What is the Effect on Critical Thinking when Journaling is Introduced into an Advanced Placement Calculus Classroom?

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Inquiry in Practice

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"You can teach a student a lesson for a day; but if you can teach him to learn by creating curiosity, he will continue the learning process as long as he lives." - Clay P. Bedford

Introduction

In the high school environment, different tracks of students come with different expectations for behavior, understanding, and achievement. The old adage, "To whom much has been given, much will be required" rings true in classrooms all over the world. During my teaching career, I have worked with age groups ranging from middle school to high school, and from the most basic level of student to the brightest students our school has had to offer. It wasn't until I had worked with some of the brightest that I had realized that I had to make some improvements to my teaching style.

Origin of Research Question

In examining my own twelve-year teaching career, I have found that I have not pushed students to reach their maximum potential, opting instead for a comfort level that suited both the students and myself. Almost at the midpoint of my career, I found myself "going through the motions", worrying about covering all of the material in the curriculum and keeping up with the other teachers in my department. Every year, days and weeks would pile up quickly. When I would reflect back on my classes and ask myself what they had learned, all too often, the answer was "nothing". I blamed myself for the students' general lack of genuine learning. By rushing through or by not preparing lessons as well as I could, I had shortchanged the students year in and year out. How could I improve my own teaching and still make the students accountable for their own learning?

It was about two years ago when I decided to enroll in Regional Training Center classes, and immediately I knew that these classes would help me to become a better teacher. Through the three core classes, which I consider to be reflective and internal, and the seven other classes, which helped to introduce me to many different teaching and learning styles, I felt that I had the tools necessary to implement change in my own classroom.

It is my own personality style to be a harsh critic of myself. I could attribute that to many things: being a perfectionist, being the youngest of six children, even having failed at more things in life than I have succeeded at. However, one thing I have always been hesitant about doing is closely scrutinizing myself. I have never been successful at talking about my own shortcomings or examining my faults. It is perhaps for this reason that I decided to really challenge myself for this project. In a session dedicated to examining a number of possible research topics, a number of ideas presented themselves to me. Ideas such as assessment, mentoring, teacher-administration relations, and working with mainstreamed students all presented themselves as possible research possibilities. However, a discussion with a colleague about journaling made me realize that I should give myself a real challenge and see what I could possibly to do change my teaching style, and perhaps even force a change in my own view of myself. The only challenge would be how would I use joumaling? What level of student would I use as my test group? Would I be using a journal myself? What would be the goal of using journals with my students?

When I reflected on this, as well as the concerns discussed earlier regarding what students actually left my class knowing, I decided that I would focus on the critical thinking skills of my students, specifically the Advanced Placement students. On the face of it, it doesn't seem like much of a challenge, asking the brightest students to be reflective about what they are

processing in their heads, but as you will see in the next section, this group of students proved to be quite a challenge to work with.

Context

Educational Setting

Northern Highlands Regional High School District is an upper-class regional school district located in Allendale, NJ, in the northwest corner of Bergen County. What makes this district unique is that the district consists of one school. The elementary and middle schools are not regionalized, but are run by the corresponding four towns. The 1309 students in this district are residents of Allendale, Saddle River, Upper Saddle River, and Ho-Ho-Kus. Over 97% of graduates will go to a two- or four- year college. Over 86% of the students are white, with Korean students being the number one minority. Northern Highlands takes pride in consistently setting and meeting high goals for success in academics, athletics, and community service. Parents hold their children to very high levels of expectation, and there is a lot of competition in all aspects of academic life for the students of our school.

Our school uses a rotating block schedule. Each student has eight classes in his schedule. Only six periods meet per day (two are "dropped"), so in a four-day cycle, all eight classes meet exactly three times. I think this is beneficial as it allows the students to have some variety in their schedule, and classes meet at different times each day. This is especially helpful as the first morning class can be extremely dull, and the afternoon classes tend to be more rambunctious than most. One detraction against the rotating schedule is that it reduces the number of times over the year that the class meets.

