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To almost everyone's surprise, The New York Times Editorial Board published a statement on December 14, 2013 supporting the expansion of programs for gifted students. The reason for this statement was US students' poor performance on international measures of mathematical ability (PISA 2012 test results), and the persistent malaise that exits in our public schools. This editorial recommended more state and national government support for gifted education, increased opportunities for accelerated learning which emphasize reasoning and rigorous problem solving, early college admission, and psychological coaching. It is ironic that The New York Times unexpectedly made this positive statement about the national need for improving gifted students' educational opportunities because previous articles in the "newspaper of record" have been downright hostile or provided little support for properly educating the gifted. In addition, the New York City Public Schools has been less than welcoming in its support for gifted education programs. Other than maintaining such outstanding specialized secondary schools (where staff and teachers are under persistent duress from critics) as the Bronx High School of Science and Stuyvesant High School, the hostility against gifted education has been particularly vitriolic in this area of the nation. Time will tell whether the new Chancellor, Carmen Fariña, will provide increased support for gifted students, and whether the NYT editorial signals a new era for gifted education like the one that previously occurred during the post-Sputnik era of the 1960s.

As reported in Newsweek (online version, January 17, 2014), Professors David Lubinski and Camilla Benbow of Vanderbilt University have reported very positive results from their longitudinal study of mathematically talented students. Professor Julian Stanley began this study at Johns Hopkins University in 1971, and current results document the high lifetime achievements of study participants in areas such as law, medicine, the arts, humanities, engineering and business. Their accomplishments apparently occurred in spite of poor opportunities to participate in challenging gifted programs. Clearly, many gifted students are still not being provided with sufficient opportunities to develop their maximum abilities. Time will again tell whether the impetus provided by the NYT editorial and other news sources will lead to increased government funding and better teaching for the gifted.

The articles in this issue are as follows: **1. Professors Dorothy Sisk, W. Ted Mahavier and Joanne Baker of Lamar University** discuss their research on using inquiry-based learning (The Moore-Method) to teach mathematics to gifted and high potential secondary students. Dr. Sisk is currently an endowed professor in education where she directs the Conn Gifted Child Research Center. She served as the Director of the U.S. Office of Gifted and Talented, playing an instrumental role in increasing the cadre of professionally trained teachers/consultants for the gifted, thereby expanding opportunities for students. **2. Harry T. Roman, inventor and design engineer, and the teachers at Hillside Grammar School in Montclair, New Jersey** show how game design was used to stimulate gifted students' enthusiasm for learning and problem solving. **3. Professor Sanford Aranoff** argues that teachers in math and science areas must identify the basic principles of their subjects and effectively apply them to teaching all students. **4. Professor Michael E. Walters** wraps up the current issue with an analysis of the creative background for Aaron Copland's classical music of Americana.

There have been several interesting articles and commentaries published in the last few months on the role of innovation in American society. Among them are: • ***Finding the Next Edison*** (The Atlantic, January/February 2014) by Derek Thompson. Discusses how the Quirky Company in NYC helps people to refine and market their inventions. • ***If I Had a Hammer*** (NYT, January 11, 2014) by Thomas L. Friedman who attends to a new book, **The Second Machine Age** (2014) by Erik Brynjolfsson and Andrew McAfee – they show how the exponential increase in modern technology is affecting job skills and intelligence.

Maurice D. Fisher, Ph.D., Publisher

The Impact of Inquiry-Based Learning in Mathematics on Gifted and High Potential Secondary Students

Dorothy Sisk, W. Ted Mahavier and Joanne Baker

Lamar University Beaumont, Texas

Outstanding mathematical ability is a precious societal resource, sorely needed to maintain leadership in a technological world (National Council of Teachers of Mathematics, NCTM, 1980). Even though this statement was made over 30 years ago, progress since then has been slow. The latest trends in International Mathematics and Science Study (TIMMS, 2012) reports TIMMS results in 2011 that indicate in grade 4 the mathematics scores of Singapore, Korea, Hong Kong, Tapei, Japan and Northern Ireland were higher than those of the United States. The percentage of grade 4 students in the United States that reached the Advanced level score of 625 was 13%, and 47% reached the High score of 550. In grade 8, mathematics scores of Korea, Singapore, Tapei, Hong Kong, and Japan Mathematics scores were higher than the United States. In the United States 7% of the grade 8 students reached the Advanced level score of 625 and 30% reached the High score of 550, which indicates a decrease in math achievement from grades 4-8 in the United States students. In addition, results from the National Assessment of Educational Progress (NAEP, 2012) indicate that although scores in Mathematics continue to increase, with 13% of fourth graders performing at the Advanced Level and 47% performing at the High level, only 7% of eighth graders performed at the Advanced level and 30% at the high level. Therefore, whether we are examining international or national measures, our present system of mathematics education (while improving) is not serving the needs of our most capable students.

Huziak-Clark, Van Hook, Nurnburger-Haag, & Ballone-Duran (2007) cited the Chinese proverb: “Tell me and I forget, Show me and I remember, Involve me and I understand,” to draw attention to the similarity of inquiry-based learning (IBL) and the time-honored proverb, since IBL encourages students to discover or construct information. IBL arouses students’ curiosities and motivates them to continue to seek until they find answers (Slavin, 2006). To explore the effect of IBL on achievement, Witt & Ulmer (2010) worked with 6th and 7th grade middle school students in mathematics with an IBL experimental group and a traditional teaching method control group. They found the students in the IBL classes increased their academic growth in math in both the sixth and seventh grade classes, and students in the experimental group were more motivated than the control group. IBL engaged the students in reflecting and thinking critically. This finding adds to the much needed data base for the National Council of Teachers of Mathematics that encourages teachers to strive for a more student-centered math classroom that de-emphasizes rote memorization of isolated skills and facts and emphasizes problem solving and communication to help students "construct" mathematical knowledge (NCTM, 2000).

