To Practice and Persevere
A Study on the Results of Direct Instruction Teaching

Kevin Blaine

This paper was completed and submitted in partial fulfillment of the Master Teacher Program, a 2-year faculty professional development program conducted by the Center for Faculty Excellence, United States Military Academy, West Point, NY, 2013.

Abstract: This study focuses on a direct instruction method for teaching an introductory advanced mathematics course. The focus is on immediate results and longer term effects for perceived understanding of the course material along with long term improvements on habits of learning. Using the Mathematical Modeling and Introduction to Differential Equations course, the second of three core courses required in the advanced mathematics core track, 48 of 247 students received teaching using the designed direct instruction style. The 48 students for the study were selected from those who received the lowest scores in the first of their core mathematics courses, Advanced Multivariable Calculus. The 247 cadets were tracked for a three semester comparison. The 48 students who received the direct instruction were surveyed at the completion of the second and third mathematics core courses.

1. Introduction

Mark Van Doren said, the art of teaching is the art of assisting discovery. In the preface of the math department calculus text the author expresses his desire for students to share in the excitement of great discoveries. He explains his intent to “write a book that assists students in discovering calculus – both for its practical power and its surprising beauty.” [1] I can relate to these expressions for the beauty of calculus and in general mathematics and its great power. I wonder though how many of our college students see the beauty of calculus after successful completion of the course. Perhaps more introspectively we might ask how many college graduates see their discovery and learning in the same fashion as a great artist would when looking back at the completion of his/her masterpiece.

According to a study at the University of California at Los Angeles, roughly 40% of students planning to major in engineering and science either switch to another subject or fail to get a degree at all. [2] The difficulty in learning the sciences is that the learning takes time. [3] [4] Science classes require more time. Math and science “students study on average about three hours more per week that their non-science-major counterparts.” [3] When it’s all done we often find Science Technology Engineering and Mathematics (STEM) students “are both ‘pulled away’ by high grades in their courses in other fields and ‘pushed out’ by lower grades in their majors.” [2]
“We’re losing an alarming proportion of our nation’s science talent once students get to college. It’s not just a K-12 preparation issue” says Mitchell J. Chang of UCLA. [2] So what can we do? I have dealt with some complex issues before and I know what kind of problem I would call this based on my experience. With fourteen years now in the U.S. Army I am conditioned to be responsible for training and preparation of Soldiers. I had responsibility for our mission success on deployments to combat zones in four different countries. It was in these conditions where so much counted on training and learning. In the Army it is called leadership. Leadership is to get people to do things that they would not do otherwise so that they have the necessary experience and skills when required. Leadership is needed at the teacher level. Education “is as much an emotional process as an imparting of knowledge.” [4] There is no substitute for a teacher who cares. What is needed is a teacher who can orchestrate the emotional process of learning, a teacher who will require time and effort from students. “The proper job of a teacher is not to make it easy, but to guide students through the difficulty by getting them to practice and persevere.” [4]

The department calculus book addresses this in a section “To the Student.” The Author instructs students to “read the text… look at the definitions to see exact meanings,” and “don’t be discouraged.” [1] Learners need to be engaged and when they become discouraged they need to become reengaged. Through the challenge and difficulty in learning complex concepts students earn their education and look back at their experience as a masterpiece that was worthy of all the effort it was given. And as a result they appreciate what they learned and recognize that “hard work leads to cool results.” [4]

2. Background

2.1 Cognitive Learning

To provide architecture for the manner in which our cognitive structures are organized, I turn to the Atkinson and Shiffrin (1968) model. This model will serve as a base for the working memory and long term memory.

The role of long term memory in human cognition is not seen as a simple storage of information, rather it is viewed as “the central, dominant structure of human cognition. Everything we see, hear, and think about is critically dependant on and influenced by our long-term memory.” [5] The importance of long term memory to cognition is evident in its use by expert problem solvers who “have acquired extensive knowledge that affects what they notice and how they organize, represent, and interpret information in their environment.” [6] This ability enhances their capacity to remember, reason, and find the best solutions to problems. [5] [6]

Working memory is where conscious processing happens. When processing new information in working memory, the duration and capacity of working memory is limited. [5] However,
limitations are not applicable to information recalled from long term memory. The information in long term memory is readily brought into working memory without limits. [5] Experts who have acquired vast knowledge have become excellent at choosing the relevant information for a particular task. [5] [6] Experts though are not experts just because they have learned a set of strategies that can be pulled into working memory, they have these strategies well-organized in long term memory and are fluent at retrieving the proper strategies for solving the problem at hand.[6]