Department

The mathematics and business departments at our school are run by the same supervisor. Our Mathematics department consists oftwelve teachers, four of whom are male. As a five-year veteran of this school's math department, there are four members with more experience then me. This can be attributed to several staff relocations and promotions, combined with some turnover related to not being asked back. Members of our department are encouraged to work and plan together. Each course has its own "leader" who is responsible for pacing and oversight of the fmal exam. This promotes discussion among the members of our department and also provides a leadership role to almost everyone. As colleagues, we get along well and we are not afraid to discuss problems related to our teaching in our department meetings.

Classroom

The setting in which I will explore my research question is my Advanced Placement ("AP") Calculus classroom. In my AP class, I have 15 students, all of whom are seniors. There are seven girls and eight boys, each with an honors background in mathematics.

There are two levels of Advanced Placement Calculus. The "BC" level of Calculus consists of students who truly are the "cream of the crop". These students are truly the best that the school has to offer, and will most likely end up pursuing majors in mathematics, engineering, or science. The "AB" level, taught in my classroom, consists of students who wish to have the challenge of Advanced Placement, but struggle with the material, despite their honors background. It is appropriate here to comment on the upper-class nature ofNorthern Highlands. There is a tendency for students to be competitive regarding academics, athletics, and generally anything where students will be compared with one another. This competitiveness causes some

students to reach higher than they should probably be reaching. An informal count shows that 80 our of the school's 320 seniors (both rough numbers, but approximately 25 percent) are involved in AP Mathematics (Calculus or Statistics). On a percentage basis, this number is clearly too high for a segment of the student population that should be considered the "best of the best". When this is coupled with the fact that most Highlands students who are enrolled in AP classes take more than one AP class (some as many as four or five!), it is east to see that many of them are in over their head.

AP courses are designed to be taught at the college level. fu some instances, depending on the grade received on the AP exam and college that the student gets accepted into, college credit may be granted for the course. Therefore, standards are set high. Because some of the students are "in over their heads", I face the daily task of providing the challenge of the AP curriculum, while at the same time, making students comfortable with where they are with their current level of understanding of the material.

Because of the challenges mentioned above, I have found two basic solutions to the problem. I have found that getting students involved in rich, critical-thinking problems forces them to make connections. Additionally, increasing the difficulty of the problems, taking each concept to its upper limit has yielded positive results for me as I have progressed in my career. However, I feel that these two solutions taken together are not enough to bridge the gap.

When I looked for a research topic in the first of the three core courses, I had several ideas in mind. Most of the work in that course was based around self-reflection. fu that course, I found myself amazed at how I was "forced" to think about my own thinking and feelings. I also realized that I learned best (even as a young student) when I had to teach others, because it forced me to think about how I processed the problem at hand. I thought that it would be a good

goal to ask my students to strive for their own metacognition. I slowly came to realize that the idea of journaling would be my concept for a teacher research paper.

Teaching Philosophy

Students are constantly changing. Attention spans and manners seem to be in much shorter supply as the years go on. Musical styles and tastes become more difficult to understan . Hairstyles and clothing styles become more of a mystery. All of these are ways that adolescents attempt to define themselves, to separate themselves from adults and authority figures. Therefore, any teaching philosophy must address the needs of students, academically and emotionally. Because students are always evolving, what works with our students one year may not work the next year. In fact, what works with one class or level of student may fail with another. I find it both challenging and refreshing to reinvent my teaching style every year. In the beginning of my career, I felt very strongly that lectures should be limited and hands-on activities should be maximized. However, as I have progressed in years, I have found myself relying increasingly on lectures and not putting as much effort into planning interesting activities. Sometimes, I chalk this up to being increasingly busy and tell myself that this is the best that I can do with the time that I have.

I have experienced success and failure as a teacher. At times, I have left school with that dreadful feeling that all of us get when we experience failure that goes something like, "Did I really *do* anything today? Did my students *do* anything today?" I blame most of these failures on myself. I can always redirect the concern by asking myself if I could have prevented this by being more prepared or by being more interesting.