Attitudes toward Math

Considerable research in the mathematics education field has been directed toward the effects of attitudes toward achievement. Singh, Granville and Dika (2002) found positive relationships of motivation, interest and active engagement with achievement in mathematics. The University of Cincinnati faculty in the Colleges of Engineering, Education, Criminal Justice, and Human Services (2006) studied the impact of inquiry-based teaching on mathematics achievement and attitude of ninety grade 9 students and found a positive effect on both mathematics achievement and attitude toward mathematics that was statistically significant. Woodward (2004) studied anxiety and its relationship to math achievement, and the research indicated that math anxiety has a negative effect not only on achievement, but on attitude toward math as well. Similar findings were reported by Michelli (2013) who found a significant relationship between attitudes toward math and achievement in math. She suggests educators become aware of attitudes and seek to improve them to positively influence the academic achievement of students. This current research builds on earlier research by Aiken (1976) who found a significant relationship between math attitudes and achievement and the meta-analysis conducted by Ma and Kisher (1997) that reported a statistically significant relationship between attitudes toward math and achievement in math.

Context of Learning Math

Still another avenue of research has been conducted on the context of learning math and the importance of IBL to stimulate student engagement. Inquiry learning, compared with a teacher-directed expository teaching approach was found to be an effective way to increase scientific thinking skills, critical thinking, and advanced content knowledge (Chin & Malhotra, 2002; Zoller, Ben-Chaim, Ron, Pentimalli, Scolastica, Chiara,& Borsese, 2000; Lott, 1983), and it would stand to reason that similar findings would result in the use of inquiry in mathematics. Inquiry approaches encourage students to develop and use critical and creative thinking processes. Sandifer (2005) emphasized the importance of using IBL to help students draw conclusions. His study found that constructivist teachers often skipped “concluding sense-making sections” of some activities which made it difficult for students to draw conclusions about the inquiries they made. Sandifer also found teachers had a tendency to reveal in advance the ideas the students were supposed to construct. If students already know the right answer, then inquiry is not present because the students are not figuring it out for themselves, and in addition they are not constructing their own knowledge.

Inquiry Based Learning (IBL) in Math

Project Math Explorers was funded by the Educational Advancement Foundation in Austin, Texas in 2013 to plan and implement an inquiry-based learning (IBL) program. The Moore-Method was used to introduce grades 9-12 gifted students and high potential minority students to a challenging mathematics curriculum in a three week residential setting. The project charge was to explore the impact of IBL on student motivation and attitudes toward math.

Major Goals, Objectives and Outcomes of the Math Explorers Project

The major goal of *Project Math Explorers* was to develop an IBL curriculum to be implemented in a three week summer residential program at Lamar University in Beaumont, Texas to increase the interest and attitudes of the participating students toward math. Secondary goals included: increase the achievement motivation, the self-concept and the leadership skills of the participating students. In addition, one anticipated project outcome was to increase the number of participating students who select Math or STEM as a career choice.

Method

Students/Participants

Three graduate students in the department of Mathematics at Lamar University were selected as instructors and 60 grade 9-12 gifted and high potential minority low-income students were identified as student participants. The students were recruited from throughout the state of Texas, and represented a wide variety of ethnic backgrounds including Asian, Hispanic, African American and Anglo, as well as a wide discrepancy in family income, including students on free lunch as well as median and high income families.

Procedures

The three graduate students in mathematics participated in a Spring course with W. Ted Mahavier to develop an IBL curriculum to be implemented in the summer residential program. The curriculum included classes in *Number Sense*, *Probability* and *Cryptography*. The Moore-Method was used as the primary teaching strategy in the project. Mahavier in Coppin, Mahavier, Ma and Parker (2009) described the Moore-Method as being associated with discovery-based, inquiry-based, student-centered, Socratic, and constructivist strategies; yet, he emphasized the Moore-Method isn't fully encompassed by any of these strategies. The bulk of a Moore-Method class consists of students making presentations of solutions to problems provided by the teacher, which the students produce individually with no external aids, such as text books. A Moore-Method class meets the students where they are and guides them at a fair and challenging pace through the materials. The teacher is a coach, mentor, collaborator and guide, and most important the teacher is a source of positive reinforcement.

For most students who are used to teachers dispensing knowledge, prescribing and demonstrating the methods to be used, and engaging them in seeking "one right answer," there is a period of adjustment. R. L. Moore for whom the method is named, developed the method at the University of Pennsylvania and used it at the University of Texas from 1920 until his retirement in 1969. Lamar University has several Moore-Method trained faculty and enthusiasts including: Drs. Joanne Baker, Dale Daniel, Jennifer Daniel, Charles Coppin, Kumer Das, Michael Laidacker and Ted Mahavier.

Each of the sixty student participants enrolled in three 90 minute academic courses – one in IBL Math, one in STEM classes in Marine Biology, Environmental Ecology or Ornithology, and one in International Issues and Relations, Chinese, Beginning Sign Language, Group Dynamics, Simulation Gaming and Programming, Psychology of the Criminal Mind and Advanced Creative Writing. In addition, each student had one 90 minute activity class in Drama, Musical Ensemble, Ballroom Dancing, Team Sports, Tennis or Self-defense. All of the classes met Monday through Friday.

Measures

Interest and attitude toward math was measured by a *Math Attitude Scale* adapted from a University of Massachusetts Math Attitude Scale as a pre-post test instrument. Achievement Motivation, Self-Concept and Leadership were measured by a *Leadership Behaviors Scale* developed by Sisk (1987) with sections of questions that addressed motivation, self-concept and leadership as a pre-post test measure. In addition, the evaluator used an open-ended interview questionnaire to gather further information from the participating students.

Results

The results of the students using the Moore-Method IBL on self-concept and achievement motivation are depicted in Table 1. Self-concept was measured by the *Leadership Behaviors Scale* and yielded a pre-test average of 15.67 and a range of 8-20 and a post-test average of 16.19 with a range of 9-20. This increase was significant at the .007 level. Achievement motivation was measured by the *Leadership Behaviors Scale* and yielded a pre-test average of 24.19. The post-test average was 24.67. This change was not significant at the .05 level.

