in facilitating the learning of students in math and reading.

The sample for the study was 25 second grade and 21 fifth grade classes in California schools (Brown and Saks, 1987). For one year, an average of six students per class were observed. Observers monitored time allocations in reading and math.

Students were given tests in both subjects at three different times of the year; October, pre-holiday December, and May. Time allocation data was collected in the interim periods. Subset scores of the reading and math tests were collected, but whole subject scores were used for analysis in this study.

Brown and Saks (1987) collected time measurement data from teacher time logs and observer records. The teacher logs were eventually not used to prevent teacher bias. Also, observer recorded times were more consistent. Observers measured time use in seven categories; proportion engaged, proportion self-paced, proportion easy work, proportion hard work, proportion substantive, proportion grouped, and proportion tutored.

The data collected was then analyzed using a microeconomic theory of schools that Brown and Saks (1987) developed. This theory took into account, limited resources and the law of diminishing returns. It also included variables accounting for pretest student achievement rankings, teacher estimates of socioeconomic status, teacher amount of goal directedness, appropriate level of instruction for the student, teacher flexibility in the use of learning materials, specificity of teacher goals, and the extent of teacher differentiation of perceived student characteristics.

Brown and Saks (1987) went on to explain that based on two production possibility curves, teachers might exhibit one form of behavior over another. These two behaviors were defined as compensating or leveling behavior and reinforcing or elitist behavior. For compensating or leveling behavior (μ-1<1), two students with unequal scores, but equally productive learning curves would require unequal allocation of resources, namely time, in order to achieve equal outcomes. The lower scoring student would require more time. Another possible scenario for this behavior is one where the student with the lower score has a more productive learning curve. In the compensatory or leveling behavior model, resource productivity play a crucial role in determining who gets compensation. A reinforcing or elitist behavioral model (μ-1≥1) is likely to result in a situation where two students with different scores, and the higher scoring student has a more productive learning curve. Here the teacher would focus their efforts inequitably on the student that already has high achievement level because they would yield more results.

Brown's and Saks' (1987) results of the utility estimates, based on their theory, for all classes showed that most of the teachers exhibited a compensatory behavior (mean μ-1 of -.92 and –1.03 for second grade reading and math; mean μ-1 of -.88 and-.92 for fifth grade reading and math). Only two teachers exhibited an elitist behavior pattern, one was in second grade math (μ-1=1.16) and the other was in fifth grade math (μ-1=1.99). The reason for this is thought to be the mitigation of technology in favor of equal achievement.

In their conclusion Brown and Saks (1987) concede that the accuracy of their results depend on their assumptions of behavior being correct. Based on the results, it seems that most teachers follow economic principles in determining how to manage the resource of time. This potentially opens the possibility that teachers exhibiting elitist behaviors may be able to justify their behavior using these economic principles. The findings of this study are supportive of the view that more time on a subject leads to more learning of that subject. In light of elitist behavior justification in some instances, the idea that all students would benefit from more time makes it likely that elitist behavior would remain a minority behavior if it is assumed, as it was in this study, that all teachers care about the achievement of all students in the class.

For students, the principles of economics are also used to make decisions concerning time use outside of the classroom. Levin and Tsang's (1987) results showed that students used economic principles to weigh the costs of time versus the benefits of achievement. Their results were congruent with Brown and Sak's (1987) and Millot and Lane's (2002).

Levin and Tsang (1987) investigated the factors affecting student choice in time use and what practices enhance student achievement. They did this by creating an equilibrium relationship based on mathematic and economic principles. In this relationship Levin and Tsang included factors such as activities or achievement, time, effort, level of resources, student capacity, technology of production or teaching ability, and factors under influence of the schools (motivation, nutrition, economic return on schooling, etc.).