I define success as a teacher in many ways. Sometimes it is knowing that you have delivered a successful lesson, that all of the work that you put into planning, organizing, and presenting paid off. Sometimes it's grading a set of tests and knowing that all of your students achieved the goals that you set for them. However, my idea of success has evolved as my career has progressed. I consider myself successful if the students participated or asked questions. The students must feel as if they took part in the lesson. I ask myself if the shyest student in the class felt like she was part of the lesson. It inay sound ironic, but I don't measure success only by the standard of achievement; I believe that the students have to get more out of the classroom experience than that.

I enrolled in RTC courses at the perfect time. I was fortunate enough to have two very good teachers for my first course. I had no idea of some of the educational philosophies that were out there: Multiple Intelligences, Brain Based Learning, Differentiated Instruction, to name a few. I have experienced them all first hand, and I feel as if I have re-energized myself in my ability to present the material. When I joined the master's program and was introduced to teacher research, I was amazed to learn the difference between "Teacher Research" and "Research on Teaching". If I am putting all of this together right, then we are handling Teacher Research in the core classes at TCNJ, and are being exposed to all of the current Research on Teaching in the other (regular) RTC courses.

Last year, after I completed the Multiple Intelligences class, I surveyed the 11 students in my Honors Calculus class. Each student was genuinely surprised to discover that there was more than one type of intelligence and that they each excelled in one or more intelligences! I presented several lessons afterward using some of the different types of intelligences, and the students responded overwhelmingly positive! It was rewarding for me to know that I had

learned something that I could apply that was different from what I was already doing. Also, knowing that the students enjoyed it rejuvenated me in ways that I never thought possible.

Literature Review

As I prepared for my teacher research project, I wanted to know how others before me had answered the same questions that I have. The different perspectives offered by these researchers helped to frame my own situation and guide my research.

In examining these sources, I searched for the current trends and discussion around the tssue. It is encoUraging to know that all of the educators who wrote the articles achieved measurable success by using journals in the classroom. One of the drawbacks was the increased amount of time that the teachers had to invest in providing genuine feedback. I also found that it is important not to assign journal entries for the sake of having an assignment.

Problem Solving

Many researchers are usmg journals as a means of exammmg problem solving techniques. This has immediate consequences for me, as my own math department has been focusing on problem-solving skills as a desired result of our teaching. As mentioned before, teachers tend to get tied up in *what* they teach, but leave little room for the *application* of the ideas in real-life situations.

Frequency of Journal Entries

Some articles were helpful to me in suggesting how many entries per week might be appropriate for my classes. Until reading this piece, I had never really considered how

frequently I would give journal assignments. Some researchers required weekly journals, 1 to 3 pages long, using different prompts, while others expected more frequent, yet shorter entries in the journal. Some were hypothetical situations asking students to compare or contrast two approaches to the same problem.

Nature of Journal Prompts

A few researchers expressed concern that journal prompts should be varied. It is not always appropriate to ask students what they have learned: sometimes it must be demonstrated. Sometimes, we will want to ask students to compare or contrast two solutions to a problem. At other times, we will want a student to find a mistake, while at other times we will ask the student simply to reflect on the learning process. By not varying the nature of the journal prompts, the students may become burned out to the use of the journals, and the time spent on journaling may be counterproductive.

Student Communication

One research piece stressed the initiatives suggested by the American Mathematical Association of Two Year Colleges (AMATYC), that students should be able to communicate mathematically both orally and in written form. The article pointed out the benefits that both student and teacher receive from the use of journals. Students get the benefit of a broader understanding ofthe material, or at the very least, an understanding of what their weaknesses are. Teachers get the advantage of increased communication that is not otherwise available due to time constraints. Koirala also points to other research that affirms the use of journals, stating that teachers often got clues as to how to improve their instruction.