Table 1 : Pre-Post Paired T-tests of Student Change in Classes using the Moore-Method

	Pre-test Mean (SD)	**Post-test Mean (SD)**	**t**	**P**
Self-Concept	15.67 (2.74)	16.19 (2.71)	-2.78	.007
Achievement Motivation	24.19 (3.66)	24.67 (3.52)	-1.85	.067

Leadership is reported in the discrete areas of predicting/forecasting, decision-making, problem-solving, organizing/planning, implementing, and discerning opportunities in Table 2.

The areas of leadership were calculated with Predicting having a pre-test mean of 7.68 and a post-test mean of 7.91, and was not significant (0.97).

Decision-making had a pre-test mean of 16.35 and a post-test mean of 16.38, and was not significant at (0.89).

Problem-solving had a pre-test mean of 12.02 and a post-test mean of 12.26, and was not significant (0.23).

Organization had a pre-test mean of 3.64 and a post-test mean of 4.00, and was significant at .00l.

Implementation had a pre-test mean of 8.33 and a post-test mean of 8.23, and was not significant (0.55).

Discerning Opportunities had a pre-test mean of 3.92 and a post-test mean of 4.23, and was significant at .000.

The lack of significance of many of these categories was due to the small number of questions addressing the different areas of leadership, ranging from one question to four questions. Leadership was also calculated with responses on the grouping of six skill areas and yielded a pre-test mean of 5l.38 with a range of 42-62 and a post-test mean of 53.12 with a range of 35-64. This difference was significant at the .05 level.

Table 2 : Pre-Post Paired T-tests of Student Change in Classes using the Moore-Method

	Pre-Test Mean (SD)	Post-Test Mean (SD)	t	P
Predicting	7.68 (1.34)	7.91 (1.51)	-1.67	0.97
Decision-making	16.35 (2.35)	16.38 (2.43)	-0.14	0.89
Problem-solving	12.02 (2.12)	12.26 (2.14)	-1.22	0.23
Organization	3.64 (1.00)	4.00 (0.94)	-3.44	0.001
Implementation	8.33 (1.36)	8.23 (1.70)	0.60	0.55
Discerning Opportunities	3.92 (0.90)	4.23 (0.81)	-4.19	0.000

Interest and attitudes toward math were measured by a *Math Attitude Scale* adapted from a University of Massachusetts Math Attitude Scale. It yielded a pre-test mean of 30.81 with a range of 14-40. The post-test mean was 31.82 with a range of 20-40, which represented a significant difference at .044.

Discussion

One of the major outcomes noted in *Project Explorers* was the positive growth in self-concept with one student achieving a pre-test score of 8 with a range of 8-20 and the post-test yielding a score of 14 with a range of 9-20. Many students reported feeling better about themselves as a learner, following the project. Positive growth was also noted on the *Attitude Toward Math Scale* with scores moving from a pre-test range of 14-40 to a post-test range of 20-40, and many students reported a more positive attitude toward math. The narrowing of the range reflects the positive growth of the students in attitude, achievement motivation and self-concept.

Another positive outcome of *Project Explorers* was the interest generated in Math and STEM with 50% of the students indicating they were considering a major in Math or STEM and seeking related careers. The students listed benefits from the IBL Moore-Method project:

"I learned to work hard and to be more self-reliant."

"I learned to be responsible and focused.”

"I learned to pay attention to details."

"I learned to persevere and think creatively."

"I made lasting friendships with the other students."

Teachers who lack the knowledge and skills related to open inquiry such as the Moore-Method may have difficulty in facilitating its use in the classroom. The three graduate student instructors had training and guidance from Dr. Mahavier and Dr. Baker. One instructor said the lessons he prepared for three weeks were covered during the first week, and he had to prepare extra lessons. All three of the instructors enjoyed the experience of working with the secondary students and they said they would like to participate again if their schedules permitted them to do so.

In summary, Project *Math Explorers* provided both the instructors and the Lamar University staff opportunities to not only offer an accelerated enrichment experience in IBL Moore-Method Math for the students; but also to provided a safe, caring community that promoted tolerance and respect for diversity. The students represented a diverse population of Asian, African American, Hispanic and Anglo students, a wide range of family income, and a range of knowledge and skill in math. The flexibility of the Moore-Method in meeting the students where they were enabled all of them to be successful. As educators, we continually strive to improve teaching practices and to achieve deeper levels of knowledge. By engaging students and teachers in IBL, we were able to challenge the students to become innovative learners and critical thinkers in a positive learning atmosphere. The results of this project suggest that inquiry-based learning using the Moore-Method can encourage students to be more positive toward math and have a positive impact on their achievement motivation, self-concept and leadership.

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Making Games: STEM Learning in Action in the Gifted Classroom

Harry T. Roman

Distinguished Technology Educator

If you have not been playing any games lately, you may not be aware how interesting and lucrative they have become. They are there for the taking on your smart phones, or your PC/laptop rig at home. Look at all those "shoot -'em-up" sci-fi and conflict games on Xbox and other media delivered platforms.

Companies routinely hire young folks to test their new games; and some companies host contests for young "gamers" to get their hands dirty designing new games, competing for prizes and recognition. Games are big business, and they are likely to enjoy a brisk and profitable future in many different forms.

Want to get some STEM-style creativity boiling over in your class? Try challenging your students to work in teams to create their own games. You don't need to have your G&T students to develop high-tech, computer-based games. Simple board games will suffice to get those creative juices going. I have done this several times in different schools always with the same result – high enthusiasm and incredible commitment to make something fun to play.

Let's examine this challenge from the students' perspective. What STEM-like aspects do they practice with this activity or design challenge?