2.2 Direct Instruction vs. Discovery Learning

Direct Instruction is providing information that explains concepts and procedures the student is required to learn. Minimal guidance or discovery learning seeks to recreate conditions under which a student can discover through inquiry learning. [5]

Experts and novices learn best under different learning conditions. “Research has provided overwhelming evidence that, for everyone but experts, partial guidance is significantly less effective than full guidance.” [7] Guided or Direct Instruction helps less-skilled learners by providing task specific learning strategies. [5]

When introducing a new type of problem, direct instruction gives specific guidance and instructions are provided to the novice to help them learn the necessary steps for these problems. Guidance can then be faded away as exercises are completed by the novice. This allows for the novice to complete many problems and see many correct processes to solving similar problems. To be effective this strategy requires students to be engaged in explicit, attention-driven effort. [5] The working memory load is reduced by following the process established in worked examples. This frees up attention for students learning to recognize patterns in the problem solving process and to begin to build and effectively organize knowledge in long-term memory. [5] Experts do not normally become experts over the time span of a single course or semester. Becoming an expert takes time.

Discovery Learning on the other hand provides minimal guidance allowing the student to recreate the process for solving a new type of problem. Discovery learning favors only the brightest and most prepared students. [7] In fact, this method is preferred by experts who can draw on their extensive knowledge to find best ways for solving various new problems. Novices often struggle and become frustrated with this approach. They don’t have the knowledge base to rely on for solving new problems. [5] Experts learn best in a discovery environment.

3. Motivation

3.1 Standing on the Shoulders of Giants
While this phrase is often attributed to Isaac Newton, it can be traced back to Bernard of Chartres in the 12th century. He used to say that “we are like dwarfs perched on the shoulders of giants. He pointed out that we see more and farther than our predecessors, not because we have keener vision or greater height, but because we are lifted up and borne aloft on their gigantic stature.” [8] Discoveries made by these giants (experts) laid the foundation to many of the great innovations of modern times. In general, students in an introductory course are not among the experts.

The directive instruction in this study is to provide clear instruction for problem solving techniques on each topic, then to allow the learners to apply the process to a number of examples. In this way the student can see the key ideas used in various ways and build experience for later reference. The students begin their homework while still in the classroom where an instructor and peers are available to assist with the new techniques. Then for valid learning to take place in preparation of the next lesson there is homework to be completed outside of class. This reinforces the problem solving techniques and expands the number of worked examples by the novice.

3.2 Habits of Learning

Did you meet the marathon champion that did all his training for the big race the night before the big race? Of course not. Unfortunately enough information can be crammed into the head of students the day before an exam so that they do ‘good enough’ on the examination. This type of study habit should not be considered learning. The material is most often quickly forgotten and more importantly has not been properly organized.

A primary goal of this study is to evaluate any long term effect of creating a learning environment that assists a learner in feeling the satisfaction that comes from learning. The idea is to the use directive teaching in the classroom to get students successfully solving problems using proper and effective techniques allowing the student to complete more homework and complete it properly. A leadership emphasis is needed early on to build the process. This includes quick turnaround of completed homework for feedback, identifying who is slow to get started on work in the classroom and providing encouragement and motivation, an emphasis on the need to learn today’s material in order to be ready for tomorrows, and the list can go on and on with specific needs. Upon the completion of the first examination these students begin to feel and understand the benefits of regular and steady habits of learning. They realize that they no longer need the night before to cram for an examination. They are becoming more confident in their abilities.

This study will look for the development of study habits and did those study habits last beyond the prescribed course.

4. Implementation
4.1 The Demographics

The advanced track program consists of three courses. The first is Advanced Multivariable Calculus, the second is Mathematical Modeling and Introduction to Differential Equations and the third is Probability and Statistics. Using the Mathematical Modeling and Introduction to Differential Equations course 48 of 247 students received teaching using the designed direct instruction style. The 48 students for the study were selected from those who received the lowest scores in the first of their core mathematics courses, Advanced Multivariable Calculus. The 247 cadets were tracked for a three semester comparison through the program.