With their relationship, Levin and Tsang (1987) evaluated three cases. In the first case, if the technology of productivity is moderate, increasing influence will increase achievement. But as imposed school time is increased, the rate of effort will decrease leaving the rate of achievement unchanged. If school time is increased greatly the student will not be able to adjust effort enough to reach equilibrium. This would lead to an increase in achievement, but the increase will not reach optimal levels due to the decrease in effort. In the second case where the technology of productivity is low, Levin and Tsang explained that increasing school influence will help to increase effort and/or time spent by the student, but imposing time on the student will reduce the productivity of the student through a reduction of effort from the student. Here, increasing influence also had a positive impact on achievement. In the third case where productivity technology is high, the impact of increased time imposed on the student was indeterminate.

Based on this analysis of the three cases, Levin and Tsang (1987) presented three implications on student time, effort, and achievement. The first implication is that the gains in achievement are not worth the cost of increasing instructional time. For support they cited three other studies that reached the same conclusion with similar levels of consistency. The rate of return is less than 1 in this case. This was further exacerbated when non-instructional time was taken into account. Any increase in time would likely have a cost in additional non-instructional time.

The second implication Levin and Tsang (1987) made was regarding the payoff of learning. Citing several reports, they illustrated a trend for diminishing benefit of going on to higher education when compared to graduating from high school only. This lack of incentive might account for the cited decline of college entrance exam scores and the increase of student acceptance rates. The increased acceptance rates are a product of fewer applicants for the same or increased number of colleges. Levin and Tsang suggested more attention be paid to the incentives to be gained from increased achievement.

The third implication addressed the effects of increased technology in learning tools such as computers and other resources (Levin & Tsang, 1987). This increased technology in schools has the potential to decrease the time and effort demands on students thereby increasing their motivation. The increase in motivation might lead to the desire from students to allocate more time and effort to learning as efficiency of learning increases relative to other activities.

Based on these three implications, Levin and Tsang (1987) discussed the policy implications regarding increasing the daily or yearly amount of instructional time. They argued that any involuntary increase in allocated time would result in a student response of reducing effort. One alternative to increasing allocated time would be to increase awareness of the benefits, both intrinsic and extrinsic, of increasing school achievement. Of four alternatives for increasing achievement, Levin and Tsung found that increasing time and reducing class size were the least cost-effective while cross-age tutoring was the most cost effective.

Levin and Tsang (1987), while not submitting any empirical data to support their assertion, did support their ideas through careful use of mathematics and previously tested thoughts on the subject. Furthermore, they used the findings of other studies to verify their model.

Roecks (1980) performed an analysis of the interactions between teachers and students. This analysis acts as a bridge between what Brown and Saks (1987) found about teachers and what Levin and Tsang (1987) found about students. His study examined the cost of various types of interactions and how both teachers and students behaved as rational actors to maximize benefit while minimizing cost. Roecks also determined the quality of the time used through time on task and efficiency calculations.

Roecks (1980) used a sample of 36 fifth grade students from two different schools using a computer managed instruction curriculum for math. From each school, 18 students, three girls and three boys were randomly selected from each of three achievement levels, low, medium, and high, to be observed. Students fell into categories based on their scores on the STEP Test of Basic Mathematics Concepts (reliability=.89).

Students with extreme scores were excluded due to special learning characteristics. Each student was observed for four class periods of 45 minutes in duration.

Observations were recorded every 15 seconds (Roecks, 1980). Observers coded activities as either time waiting, time productively used, or time unproductively used. Interactions were broken down into five categories, student-teacher, student-aide, student-self, student-student, and student-instructional material. For the interactions, a dollar value was attached at a per hourly rate. The example Roecks gave was for student-aide; students were given a wage of $1.00 per hour while the aide was given his or her actual value ($4.00 per hour). The total cost for a student-aide interaction would be $5.00 per hour. Due to their relatively small cost, student-instructional material interactions were not included in cost calculations. Interrater reliability ranged from .82 to .99.

Roecks' (1980) findings showed that students in the low achievement group had the highest instructional cost ($2.83 SD $0.93) and the lowest time on task (84.0% SD 7.0%) and students in the high achievement group had the lowest instructional cost ($1.66 SD $0.47) and the highest time on task (92.9% SD 3.4%). For efficiency, calculated by time usable for instruction divided by time allocated for instruction, both the low achievement group's (82.5% SD 8.2%) and the high achievement group (83.1% SD 3.7%) had higher efficiency rates than the medium achievement group (76.6% SD 3.4%).