1) The opportunity to take something that interests them – creating a product they can enjoy again, many times. ***(Raw idea to product. The invention process is put to use to arrive at a finished product.)***

2) The chance to do something totally different where they control the rules and design of the game. There is no right answer, just what they envision. ***(To succeed, student teams must constantly ask questions about what they are doing, playing the game in prototype form, adjusting it to multiple constraints to see it develop and reach a mature level.)***

3) The creativity involved does not stop at the making of the game itself and the rules but extends to the game pieces and ancillary parts as well. (***Many inventors often marvel at how they must see the forest – the product – as well as the trees – the individual components of the product at the same time. Thomas Edison was a master at this. His several inventions covering the light bulb were then backed-up by another 300 patents that covered everything from the electrical wires to bulb sockets, switches, and meters to measure electric energy use.)***

4) An intense team-based experience, where give and take and compromise is learned, in a fun manner. ***(Teams are the most fundamental aspect of corporate problem-solving; therefore, compromise is an important art form to learn in the work-a-day world. Strong friendships, leadership, and management skills can develop from such shared experiences.)***

5) Practicing good written communication skills. ***(Writing up those game instructions is as difficult as writing a new product manual or maintenance procedures for your company's latest new thing. In my estimation, one can never get enough written communication practice. Developing game instructions is a fun way to make this medicine go down!)***

Game-making is close to my heart. I remember spending an entire summer with my best friend, radically redesigning the classic Monopoly© game, writing up rules and designing a new board and associated components. Somewhere deep in my basement archives resides that old game. We learned a great deal about how creativity is an iterative process, requiring many "tunings and tweakings" to make something work. Writing up those game rules was a big challenge, saying things clearly and succinctly so strangers could understand the game's operation. And lastly, we actually submitted the game to a game company … requiring us to learn how the game business worked, how to protect our intellectual property, and write letters to get people interested in our product. I still practice the fine art of game making today, creating and marketing math card games to improve student skills in everything from basic math to trigonometry. Nine of my games have been sold and marketed, with three more being readied for production and sale. I always marvel at how difficult it is to make those card game instructions easy to understand, and the questions my editors always seem to have as we approach the final phases of the game's production. Writing well is hard work – the craft requires lots of polishing or "word-smithing" as they say. Game making is a fun way to make this happen for your gifted students.

In the article that follows, you will see what 5th graders at a local gifted and talented magnet school were able to accomplish with their game designs. In visiting the classes and mentoring the students along the way, I was a big kid once again, remembering that summer 50 years ago when my best friend Lou and I set out to change the game world. I think I shall give him a phone call and re-live that fun!

Game Design for 5th Grade G&T Students

S. Bermeo, **Science Lab Teacher**
C. Brantner, **5th Grade Teacher**
D. Gerdes, **5th Grade Teacher**
H. Roman, Inventor/Retired Engineer

What is described herein took place at a grades 3-5 G&T grammar school – the Hillside Grammar School in Montclair, New Jersey. It was meant to be a warm-up exercise to a much larger team-based design challenge to occur the following academic trimester. This game design activity and the upcoming design challenge are all part of an educational grant awarded to the school to bring STEM based learning into the classroom. The grant was administered by Montclair State University through its PRISM Center, with the funds made available through the Bristol-Myers Squibb Company.

The stated goal of the grant to Hillside grammar school was: "Enhance students' application of STEM skills in a real-life context…develop a unit that involves invention, sustainability, and STEM skills, as well as provides for professional development for science teachers that facilitates collaboration as a professional learning community."

In a larger team-based design challenge, students were to be challenged to design an alternate energy system (sustainability) that could be located in a developing country; so what they learned about team based design would be ramped up to a much larger and more complex inventive activity

Prior to this, science and math teachers in the school attended a day's worth of in-service education discussing invention, creativity, engineering, STEM and sustainability concepts.

The Setting

-5th grade student teams [typically 4-6 students per team] were challenged to create their own game designs.
-No other directions were given. They had maximum freedom to create what they decided upon as a team.
-18 teams created games, and played and demonstrated them.

Setting the Stage

Prior to demonstrating their games in a double period setting, the students were asked how they enjoyed the team venue – what they liked and did not like. The enthusiasm was quite palpable. All wanted to describe what they had done. Here are some paraphrased positive comments about the team experience:

-Really enjoyed the team atmosphere
-Could see each one's ideas in the game
-Felt like they learned more about their classmates by doing this (becoming better friends)
-Enjoyed the socialization as much as designing the game
-Wanted to do more of this type of project/challenge
-Seeing their ideas come to life
-Allowing themselves to be creative.

On the negative side, one universal item emerged. They did not like when classmates were unwilling to compromise or give in to the ideas of others. We did discuss how this conflict could dampen creativity and how this is a natural part of growing up and socialization. For the most part students understood this.

We talked about how many heads on a project are better than one, and this produced a very spirited discussion. All recognized the value of a team for generating creative and plentiful ideas. It was explained that a team can be 10-12 times more prolific in generating ideas than a single person. Students had no trouble accepting this.

We also talked about the concept of diversity, and how it works here. Team members bring different life experiences, subject readings, cultures and interests to a team, enriching its pool of resources. We talked about how engineers and STEM workers thrive in teams and how most companies rely upon teams to generate ideas and invent new products and services. Aiming for diversity on teams and employees in a company is an economic plus for companies.

Students were asked how they view "failure." This can be a sensitive subject, especially in design settings where students may learn that a single, right answer is not possible. First, the answer may be the result of a series of iterative designs that eventually satisfies the entire team; and second, the answer depends on what questions are asked about the design by the team members – where they feel the game design should go. This double edged aspect of design may be both liberating and scary for team members. After all, their entire experience in school is generally associated with getting the right answer. All in all, this did not inhibit the students as their natural enthusiasm for doing something different and having the freedom to create as they decided among themselves won out. But it is something to keep in mind for classrooms where students may have trouble bootstrapping or self-starting.