Feelings vs. Knowledge ·

Another common thread in the analysis of student journals was the split between journal prompts that expressed students' attitudes and feelings about what they were learning, and those prompts that demonstrated actual mathematical knowledge and processing. I think that this distinction is important: these are the two major forces in most any high school mathematics classroom (or most likely *any* classroom). The authors used the constant comparative method of coding to search for patterns in the students' writing. As a drawback, they also expressed that students tended to write about their feelings even when asked for what they had learned. In fact, almost 80 percent of the time, students wrote about their feelings and beliefs about mathematics.

Summary

Generally, most researchers reported that students were able to make genuine connections through joumaling, especially as the course wore on throughout the school year. Some note that as the course progressed, students generally gained the confidence to express their own frustrations and joys about mathematics. They note, however, that sometimes the students lacked the metacognition to analyze their own thought processes.

It is encouraging to see that there are other professionals who share many of the same concerns that I had in developing my questions.. By examining all of these perspectives, my own research was be more rich and meaningful. Despite any shortcomings that the authors may have encountered, all of them benefited by using journals in their cla.Ssroom.

Methodology

Data Sources

There were plenty of opportunities for gathering data for this project. Since the research project was about the effect on *critical thinking,* I needed some objective ways to gather data and measure the increase or decrease that joumaling had in student perfomance. For this, I used two primary sources. First, I used a collection of questions specifically designed to measure student progress in Calculus. The book, "800 Questions in Calculus", is a collection of Continental Math League (CML) contests pulled from over 25 years of CML competitions.

I also used released exams from the College Board, the same organization that administers the Advanced Placement Examinations. By their nature, these questions are designed to give an advantage to those students who have not merely memorized the content of the course, but who have internalized the concepts and can make judgments based on the questions. One must read each question carefully and go through several layers of understanding to get to the "answer" to the question. As many a calculus teacher will tell you, it is the process that really matters, sometimes even more so than the product.

I gathered other non-objective data through several sources. My own personal journal was essential in tracking what methods worked and what didn't work with my students. Sometimes it wasn't only the journals that effected change. Sometimes it was letting a particular type of student work with a similar student that caused a breakthrough. Other times it may have been putting the notebook away and havirig a discussion about the topics we were learning that really worked. And there were plenty of methods that I used that didn't work at all.

Of course, since the research paper is about the *students'* journal entries, it was the most prominent non-objective data source that I had to use. Not only were there student comments in

the journals, but my own comments reacting to what students liked or disliked. I referred to these journals every time I would take notes for this paper.

As mentioned earlier, my own mathematics department has been a strong source of support and encouragement for me. Several of the veteran members have offered advice on critical thinking, and others have given me good ideas for writing prompts or just provided suggestions for using different teaching strategies.

An additional source of data was online journals, forums, and websites. Although these are probably three different sources on the.ir own, I consider them one and the same as I viewed them all from the same place. Using the extensive database provided by my own school (and TCNJ), I was able to view articles on any subject that I wished. Although not everything I read was useful, I still was able to consider these online articles as a source of data, using what was convenient for me. I even joined a number of online support groups for education, and was even able to have an online chat with one of the authors of the articles!

Collection Activities

Writing prompts were assigned almost every day. Students would keep their journals in a file cabinet in my classroom and I would typically take them· home over the weekend to comment, or if I had free time during the school day, I would examine them during school.

Students were assigned critical thinking exercises two to three times per week and were instructed to make a chart of their progress. I would give points not only for correctness, but also on original thought and attention given to the process of solving the problem. By sticking to an objective scale, the tendency to estimate student progress was minimized.

Inside the front cover of the students' journals, a chart was drawn measuring the scores from various critical thinking activities. The assignments would always consist of one open-ended question per assignment (fifteen minutes, timed), and ten multiple-choice questions per assignment (fifteen minutes, timed). This assignment was given twelve times throughout the course of the project and the results are summarized later in the appendix of this paper.

