**Numbers serve to discipline rhetoric. Without them it is too easy to follow flights of fantasy, to ignore the world as it is, and to remold it nearer the heart's desire**.  Ralph Waldo Emerson

**A Multicomponent Approach** to **S**TEM **Education (AMASE)**

Joseph E. Johnson, PhD

jjohnson@sc.edu © August 29, 2022

**Introduction and Overview**

 Our central hypothesis is that the instructor presents lectures, notes, and other materials to enable students to answer questions and solve problems that reflect mastery of the material posed to them, and likewise, the correct responses by students are an exact metric of their achievements of the goals and objectives of the course. We will present a means that will optimally achieve that objective. The infrastructure for STEM education that we propose uses the best of modern technology to empower the instructor to achieve the maximum in education with the minimum of both instructor and student effort but does require an initial investment in materials. Science, Technology, Engineering, and Mathematics (STEM) differ from other subjects in that most questions are problems with numerical solutions as opposed to language, history, and the arts and thus allow automated grading (if dimensional units are managed as our (MN) software does).

We require that the instructor has a laptop with wireless internet connectivity allowing connections to individual smart student devices (laptops, tablets, or phones) using the Google cloud to manage data and Google Forms to support the transmission of questions to students and to receive the student’s responses (called a Student Response System – SRS). Grading is done automatically both by instructor specified correct response, and additionally by our Artificial Intelligent (AI) software that separately determines the optimal response. Results from both systems are displayed in a matrix form on the instructor’s device with the columns labeled first with the questions, and correct response, then the class grade, followed by the student responses. The rows are labeled first with student id, then name, then the grade which they have achieved at the time of viewing. Question number “0” always takes attendance with the time of arrival when the student signs in with password and seat number. Two or three questions are asked during each class allowing the instructor to determine the extent to which each student is mastering the material. By knowing the seat number, the student can be addressed by name from the first day on. When exams are given, and homework is submitted, the same display is used allowing the instructor to monitor all student progress with exact metrics including the capture of the time required for each response. All grading is automatic both for numeric and text responses and the date-time of submission is captured for each response. There is to be a course web site that is to contain a syllabus with dates indicating the material or exam to be covered on each date. Past exams are posted on the web site to be used as homework and to inform the student of the type of exam and level of performance expected. The instructor will put the class notes for the year on the server for the students to print and to use to follow the lectures. There will be previously recorded video lectures that correspond to the notes. A required text will also be listed along with other web available references.

Justifications: many students come to class and rapidly try to transcribe the instructors lecture, but this distracts from their full attention, and they often end up with errors in their notes. Also, students may miss a lecture due to illness, or other issues and the video lectures, notes, and text can be used instead of the live lecture and as a review for difficult material as needed. There will also be a required text that will also serve as subject backup as well as an alternative method of explanation of concepts. Many students are not fully prepared, have challenges in different forms, and are from underserved groups. The SRS can exactly identify these students and the challenges that they face and thus allow the instructor to provide the necessary assistance and support. The instructor can exactly monitor student responses and grades and thus know exactly to what extent mastery is being achieved. Students receive their daily, homework, and test grades with no delay giving instant reinforcement. Special (MN) software evaluates mathematical expressions submitted with automatic unit conversion for responses that begin with a “=” and for complex numerical expressions. Extensive analytics are available to the instructor for analysis of the class performance and for each student’s progress. Furthermore, this analysis identifies both challenges that different students are having as well as the performance of gifted and talented students.
 We have fully developed a one year introductory university or high school AP physics course: (a) class lecture notes, (b) video lectures on DVDs, (c) 3 years of exam problems, (d) fully operational MetaNumber Python code, and (e) identified text books. We seek to use the Google or Microsoft forms software to (e) rebuild a web Student Response System (SRS), and (f) to rebuild our AI grading and analytics software for deployment at USC and a local high school AP course for proof of concepts.

**Details of the Couse Components**

1. **Proposition I: Academic Objective1**:

 The exact goals and objectives for any course are explicitly stated by (a) the questions & problems posed to students and (b) their grades that result from the evaluation of their responses on quizzes, exams, and other questions which measure the extent to which each student, and the class as a whole, accomplished those goals and objectives. The listing of all questions and problems given to students show exactly what they are expected to learn, and the student responses show exactly the extent to which they mastered the questions with well-defined numerical metrics showing the credit given.

1. **Proposition II: Motivational Objective2**:

 A student’s motivation, determination, passion, and drive to succeed, is reflected not only in their in their academic achievement but also in responses to questions on life goals, professional ambitions, and “life journey”. An instructor has a responsibility to explain the purpose and value of the course material for later success both in professional work and in the vast collection of skills needed in life as an adult.