Playing and Demonstrating the Games

The 18 teams produced a variety of games that were generally in the following categories:

-Modifications of traditional board games like Monopoly© and Candyland©
-Themed games having to do with certain subjects like history, rock-gems and art, and involving some intellectual aspects like questions and points totaled
-Combinations of sports (like hockey and soccer, and skiing and hockey)
-Dynamic games where things moved and players had to score points.

As might be suspected, different student learning styles resulted in different types of games. Some of the games had detailed questions that needed to be answered in order to move along the game board or to score points. Some games involved more sports-minded thinking or even action. One such outstanding example was a game based on alien invaders that had to be destroyed. A tinker toy rotating disk device (hand operated) presented the alien spaceships that had to be destroyed by launching small candy mints at them. Hitting the ships scored points and eventually resulted in winning the game. What was highly original about this game design was the system approach the students used. They designed and built everything from the rotating disk to the candy launching apparatus – even designing the trophies for the people with the most alien kills!

Three teams did not build or make display boards of their ideas; but had detailed diagrams and descriptions of their games. One of the teams created a ramp launching mechanism that could be used to shoot balls into a scoring matrix – not unlike what one finds in the arcade game Skeeball©. Discussion with the team indicated they completely understood the mechanism they were designing. It would allow the end of the launching ramp to be adjusted by the players in order to aim their balls more accurately at high scoring targets. We discussed the math applications of the adjustable ramp end, how it resembled a triangle, and the math involved in all of this.

One team made a computer generated commercial featuring the team discussing the characteristics of their game – a most unusual and surprising aspect of the game design challenge!

When questioned about writing up the rules of the game, most teams had a general distaste for doing this, but realized how important it was so people could learn the game rules. Perhaps it is the general dislike most students have for writing that is reflected here. It was emphasized that in the business world, everyone is expected to be able to write well, expressing their ideas and such for new products their company may want to offer. All communication (both verbal and written) is a key component to one's success in the professional world. If one cannot "sell" their idea to a company's leaders, then it would likely not be funded. Good communication skills are very important.

In one of the designed games, students were able to apply the concepts of probability. In another game, students were able to demonstrate the relationship between a large wheel rotating a small wheel (mechanical advantage, gearing up/down).

Tying in Thomas Edison

Because the school is very close to the Thomas Edison National Historical Park [TENHP] in West Orange, New Jersey, the students naturally talk about him in class. Here is how we brought him into our discussions:

Edison was a tenacious inventor, never discouraged by failure – always learning from it and moving forward. In both his light bulb and storage battery developments, he conducted thousands of experiments before he was able to produce a workable and practical product. His famous utterance was most applicable here for the would-be inventors …. "Fail your way to success."

Several teams were quite active in trying to improve their games, taking notes during play to make it better. Edison was a big proponent of this, always striving to improve the salability of his inventions. Continuous improvement was a watchword of Thomas A. Edison Industries.

Although the students were not instructed to keep invention notebooks or journals of the development of their games, this is going to be required of them in the next design challenge. Edison was noted for keeping extensive laboratory notebooks. In fact, these totaled about 4,000 volumes. Throughout his lifetime, Edison generated over 5 million written documents that have been studied by historians, technologists and scholars.

Conclusion

Team-based design activities are a positive way to engage 5th graders, unleashing great amounts of creativity and team cohesiveness. The teams engaged in this activity all completed their assignments, and responded well when describing what had been done. The teams will be ready for the much greater design challenge that awaits them.

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To Teach, We Need To Build the Course around Principles

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I. Introduction

The Enlightenment began in the 17th century as a revolution against the Dark Ages, the intellectual and economic repression that held sway for a millennium. The consequences were rapid growth in human prosperity, health, happiness, and population. The teachings were that all reality consists of ideas created by people freely formulating arbitrary, consistent, and simple statements along with the logical conclusions verified by statistical analyses of observations.

There is a counter-revolution currently in progress, with many saying that ideas are not necessarily freely created by people, but by God or government. As this spreads, we can expect poverty, suffering and death. We educators have the responsibility to help carry out the principles of the Enlightenment to further advance humankind, that is, their own lives, the lives of their families, and of their country.

President Kennedy understood the message of the Enlightenment when said that the sky is not the limit for Americans, but we must strive to go higher and go to the moon. We must all strive for excellence, to be exceptional, to be as great as we can. Our schools must strive to help students excel, and give the highest priority to the gifted, in the interests of the students and our nation. We must be proud of our achievements, and thereby encourage our students.

How do we accomplish this, when the vast majority of students in our schools and colleges are not gifted? This is related to how we can best teach our university students. Students must be at the Piaget level of abstract thinking in order to teach and explain ideas in the spirit of the Enlightenment. For students who are not gifted, the only thing possible is to explain rote ideas, for example, to show the steps necessary to solve a problem and expect them to memorize and reproduce the steps. If we try to explain things in the correct abstract method, many students will rebel. We need to understand the nature of this rebellion and think what we can do to counter it.

Mathematics is a collection of simple principles and logical conclusions. I stress this to students. This is in contrast to high school, where students learn how to mechanically solve problems, unless they have a teacher who recognizes the fact that they are gifted. A university differs from high school in stressing creative thinking.

Stressing simply stated principles is very successful by various measures.[1] As a scientist, I look for evidence. My students' grades indicate correct understanding, as they need at least 60% to pass. Other professors require 30%; students pass without correctly understanding. This and other evidence show I am a good teacher. There are issues, of course.

This approach is especially useful to teaching gifted students. This is because speaking in terms of principles is more natural to gifted students, rather than simply presenting a large collection of rules and facts.

II. How to Teach by Stressing Principles

All knowledge is based upon principles. By knowledge, I do not mean skills or works based upon emotions, such as music or other forms of art. Although literature is an important part of humanity, here we are talking about knowledge based upon principles, logic, and, for science, empirical verification. Mathematical statements are not true but consistent. Science statements are true to the extent that they are verified by statistical empirical evidence.