In his discussion of the results, Roecks (1980) explained that the reason for the cost values stemmed from the students in the low achievement group's use of more student-teacher, student-aide, and student-student forms of interaction. Students in the high achievement group spent more of their time on independent activity, meaning lower cost values. Roecks went on to say that with the increased pressure for accountability in education, such cost analyses could be used to aid in the allocation of school funds.

One point that Roecks (1980) mentions, but does not discuss, is the efficiency results for students in the medium achievement group. Could it be that since students in the high achievement group did not require as much interaction with the teacher or the aides that their time was shifted to students in the low achievement group? This, when compounded by the time on task results show that for students in the low achievement group, more interaction with the teacher may make up for the low time on task as far as efficiency goes. Students in the medium achievement group had a time on task 2% more than the students in the low achievement group, but a cost difference of $0.81. When compared to the differences in these areas for students in the high achievement group, students in the medium achievement group had 6.9% less time on task with a cost difference of $0.36. If the ratio of change in percentage to cost difference was calculated, the result would be a ratio of 5.22 between medium and high achievement groups and a ratio of 40.5 between the medium and low groups. This disparity shows the benefit of added time from interactions with teachers and aides. This is an area where further study might help to clarify Roecks' result for efficiency.

The sample size also draws Roecks' (1980) results into question. With a total of 12 students in each achievement group pulled from only two schools may yield the possibility of a Type II error. A larger sample size might help. The inclusion of specific data on the amount of time used in each type of interaction would also add clarity to some of the results of this study.

Where Roecks (1980) analyzed general classroom interactions, Arlin and Webster (1983) experimented specifically with mastery learning. They compared mastery learning with non-mastery learning in the attempt to ascertain the difference in learning rate between the two methods. They also were trying to answer whether there would be a difference in the amount of remedial help needed by students in the mastery situation, and the difference in individual learning rates change with time. The latter condition suggested a possible connection to the research Burns (1980) conducted.

Their experiment started with an initial sample of 122 seventh grade students divided among four classrooms in two middle class suburban schools near Vancouver, Canada (Arlin & Webster, 1983). The final sample was reduced to 88 students with 22 students per class. The reduction was due to some students having some prior knowledge of the subject matter, and some students in the mastery section not meting criterion in the allotted time for each session. Seven of the nine students with the lowest reading test scores were eliminated from the experiment, to retain orthogonal balance, this was done in all four classes. One more student was eliminated because she was learning English as a second language. Students were randomly placed into four situations; mastery illustrated, mastery non-illustrated, non-mastery illustrated, non-mastery non-illustrated.

Arlin and Webster (1983) used an adapted juvenile book about sailing, a subject that few students were assumed to have much prior knowledge of. The book was modified to be 32 pages in length divided into four chapters of eight pages each. Half of the pages were full text, the other half were full-page illustrations. Half of the books had the illustrations removed to represent poor quality learning materials.

One month before the experiment, Arlin and Webster (1983) administered the Gates-MacGinitie Reading Test (survey E, form 1M) to all students initially sampled. A sailing pretest was given one week prior to the experiment. The experiment began for each class on a Monday with one chapter being covered each day consecutively. Each day's session was limited to 90 minutes. The following Monday, the class took a 15-question multiple-choice retention test. Students also took small tests at the end of each chapter. For the first two chapters the test had 15 multiple-choice questions, 10 on the last two chapters. All five tests had a total reliability of .86.

Mastery situation students were told to go back and correct the missed answers on their tests if they got below the criterion of 80% (Arlin & Webster, 1983). They were given a second test after making corrections. Non-mastery students got no feedback. In both groups, students finishing early were allowed to work on homework from other subjects.

Arlin and Webster (1983) examined the five variable of achievement (final test scores per chapter), retention (retention test scores), time (total time in minutes spent in study, test-taking, and review), learning rate (number of items learned per hour per chapter), and retention rate (retention score divided by time spent learning for all four chapters.