4.2 Assessments

The 48 students who received the direct instruction were surveyed at the completion of the second and third mathematics core courses. The means of assessment included USMA wide end of course surveys, in class surveys and the use of survey monkey for results following the completion of the core math program.

The assessments are designed to look at the effectiveness of the directed study program. The first emphasis is on both immediate results and longer term effects for perceived understanding of the course material. The second emphasis is on any long term improvements on habits for learning.

5. Results and Discussion

5.1 Direct Instruction - Student Learning

This section focuses on student learning and retention of the material. A discussion of the results follows the
Fig. 1. Grade averages of the cohort compared with the grade average of students taught with direct instruction. Results include the semester before the study, during the study, and after the study.

![Bar chart showing grades](chart)

**This instructor used effective techniques for learning, both in class and for out-of-class assignments.**

Fig. 3. Results of Academy wide survey.
This instructor encouraged students to be responsible for their own learning.

Fig. 2. Results of Academy wide survey.

My instructor cared about my learning in this course.

Fig. 4. Results of Academy wide survey.
To Practice and Persevere - A Study on the Results of Direct Instruction Teaching (Kevin Blaine)

Fig. 5. Results of Academy wide survey.

Fig. 6. Results of Academy wide survey.
The cadets in this study were more than 6 percentage points below the average after the first course. After a semester of direct instruction these same cadets had an overall average above that of their peers.

Since measuring actual learning is difficult, the student’s perspective of their learning is used in comparison to other groups across the math department and campus. On all metrics used by the instructor, the course program, or the university those cadets that received direct instruction expressed an increase in growth and critical thinking over that expressed by their peers.
Fig. 2. Results of Academy wide survey.

Fig. 2 shows the results of a survey taken 9 months after the completion of the course by those cadets who received direct instruction in their Mathematical Modeling and Introduction to Differential Equations course. In this survey 66% of the cadets still felt they retained the basic concepts taught during the course.

These results suggest that the directive teaching method has had a positive effect on their learning. Caution though must be taken to not underestimate the value that the proper leadership provided encouragement and motivation as well to practice and persevere in their learning.
5.2 Direct Instruction - Habits of Learning

This section focuses on the development of habits of learning.

My motivation to learn and to continue learning has increased because of this course.

![Chart showing survey results](chart1.png)

Fig. 2. Results of Academy wide survey.

As a result of the required daily work you were able to develop a level of discipline/focus for daily study.

![Chart showing survey results](chart2.png)

Fig. 2. Results of Academy wide survey.
Fig ## shows that the percentage of cadets receiving direct instruction that strongly agree that their motivation to learn and continue to learn as a result of this course was ###% of above that of the average cadet across the academy for any given course. ###% of the cadets expressed that the consistent focus on daily study helped them develop the discipline they needed to study. With ###% agreeing that without the course they would not have developed this same level of discipline.
Fig. 2. Results of Academy wide survey.
Fig. 2. Results of Academy wide survey.

You have consistent study habits, whether homework is required or not.

Fig. 2. Results of Academy wide survey.

You feel that your experience in this course helped improve your study habits.

Fig. 2. Results of Academy wide survey.
While ##% of the students that received direct instruction feel they have improved their study habits while at West Point (Fig ##), ##% feel that their experience with direct instruction helped improve their study habits. Only ##% of them feel they have consistent study habits without the requirement of homework. The percentage that feel they have consistent study habits regardless of the demands of required homework is ##%.

Fig. 2. Results of Academy wide survey.
Nine months after the completion of the directive instruction course ##% of the students felt they had the needed focus during the previous semester, while ##% expect their study habits to be what they need in the next semester of their college experience.

6 Conclusions

6.1 Future Research

This study used a single Instructor to teach the directive course classes. To expand this to more than one instructor would allow for a deeper look at directive instruction. With one instructor his/her individual techniques to motivate students (previously referred to as leadership) may or may not have a large influence on the overall outcome of the study. With multiple instructors participating in the study a stronger case on directive instruction could be made.

6.2 Final Remarks
The results show a strong trend between the methods used to teach via direct instruction and the real and perceived improvements by the end of the course by those who received this instruction. The Habits of Learning objective is more difficult to pinpoint though. Both the results from the cadets at the end of their directive instruction experience and nine months later do suggests that they perceive a positive influence from this course on their overall increase in their desire to learn.

Works Cited