A scientific theory is based upon a consistent mathematical system, combined with evidence. Science also includes empirical facts and partial explanations called hypotheses. We need to be careful when teaching science that we do not confuse theories with hypotheses. We need to teach both, the consistent mathematics of theories along with facts and hypotheses. We need to encourage students to try to be creative and to try to imagine alternate theories.

Teaching principles includes explaining *definitions*, both formal and informal. For example, the formal definition of a prime number is a natural number that cannot be divided by any other natural number except 1 and itself. Note that this definition is based upon a previous definition, namely, natural number. An informal definition could be that a prime number is any number that cannot be divided by anything else. For the informal definition, we do not have to specify the exclusion of dividing by one, as it is obvious. Further, we do not have to specify that we are talking about natural numbers, for this is the subject of the chapter. We must know both informal and formal definitions. Textbooks should discuss informal definitions to help students think, instead of writing only the formal definitions, as they currently do.

We arrive at new principles based upon the existing principles. In geometry we start with principles called *postulates*. We then derive *theorems*, which can be used to derive new theorems. We do not have to start with the postulates in order to derive a theorem.

There are only two emotions in mathematics. This is in contrast with music and art, where there are many forms of emotions. One emotion is the good feeling when one understands something. The other is the bad feeling, such as boredom or dislike, which one experiences when the understanding is faulty. I tell students to pay attention to their feelings and to ask questions if they experience bad feelings. Teachers must also pay attention to students' emotions for the same reasons. If students look bored, it means they do not understand.

The correct way to teach mathematics is to start with the principles, properly explaining them, their rationales, and giving examples. Of course, this is not always possible with young people; however, in my opinion, this is the correct way to teach college mathematics. The reason is because this is what mathematics actually is – namely, a collection of principles, deductions from the principles, and examples and problems. We tend not to teach this way, and also students do not show interest in learning this way. I'll discuss below some reasons for this and what we can do to get on the right track.

III. Examples of Stressing Principles when Teaching Mathematics

Examples of teaching, stressing principles of science were given in Aranoff[2]. Let us look at some examples of teaching mathematics. Let us start with the binomial probability formula as Aranoff[3] wrote. If we toss a coin n times, this formula gives the probability for getting exactly x heads. Here are the principles. Each principle is easy, but there are many principles involved, which makes the formula difficult. Look how many bullets we have, where each bullet is a principle!

- We define the set of desired results, and look at its cardinality. For example, if we want to get the probability of getting a head after one toss, the set of desired results is {H}.
- We then look at the set of all possible results. For one toss, this is {H, T}.
- We now define probability p as the cardinality of the set of desired results divided by the set of all possible results. The probability of getting one head is $p = ½$.

- We need to know the probability of getting two heads. This is the product of the probabilities of getting one head twice. This is the principle that probabilities multiply. The probability of the first *x* tosses being heads is p^x.
- We want to get exactly *x* heads. This means we do not want to get *n* – *x* heads. We define a symbol *q* for the probability of not getting a head after one toss. The probability of not getting *n* – *x* heads is q^{n-x}.
- If we get exactly *x* heads on the first *x* tosses, the probability is $p^x q^{n-x}$.
- We may get the heads not on the first tosses. We have to count the number of ways this could happen. This is the number of ways of choosing *x* items out of *n* items, where the order does not matter (discussed earlier in the course). We then multiply our probability by this number of ways, ${}_nC_x$.
- The probability of getting exactly *x* heads out of *n* tosses is, multiplying each probability, ${}_nC_x\, p^x q^{n-x}$. this is our desired result.

Note the sequence. Each step is based upon a simple principle, definition, or previously defined principle. A principle can be simple enough for children to understand. We go one step at a time writing them down. Had we just explained this by writing everything in just a few sentences it would be confusing to students, leaving them frustrated. The extra time explaining it by single steps is very important. Textbooks do not take this approach, and professors probably do not either. This breakdown requires effort. When we fail to break down ideas into the simple basic principles, definitions, or derived principles, as this example shows, we are not fully and properly teaching the mathematics.

An *example* of the binomial probability formula is this. Given families with 5 children, how many families have exactly one boy, assuming the children are randomly distributed in all possible arrangements?

There is another major advantage to breaking things down like this. This permits people to try to be creative, to imagine what would be the case if some of the conditions were different. We can ask what would be the formula if we wanted *x* heads, but not *exactly x* heads. Given families with 5 children, how many families have at least one boy? How many families with 5 children have one boy who is the firstborn? (Answer these questions for homework!)

Let us take a simpler example without all the steps of the above example. Cantor proved that the set of real numbers has more elements than the set of natural numbers. That is, there are more real numbers than natural numbers. This result surprises people, and was very confusing to the mathematicians of the day, as both sets are infinite. The surprise is that one infinite set can have more than another. Again, let us take one principle at a time. Let us first discuss the idea that one set can be larger than another without counting, without the concern with infinity.

I explained this to my grandchildren, focusing on one single simple principle. I put down two piles of candies in front of the girls. I asked which pile had more candies. Geula, 5, said to count the candies. Teferet, 3, said she cannot count past 16. Geula said she can. I said since Teferet cannot count, then we cannot use counting to see which had the most. I said each girl should take out one candy at a time and put it in another pile. They slowly and carefully took one at a time, until Teferet had none left. Geula exclaimed, "I won!"

The children understood that one can determine which of two sets had more elements by matching. Remember, that as far as Teferet is concerned, her pile has an uncountable number of candies. Note that I focused on the one principle of matching, and not letting the other idea of an infinite set to confuse the issue. As children mature, they learn about closure (without using this word). They know that a person can always add one to any number, no matter how large, and still get a number. Children are very excited when they learn this. I remember how excited I was. The set of natural numbers satisfies closure.