The results for this study showed that students in the mastery groups learned significantly faster than non-mastery groups ($F[1, 80]=7.15$, $p<.05$) (Arlin & Webster, 1983). The averages were 15.75 and 12.08 items per hour for mastery and non-mastery groups, respectively. Mastery students had higher achievement ($F[1, 80]=396.5$, $p<.05$) than non-mastery students. The means were 79% and 31% for mastery and non-mastery groups, respectively. Although mastery students had a criterion of 80%, some students still scored less than 80% resulting in the average of 79%. Mastery groups spent more time than non-mastery groups ($F[1, 80]=134.6$, $p<.05$). The means were 40.9 and 20.8 minutes per chapter for mastery and non-mastery groups respectively. Finally, for rate of retention, mastery students scored higher on the retention test ($F[1, 80]=10.9$, $p<.05$) with an average of 9.3 items correct versus 7.2 for non-mastery students. When divided by time though, students in the non-mastery groups were more efficient ($F[1, 80]=30.0$, $p<.05$) with 5.6 items retained per hour versus 3.6 for mastery students. In each of the above comparisons the presence or absence of picture play no significant role.

Arlin and Webster (1983) noted three limitations in their experiment. The first had to do with the metric for learning rate. It assumed that the items were similar in nature when it is likely that they were not. The second limitation was not providing feedback to the non-mastery students. Arlin and Webster recognized that this was an extreme situation but it was necessary to get results not influenced by feedback. Finally, the need to eliminate some students, including the seven of the nine lowest scoring students on the reading test, meant that this experiment can’t be used to generalize about the lower 15% of students.

In their discussion of the results, Arlin and Webster (1983) acknowledged that, for mastery students, there was a net gain in short-term learning with time, but that there was also the possibility of a point of diminishing returns with respect to longer-term learning. Some of this might come from their finding that the faster students spent 24 minutes on average working on the chapter and 37 minutes waiting on the slower students. Extrapolated out for number of chapters, the faster students could have gone through ten chapters in the time they went through four. Overall results with respect to retention showed that non-mastery students were more efficient, perhaps based on the nature of the material learned. Also the cost of achievement is additional time needed.

One result that was not too well discussed by Arlin and Webster (1983) was the effect, or lack thereof, of instructional quality on mastery with respect to time. The pictures made no impact though intuitively it seems that they should, especially if studies on verbal and visual processing is taken into account. Perhaps a larger sample, or a subset of data from students tested for processing preference analyzed against time, achievement, and situation would make clear some of the finer details of instructional quality.

One principle of economics suggested by Brown and Saks (1987), Gettinger and Lyon (1983) and Tate (1981) was the idea of diminishing returns, the idea that in some instances with more resources invested into something the return on that investment becomes smaller. Walberg and Tsai (1984) investigated this phenomenon in reading achievement. This implication of their results were congruent with those of other studies in this section. One of these implications is that there is a point where more time spent learning yields so little achievement that it is no longer efficient to continue spending time learning.

Walberg and Tsai (1984) used data collected from the 1979-1980 National Assessment of Educational Progress. This data was collected from a 2,912 13-year-old students. They narrowed this data down to the 2,890 students responding to Test Booklet 15 which included a general reading achievement test. 95% of the students attended public schools and gender and ethnic make-up approximated national population estimates. The reading test (reliability=.83) had 27 multiple-choice questions falling into the four categories of knowledge, comprehension, study skills, and application.

The data collected was analyzed using ANOVA between reading test scores and various categories (Walberg & Tsai, 1984). The data was also examined using categorical, linear, root, reciprocal, and logged regressions, while also undergoing linear and quadratic forms to test diminishing returns.

The results show a mean reading test score of 15.53 (SD=4.27) (Walberg and Tsai, 1984). The test was determined to discriminate well across achievement ranges. A multiple correlation was calculated between reading test scores and 24 variables that yielded a positive relationship ($r=.574$, $p<.001$) suggesting that the variation in reading test scores was greatly influenced by the 24 variables. When Walberg and Tsai (1984) examined correlations of reading achievement to the 8 variables that involved time, they found that the categorical regression or ANOVA form fit the data best for all 8 categories. The linear form, discussed earlier in their paper to be more commonly used, was the worst fit.