In summary there was a nice balance of quantitative data (the scores from the assignments) and qualitative data (the comments and dialogue from the students). Combined with the other data available to me, synthesis of the data was quite easy and such a rich experience to be a part of.

As a teacher, I struggle to know what my students are thinking. I want to know how the methods I am using in class are interpreted and processed by the students. It is neither practical nor possible to make time to meet with students during or outside of class, given the time constraints that teachers and students are under. Joumaling is a great way to get feedback from students and find out which methods that I use are making an impact in the class. Among my anticipated goals were improving communication between my students and me, providing students with opportunities for reflection on their own education, extending the curriculum with more challenging and rich problems, getting feedback about what works and what doesn't in class, and enriching the process of "going to math class".

Findings

Teaching

Regarding teaching, I found that journaling did indeed have a positive, measurable effect on my group of students. That is not to say that it would work with everyone. I believe that the right atmosphere must exist: students must be willing to work, the teacher must be willing to devote the time to engaging in reflection and conversation, and there must be a need for improvement. fu conversations with my colleague who teaches the higher level Calculus class, she stated that it is an excellent idea but that the "BC" kids would not benefit from it as there is not much room for improvement and the time frame allotted for the course does not allow for such an endeavor.

On the first day, I was surprised to see a journal entry from "Sue", who responded to the question, "How do you know that you have learned something in this class or any class?" by saytng:

> It's very common to come out of an experience and think to yourself, "Well, that was a waste." And I'm not going to lie, throughout my high school career I have ended my years feeling somewhat dissatisfied. Maybe it was because I didn't like the course [. . .] or teacher. In retrospect, it doesn't really matter, because when you do learn something, it feels great. I find that I know that I learned something when I start relaying it back to someone in a conversation. Many times, if you enjoy what you are doing, you tend to retain more.

School

My colleagues and administrators fully support that idea of journaling. No other math teacher in the building is using it, and as a "pilot program", it worked very well. I am going to try it in three of my classes next school year. I think that it will be interesting to see how it works when it is done from the beginning ofthe school year.

Beliefs

It is always helpful for me to ask myself"What do good teachers do?" Every year I plan ask myself this question every time I plan. As an opening-day activity, I will ask my students two questions, and have them brainstorm their answers with me. The two questions are "What do good teachers do?" and "What to good students do?" In this way, we are setting expectations for each other without doing so explicitly. I will keep the completed maps posted in my room. It is no coincidence that my teaching philosophy is mirrored in the expectations of the students' responses, because I think that most students have the same basic needs. They want a teacher who cares about them, doesn't overwork them for the sake of being overworked, is organized, knows his material and can present it in an interesting manner, and understands when students make mistakes.

My consciousness about teaching has evolved as welL I believed that the key event that has given me awareness about my role as a teacher (especially of mathematics) is that students don't always see the practical nature of mathematics. As a teacher, it is very difficult to make the students understand that what you are doing is relevant. As I have reflected on this, my most common observation is that the only kids who fail to see the relevance are those who don't understand what I am doing. This pushes me to do everything that I can to make sure that kids are interested and understand what is going on. My goal as a teacher is to focus on the *process* (how the student thinks), not the product (what the student provides as the answer). When the students get to the higher levels of mathematics, it is the cognitive skills that are so important.

Professionally, there are .many things that get in the way. Time is a resource so valuable that you cannot possible meet every goal that you set out to meet. It is so difficult to be creative, plan activities, make phone calls, give progress reports, create report cards, grade and provide

feedback on papers, and handle so many other administrative tasks while at the same time try to be an outstanding teacher. Add to this any extracurricular activities that you may handle, as well as any attempt that you might make at a social life, and you have the perfect recipe for a challenging career.