A music professor observed my class. During the class, he started thinking of the difficult abstract concept of infinity, and remarked to me after class that music also has the idea of infinity. I commented by saying we were discussing two infinite sets – one with more elements than the other. The abstract concept of infinity distracted him from the simple idea of matching. Students are the same way. They learn something that is, to them, abstract and confusing, and then forget about simple underlying principles. For this reason, we need to write each principle down for the students to see, one thing at a time.

Speaking of one thing at a time, I stress the need to write one thing at a time when doing problems. This helps clarity in thinking and facilitates checking.

In summary, to understand Cantor's idea about infinite sets, we can separate the idea of closure from the idea of how to find which set has more elements without counting. When we separate the ideas, the ideas become clearer. Textbooks do not make this separation, and this leads to confusion.

Let us give a very simple example of teaching with the stress on principles. My 9 year old granddaughter wanted me to explain fractions. I gave the example $\frac{2}{3}+\frac{3}{4}.$ I stated the principle that we can multiply any number by one without changing the number. For the first term, we write 1 as $4 / 4.$ We have a second principle that we can collect similar terms and put them in front of the parenthesis sign. We simplify, which is another principle. The girl fully understood. The next day I asked her about this to see if she still understood and remembered. She did.

Although this sounds so easy, when we say things like this to a college class, it does not always go over smoothly, because students are so used to doing it the mechanical way. Students tend to dismiss talk about principles if they know exactly how to do it mechanically, and, as a result, do not fully understand the principles. We must stress the point it is not how to solve a problem, which may be very easy, but how to understand and apply principles.

Here is another example. Consider a problem from the first chapter of the textbook I use in my mathematics course. A frog is at the bottom of a 20 foot well. Each day it climbs up 4 feet, and slides back 3 feet each night. How long does it take to get out? Ayetam, 10, said 20 days. This illustrates a characteristic of people quickly responding clearly, decisively, and *incorrectly*.

I explained that the last day the frog does not slide back. He looked puzzled, but understood it. Later he was telling others the problem, showing he fully understood it. Sometimes people have a puzzled look on their faces when learning something new. Sometimes they beam and smile when the get the new idea.

This exemplifies the important mathematical principle of boundary conditions. The textbook does not mention this as an example of a very important principle.

IV. Examples of Stressing Principles from Other Subjects

Chess. Consider how beginning chess players and chess masters view chess. Beginners think of the varied possible moves, such as a bishop moves in the diagonal. A master sees the chess board as complex patterns with the goal of checking the king. Imagine a class in teaching chess, where some of the students are gifted. The teacher would demand students pay attention to the individual moves. Obama said to a classroom he visited that students should pay attention. This would bore the gifted student, possibly thwarting his development in chess. A good teacher would explain the goal and patterns and not just the individual moves. It is strange that most people think of individual moves in spite of the knowledge that the goal is checkmate.

History. Here is an example from history. Students learn different events, statements, and dates. This happened, this person made a speech saying, and so on. This bores students, as they say they do not care what happened a long time ago. A better way is to focus on goals. Lincoln had the goal of eliminating slavery. He succeeded, but the cost was huge. Could he have achieved this goal with a lower cost by gradualism? For example, could he have passed a law saying slave families could not be broken up? The idea is to make students aware of the goals and ideas, and to see if they could have thought of alternative solutions. History is not merely a collection of facts, dates, and speeches, but a collection of goals and the decisions people made in order to achieve these goals.

V. Some Challenges to Teachers

Every scientific theory has examples contradicting the theory that represent challenges, resulting in modification or additions to the theory. There were students that failed to appreciate mathematics and to properly understand it. This problem bothered me for a long time. It represents a challenge to the theory that mathematics should be explained by stressing principles.

Since educators are under student pressure to please, and "if the professor makes the lecture like a story, and the students see the patterns, everyone is happy[4]," some educators shy away from principles.

Recently I thought of a solution concerning how to deal with students who refuse or are unable to accept the idea that mathematics is based upon principles, and we need to analyze principles to solve problems. Rider University has a policy requiring professors to have office hours to meet with students. The principle here is that some students require individual attention. My idea is to generalize this principle from the mandatory requirement of professors to have office hours to make student attendance at office hours mandatory, if I ask. I can see issues very early, sometimes as soon as the first days of class, and need the ability to act.

In the past I did not know what to do, and so the problem festered, causing students to rebel. Student rebellion takes many forms, such as absenteeism, disrupting the class, not doing homework, sitting passively, not responding, or complaining to a dean and so harming the professor. Absenteeism is a widespread problem, with various professors trying various things, such as lowering the grade. Disruption is a well-known problem in high school, where teachers can call security. When I realized that some students simply do not do homework, I decided to write in the syllabus that homework is mandatory.

Some students demand that first-year mathematics be an extension of the mathematics they know from high school. They are interested only in rules to mechanically solve problems, not principles. Some are incapable of abstract thinking. Many do not know how to pay attention and learn in class, how to study at home, how to do problems and to check their work, how to study and take tests. The solution to these issues is to spend time giving individual attention.

My personal experience and evidence verifies the statement that students can get considerable benefit from private attention. When students come to my office, I see significant improvement. When I substitute in high school (see Aranoff[5]), I follow the plans, and walk around the room talking to individual students. The students greatly appreciate this. Walking down the halls, I overhear students saying that I really help them understand.

Okay, we see the need and benefits of private time in office hours. Let us look at the details of how this helps the various problems discussed above.

The student who merely wants to mechanically solve problems must understand that if the student does not use principles and is capable of creative generalizations, he would be useless in the workplace, for computers can do whatever is mechanical.

Some students need attention, but are too shy to ask. When we give them attention, they greatly appreciate it and become better motivated.

A student is bored doing homework. I tell the student in my office about my 4 year old granddaughter Odalya. I bought her a card with seven stars. I counted the stars: 1-2-3-4-5-6-7. She then began counting in order, not jumping around. She counted again and again and again. This shows she instinctively knew the need for review in order to learn. As students get older, they forget this important lesson, and we have to remind them that review is an integral part of learning.