Further regression analysis and 3-D plotting was done for the four variables, homework last night, read for enjoyment, news source-magazines, and news source-newspapers (Walberg & Tsai, 1984). When regressed with hours of homework and days per year of leisure reading, reading achievement showed diminishing returns for both. The 3-D plot and the equation for it estimate that homework had positive effects for values of 30 minutes or less while leisure reading had positive returns for around 7 days a week. Both of the other variables showed diminishing returns for little more than a few times a year.

Walberg and Tsai (1984) concluded that while reading achievement is influenced by many factors, these other variables may constrain the amount of return gained from more time spent on an activity. This idea, restated suggests that factors such as ability, social status, access to better instructional technology, etc. might have a confounding influence on reading achievement. Another idea considered was that other activities compete with those that might increase reading achievement as far as motivation or enjoyment are concerned. Here TV watching might compete with homework thus making it likely that more homework might be viewed as a negative experience further reducing the motivation to spend time on homework.

This report by Walberg and Tsai (1984), had a very large sample size with a large amount of data, but the data was not designed for such analysis beforehand making it seem like it was awkward for them to try to fit their results to their objective. They did show diminishing returns with certain activities cited in previous research as being beneficial to increasing reading achievement, but these data were almost as an afterthought.

The studies in the section, in summary, seem to lead to an idea that time, if viewed as any other finite resource, has costs associated with the benefits of its use. Taking this idea further, there comes a point where the cost of using more time outweighs the benefit leading to waste. The major critique for this concept is that does not take into account that there are other costs to not using extra time, social costs that are not as easy to quantify as test scores or graduation rates.

Summary

In this chapter I discussed 30 total studies relating to my question; what is the role of time in learning and teaching? I started with eight general studies of time and learning. Following this, I examined two studies each of how both teachers and students use time. Next, I focused ten studies highlighting on the relationship between aptitude, achievement, and time. Afterwards, I explored the effect of time on cognition in two studies. Finally, I investigated six studies on the application of economic principles on time allocation in learning. In the next chapter I will discuss a summary of findings, classroom implications of those findings, and implications for further research.

CHAPTER FOUR: CONCLUSIONS

In the previous chapter I discussed research conducted in the areas of general relationships between time and learning, teacher use of time, student use of time, time and aptitude as competing factors of learning, cognition and time, and, finally, the economics of time use. In this chapter I will discuss a summary of the findings, classroom implications of those findings, and future research I, or others, will need to conduct to further understand the nuances in the relationship between time and learning.

Summary of Findings

In my research I was able to separate my sources into the six categories covered in chapter three. The first of these investigated the general relationship between learning and time. The trend in the results of these studies showed that, when an investigational procedure was not a factor, time and learning did have a relationship. Some studies, such as the one done by Gettinger (1985) also suggested other factors influenced achievement. Considering these other influences it would appear that time, although a factor in learning, is not as determinant as Carroll's (1963) model suggested. But if Carroll's rationale for the model are taken into consideration we can see that his model took these other factors into account, just not explicitly.

When this consideration was extended to how time was used by both teachers and students, the data seemed to support Carroll's (1963) modeling. Sanford and Evertson (1983) found that how teachers used time has an effect on learning. This was factored into Carroll's model as quality of instruction which, in the model influenced time needed, the general measure of time to which the amount of time spent learning was compared. Students' use of time and their motivations were akin to perseverance in Carroll's model. Smith (1990) and Bruno (1995) demonstrated the effect of student time use on achievement, but also found that there are factors that are common between teachers' and students' methods of time use that support a sometimes antagonistic effect.

In Carroll's (1963) model a reference was made to aptitude. This was the subject of the next section of studies. Some of theses studies (Gettinger, 1979; Hughes, 1983; Arlin, 1982) attempted to determine what correlation aptitude has with learning and how it compared with the correlation with time. Here, if we examine Carroll's models we see that any attempt to determine which factor, aptitude or time, correlates better seems moot since they are co factors in learning. Carroll's model chose time as a focus, but aptitude could just as easily been the focus of the model.