I am always thinking about my own professional development. I never feel as if I am doing it right, even though I know that is not entirely true. I always feel that someone else is doing it better than me, and that is not acceptable to me because I want to give the best possible experience to students who enter my classroom. I know that I will continue with the questions of how best to handle professional, administrative, and social tasks within the classroom. I feel that RTC has been beneficial in helping me achieve my goals. For a good teacher, professional development has a start date (your first day teaching), but it has no ending date as long as you are still teaching. As a teacher, I will never be perfect, nor will my students. But by working together, we can strive for the most enriching, exciting experience possible.

Attitudes

I cannot overstate how impressed I was with the attitude of my students in setting goals for us as a class. Rarely have I seen students come together for achievement of a common goal as I have with this class. I believe that involving them in the planning process was essential in gaining their enthusiasm and drive to succeed.

"Rob" is a student in my class who I would consider representative of the attitude of the students in my class. Rob is a hard worker, and genuinely wants to learn the material in class. fu one of his journal entries, he discusses the downside of rote memorization:·

> Most of the time, I am forced to just memorize facts and data in order to do well on tests and ultimately, the class. In subjects such as biology and history I rely on brute memorization and once the assignment is given I forget most of the specific dates and other info.

Assumptions

Many teachers of mathematics assume that it is not appropriate to use writing in the math classroom. It is because of this assumption that many do not aspire to use journals to monitor student progress. In fact, it took me twelve years in order to see the benefit of doing it myself. Dr. Jenny Antos-Deane is a researcher whom I was fortunate enough to speak with after reading one of her research pieces. She supported my belief that it is healthy for students to be writing, even if it is in a math classroom:

> [Writing] helps them to think more deeply about the subject matter. [I]t informs instruction for the teacher as students either clarify their thinking or share their misunderstandings, and it is important for students to understand how they learn and for them to monitor their own progress. Was this process difficult for them? Do these students have difficulty with writing in other areas? [Give] them a few different prompts from which to choose. Students also love having choices as it empowers them.

Dealing With Obstacles

There were few obstacles along the path of my research project. Although the students never voices opposition (by speaking or in writing), there were times that I felt that the joumaling was becoming old hat. When that happened, I would switch the style of the prompt from something academic to a problem solving approach or a freewriting exercise.

Emerging Questions

Over the course of the Inquiry class, I came to realize that teacher research was a topic that I was already concerned with, if even informally. During my career in teaching, I have

always felt the need to "reinvent the wheel" every year. I am always searching myself for the best way to not only teach the curriculum, but also to make connections, teach students to learn in the general sense (not just in mathematics), and be as entertaining (or at the least, not boring) as possible.

As I read the assigned works and did the reaction papers, I found several emerging questions which deserved a closer look. Most notably, joumaling seemed to be a topic that seemed to keep tugging at me for attention. We devoted a lot of time to joumaling in our class: keeping a daily journal, using writing prompts for "impromptu journals", spending time reading about journaling, and also examining the role that journaling plays in teacher research (it was prominent in both the published and non-published teacher research that I studied with my group). Further, when Shirley Brown came to visit our class, I got into a short discussion with her. I shared with her the challenge (and also the benefit) of joumaling, and she suggested that one of my research questions might be "What happens when I introduce journaling into my classroom?" I am still leaning towards this as a topic.

As I progressed in my own research and reflection, my journal provided me with a list of questions that emerged: Will my students fluff their journals or will they genuinely embrace the concept of what I am trying to do? Do students care about learning for the true sense and enjoyment of learning? How can I devise journal prompts that will stimulate critical thinking? How will students react to my comments? Will they think that I am judging them? How can we effectively measure metacognition and critical thinking? Is it all subjective or can one 'just tell" by the quality of a response? Perhaps a rubric is needed? What is the effect of cooperative learning on student achievement? How is student learning affected when they are free to discuss topics without having to take notes for themselves? (assuming teacher plans are made available

to the students) What is the effect of non-traditional teaching methods in the classroom on student performance?

These are all excellent threads for discussion with colleagues and even students. I have found that in teaching older, more mature students (juniors and seniors) that .it is possible to engage them in discussion about their own education and adapt my teaching style somewhat to suit them.