There is much more we can say. We can all agree to the important benefits to private time during office hours. There are issues, however, that need to be solved. One is the reluctance to come to office hours. The solution is to make it mandatory by writing this in the syllabus. The other issue is lack of time. Here my suggestion is that students taking courses like mathematics or science have a scheduled free hour called study hall in high school. This free hour should be later than the class, but no later than a few hours. This way when the professor asks a student to come to the office, the student will not be able to say she cannot due to a heavy class load.

A student asks a question in class. I have to answer it. However, others already know this, and so are bored and unhappy. Once we have formal times for study hall, instead of spending class time answering the question, I can invite the student to my office, knowing that student then will not have the option of refusing my invitation. Currently, since I know students will not come to my office, I answer the question in class.

Intellectual development requires quiet blocks of time to contemplate and think about material learned. Personally, I have been very productive in publishing papers through thinking while taking long walks. Physicists of recent generations also took long walks during which they developed great ideas. Students too need quiet time, and the university should make this a formal requirement. The professor should then be able to see when the student has a study hall, and then would know that the student would be able to come.

Dr. Patricia Mosto wrote on her webpage on the Rider University site, "We understand that teaching is a reflective process of dialogue, observation, deliberation and assessment." This reflective process takes time, including quiet time, and so the university should do what it can to insure students have undisturbed quiet time during the day.

In summary, there are several things that should guide a teacher. One is to stress the principles and to build the course around the principles. These principles should be simple enough for a child to understand. Follow this with definitions, logical deductions, examples, homework, and review. The other thing is to carefully observe students for signs that they would benefit from private office time.

VI. Summary

Our educational system is failing to stress principles. A student shouted in class in anger, complaining about the need to learn imaginary numbers. This student did not understand the concept that mathematics is a collection of principles, not of practical applications.

If all that our schools can accomplish is teaching students how to do things, then students are like medieval apprentices. We are failing to install the messages of the Enlightenment.

In order to get this message out, courses must be based around principles. These principles must be very easy to understand, clearly written, and consistent with the other principles and their conclusions. For courses other than mathematics, the course must include discussions of the empirical evidence. The teacher must insure that students understand and appreciate the principles by review, looking at their homework, discussions in class, and inviting students to the professor's office for private instruction. All these activities must be directed to understanding the principles and consequences. Good students, especially gifted students, should be encouraged to think of original extensions of the principles and possible counterexamples.

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[1]"To Educate the Gifted, We Need to Stress Basic Principles," S. Aranoff, *Gifted Education Press Quarterly*, Winter (2009).
[2]*Gifted Education Press Quarterly,* Ibid, p. 3.
[3]*Finite and Infinite Mathematics*, Sanford Aranoff, Amazon.com, ISBN 978-1463692698, p 171 (2013).
[4]*Gifted Education Press Quarterly,* Ibid, p. 2.
[5] "Professors Substituting In High School", S. Aranoff, *Gifted Education Press Quarterly,* Winter (2013).

Aaron Copland (1900-90): The Wide Range of a Musical Genius

Michael E. Walters

Center for the Study of the Humanities in the Schools

". . . .Ultimately it comes down to concentrating and enjoying. Copland invites us to listen, rather than just hear." Leonard Slatkin (p. x, Aaron Copland: America's Musical Voice in **What to Listen for in Music** (1985, New American Library) by Aaron Copland.

Aaron Copland was not just a composer of music – he was an innovator, educator and conductor who had one of greatest creative ranges of any American artist in the twentieth century. There was Aaron Copland who wrote symphonies and special compositions for specific instruments such as the clarinet. He combined elements of American culture that included ragtime, jazz and folk music into complex symphonic compositions. There are also sociological and political aspects of his music. For example, he turned the American cultural experience into a dynamic musical format, and many of his compositions are icons of American culture. Among these iconic musical forms were the ballet scores for *Billy the Kid* (1938), *Rodeo* (1942) and *Appalachian Spring* (1944). His famous patriotic scores were *Lincoln Portrait* (1942) and *Fanfare for the Common Man* (1942). Copland composed music for noteworthy American films – *Of Mice and Men* (1939), *Our Town* (1940), *The Heiress* (1949) for which he received an Academy Award for the most original musical score, and *The Red Pony* (1949). As an educator of musically gifted individuals, he was involved with the Tanglewood Music Festival located in the Berkshire Mountains of western Massachusetts. Among the individuals he mentored there was Leonard Bernstein. Copland also wrote an influential book on music education, **What to Listen for in Music** (1939, McGraw-Hill), which was transcribed from lectures he gave at the New School for Social Research. During the last twenty years of his life, he stopped composing and became a guest conductor with symphony orchestras in the United States and Europe, where he performed contemporary works by American composers.

Copland himself had many influences and mentors. First, was the liturgical music of his local synagogue in Brooklyn, New York. His mother, father, grandmother and siblings were early supporters of his musical development. At a family conference, he received support from his mother and father to receive formal training in Paris. He studied with Nadia Boulanger (from 1921-24) who was the foremost European expert on musical composition. She was a hard task master but encouraged her pupils to follow their creative endeavors. In this regard, she said that Copland was her best pupil. During the 1930s, he traveled to Mexico City to work with his friend and colleague, Carlos Chávez. His famous composition, *El Salón México* (1936), was inspired by his interactions with Chávez and Mexican folk music.

Copland had an amazing synergy with many aspects of American culture. His movie scores were inspired by interactions with authors such Thornton Wilder and John Steinbeck, and he developed synergy with film directors and actors. He had productive relationships with highly creative musicians like Benny Goodman who commissioned him to write a Clarinet Concerto (1948). This synergy represented his ability to successfully interact with different aspects of American art and culture. Other examples are modern dance with Agnes de Mille and Martha Graham, and the Group Theater as represented by Clifford Odets and Elia Kazan. His wide range of interests covered the entire gamut of American artistic and creative endeavors. He was one of the major innovators of his time and place that all gifted students should study and learn from.

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