When investigating the studies, two concerning cognition stood out as requiring a separate section. These studies were examined separately because they addressed quality of teaching and aptitude as an interaction between the student and teacher and as an interaction with time. Regrettably, this section needs further development which will be discussed in the further research portion of this chapter.

In the final section of chapter three, I treated time as a limited resource and investigated the economic impact of time use on achievement. Roecks (1980) found that there was an economic trend that showed that those who need more resources use them and those who do not, do not use them. Walberg and Tsai (1984) supported this in their study of the effect of diminishing returns on reading achievement. The results of this study supported the idea that there is a limit to the usefulness of more time. Furthermore this seems to have explained some of the results of Gettinger and Lyon's (1983) study where students would spend 29% less time than needed, but the loss in achievement as measured by retention was only 19%.

Classroom Implications

What are the implications of the findings of this research on my practice in the classroom? Based on the general relationships findings, time should be considered, but if I dissect Caroll's (1963) model I come to recognize that there are other factors besides time that need to be taken into consideration, factors such as the students' aptitude and perseverance, and my quality of instruction. While I recognize that I will not be able to dictate how much time I have in each class period, I can influence how that time is used based on the quality of instruction. This quality of instruction then influences perseverance and, on a lesson by lesson scale, aptitude, an idea that Burns' (1980) results seemed to support.

More specifically there are three main implications I can focus on in my classroom. The first is that I can try to do as much as possible to minimize interruptions to the lesson. In Gettinger's (1989) study of time and its effect on learning, she found that the greatest degree of learning occurred when time spent learning was maximized while time needed to learn was minimized. One way I can maximize time is to reduce the amount of non-learning time spent in the classroom. I can do this by working with fellow teachers and school administrators to reduce classroom disruptions to only those that are an absolute necessity such as emergencies. I can also do this by streamlining my own administrative processes such as taking attendance, handing back assignments, etc. and ensuring they have as little impact on class time as possible.

The second implication is that by focusing on depth rather than breadth and targeting my teaching towards helping students make connections between various topics, I can cover the skills necessary for them to learn without creating the sense of time stress that comes from having to learn many seemingly unrelated things in the same amount of time. I would try to develop lessons that tie into each other so that as students develop an interest in the topic of the lesson, they are able to build on it or use skills from previous lessons to enhance their learning of the current lesson. This idea was supported in the study by Swing et al. (1988) and in part by Anderson (1976). Swing et al. showed that classes that teach thinking skills can be effective raising student achievement levels. Anderson showed that giving students more time earlier in lessons for developing skills needed for more complex tasks can lead to students needing less time for those complex tasks later.

Anderson’s (1976) study also lead me to the third implications which is that students will need to be paced differently based on lesson, student interests, and student ability. I cannot use the same pace for all students and expect them all to do well. I will need to develop lessons that are time flexible, or have time built into them so that students that need more time can take it without holding up those students that would see that time as being wasted waiting or doing busy-work. This idea was also supported by Arlin (1982).

Further Research

While the studies in this paper sought to determine, in a quantitative approach, the role of time in learning, more qualitative work is needed. Negligible mention was made of the effects of race/ethnicity, gender, or socioeconomic status and the influence these factors may have on time needed for learning. Further research into these areas might help to validate, or may refute the findings of the studies contained in this paper. This might also help to develop teaching methodologies that can cope with the diversity of students found in modern society.

The process by which I improve the quality of instruction can be varied depending on the students I have, but one area I need more research on is the area of cognition and what practices develop those skills that take learning from and extrinsically motivated activity to an intrinsically motivated activity. How do I increase student perseverance and increase aptitude? More specifically, how do I do that in math and science, especially for the students who are already disinterested in those subjects, or have a lower aptitude than other students? How do I ensure that when the student leaves my classroom at the end of the year, a finite amount of time, he or she has the cognitive skills that will prepare him or her for the next year? These questions with respect to time and efficiency, are what I aim to answer with future research.

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