Connections

The joumaling process is rich with connections, not only to other curricula, but also in relating both sides of the brain. By combining logical, numerical skills with reflective, writing skills, I believe that the students were making neural connections that they would not normally make using the traditional modeL Of course, this observation is only superficial-Idon't have the qualifications to measure brain activity, but the results support this hypothesis. This process could be used to make connections across the curriculum.

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Appendix A: Subjectivity

The cause and effect relationship between journaling and critical thinking was relatively easy to gauge. Since scoring was done according to a rubric, there was not much room for subjectivity to creep in.

Admittedly, it is impossible to put aside all bias in scoring the assessments, especially because I would like all students to succeed. I think that part comes from the teacher in me. However, I tried to save my own personal bias to be encouraging when giving feedback in students' journals.

This activity was important for my students and me to try to be successful at. I wanted them to make the connection between achieving metacognition and realizing success in mastering concepts.

Appendix B; Implementation

Enhancing critical thinking skills is not a new concept, nor is the idea of journaling to trigger metacognition. This is such a simple strategy to implement-all that is needed is the right mix of students, a need for improvement, and a teacher willing to try something a little non-traditional. The teacher must also be willing to explore his own thought process and be willing to make adjustments to his own teaching style and planning process.

Discounting the leg work required to maintain the operation, the setup is simple. All it takes is one composition book per student, which is an expense most school districts could certainly pay for.

To take it an extra step further, I found it helpful to join an online group of teachers who supported me and gave me help for whatever questions came up. Additionally, my own small RTC group, along with Dr. Amtzis gave excellent feedback and reassured me that the work was coming along fine when I had doubts that I would be able to construct a successful, measurable data set from my findings.

Appendix C: Some Raw Data, Charts, and Interpretation

Measurement of Student Progress
Critical Thinking Skills
Mr. Smith's AP Calculus (AB) class, period 7

Student	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Avg	% Chg
1	17	16	18	21	21	19	23	24	22	18	20	23	20.2	35.3
2	21	21	16	18	22	21	19	23	25	20	22	24	21.0	14.3
3	17	17	20	19	21	23	24	23	20	19	18	22	20.3	29.4
4	11	9	12	10	14	13	16	15	11	13	14	16	12.8	45.5
5	13	13	14	14	12	15	11	14	15	16	17	17	14.3	30.8
6	15	18	16	14	17	18	18	19	20	17	18	19	17.4	26.7
7	14	14	16	15	18	12	12	14	15	15	13	14	14.3	0.0
8	14	16	11	10	12	15	12	14	11	15	13	13	13.0	-7.1
9	16	18	18	15	17	14	16	19	19	20	19	19	17.5	18.8
10	18	18	19	17	17	20	19	19	18	20	20	21	18.8	16.7
11	17	20	21	19	18	16	17	14	21	20	22	22	18.9	29.4
12	17	19	18	19	20	21	17	19	21	22	21	22	19.7	29.4
13	25	22	23	24	24	26	26	27	28	27	27	27	25.5	8.0
14	26	27	26	22	26	27	24	25	27	27	28	27	26.0	3.8
15	17	14	19	18	19	16	17	17	18	22	24	23	18.7	35.3
Avg Score	17.2	17.5	17.8	17.0	18.5	18.4	18.1	19.1	19.4	19.4	19.7	20.6	18.6	**21.1**

1 Open-Ended Question - 9 points
10 Multiple-Choice Questions - 2 points

Maximum Score - 29 points

The graph below shows the students average on a week over week basis. As expected with any set of data, the results do not trend up every single week. Rather, the law of averages allows for some ebb and flow among the students. Unusually low or high scores from some students during a particular week can skew the average. Also, contributing to the slight variations in uptrend was that no matter how hard one tries, it is impossible to guarantee that the difficulty level on a week by week basis will stay the same. However, it is easy to notice that the overall trend in critical thinking skills is up, and by the end of the twelfth week, scores had increased by over 21 percent.