1. **Materials Needed3:**
2. A syllabus for topics to be covered, course requirements with dates and credit to be given for tests, attendance, and other work.
3. Textbook(s) to serve as a reference to augment class presentations as well as a list of other course resources.
4. Course video lectures preferably created by the instructor (or already online) along with class notes the instructor follows in class.
5. Past tests and exams to serve as homework to provide a level of expectation for students and to help them prepare for tests.
6. An internet linked computer, tablet, or phone to transmit questions and to capture responses input by students (Google Forms)
7. A cloud server to store and manage data from instructors and students along with analytical software (Google Forms with Python)
8. Questions exactly reflecting the instructor’s set of course objectives and goals. Responses exactly measure the success obtained.
9. **Analytical Software on the Server Using Google Forms and Python Software4:**

 The Google Forms software will serve to distribute questions and collect and grade student responses. Capturing the date-time of entry allows the software to compute the time spent on each problem. This data is displayed in a matrix of responses for homework, quizzes, and exams, along with attendance, demographic, evaluation, & opinion data captured in summary spreadsheets. The first row will give the questions & credit given, then the next row gives the correct responses, and the next row will give the average class grade on that question. The first column will give the students ID#, the second their class rank, and then their name, and then their grade. The matrix is to be filled in with actual responses (and time to respond) or optionally with just the credit awarded.

1. **Artificial Intelligence (AI) analysis of questions and class responses5:**

 Our artificial intelligence (AI) system will also estimate the correct responses and grade students in a separate matrix. It will also compute the difficulty of the question and flag questions that are too difficult or ambiguous. This data can be used to evaluate the effectiveness of the instructor. Our AI can automatically grade both numeric and single word responses. It can grade longer responses using an AI model of obfuscated peer evaluation where class peers receive grades for the accuracy of their assessments of other student’s responses.

1. **MetaNumber (MN) Software on the Server6:**

 Our MN software can perform all arithmetic and logical operations on numerical values with or without attached units of measurement and meaning. Any response beginning with an “=” sign will initiate an evaluation of the expression tracking both input expressions and output results with automatic conversion among over 700 units, prefixes, and scientific constants. Results are returned in metric or any desired units. Since MN can evaluate all Python expressions, it can be utilized for all math and logic usable from the first grade to PhD research environments. Extensive other features are available such as our extension of the metric (SI) system to seven new fundamental units for social science, economic, environmental, and information theory computations.

1. **Conclusions7:**

 Our system design can operate behind the scenes to do everything except correctly guide student achievement by selecting the notes, videos, exam questions, class lectures, and general materials for the class. These must be done by the instructor whose most essential job is to select those questions which constitute the goals and objectives of the course. Extensive analysis of student’s performance will be available to the teacher as well as an analysis of the quality and effectiveness of the questions posed.

**Discussion of System Features:**

1. **Proposition I: Academic Objective:**
	1. Usually when one is asked for goals or objectives, a long discourse follows that attempts to describe rather vague notions such as the actions that teachers take such as “explain”, “provide”, “describe”, … how they are going to teach and the methodology or description of results that they seek to achieve such as “understand”. We here suggest a specific methodology in the Materials Needed section including 1. Syllabus, 2. Textbook with supplementary references, 3. Course Video Lectures that follow explicit Class Notes, 4. Past Tests and Exams. 5. Then a “smart web linked device” such as a laptop, tablet, or phone is to connect to 6. a class cloud computer that will allow the instructor to transmit posed questions, quizzes, and exams where students submit responses that are automatically graded against given and estimated responses. The quality of the instructor’s questions and the student’s responses constitute the exact goals of this course in extensive detail
	2. The Syllabus lets students know exactly what is to be covered in each class, when exams are scheduled, material they cover, and how grades are weighted. The textbook, references, online video lectures, and class notes are critical reference material for students. Past tests and exams allow students to properly prepare. Finally, the student’s smart device enables them to respond to the instructor’s questions for course credit. At sign-on at the beginning of class, attendance is automatically taken and tracked along with seat #.
2. **Proposition II: Motivational Objective**:
	1. The student response system also allows students to enter their professional career ambitions so the instructor can relate the importance of the class material to their future employment and life goals. It is a means of communication between the instructor and students for ungraded opinion questions and interactions that would otherwise be difficult with multiple students. Students will also be asked to evaluate different components of the course and the instructor which can lead to future improvement.
3. **Analytical Software on Server Using Google Forms and Python Software:**
	1. By capturing the time of entry of each response, the system can compute the time elapsed since the last entry thus giving the time required for a student to respond to each question. The average time required for the response to each question is one measure of the question’s difficulty while the second measure is the percentage of the class that gets the question correctly. Viewed individually for each student with their response, it gives the instructor insight into the challenges of each student leading to special assistance.
	2. At the beginning of a course, instructions should be given to students on the features of the system and its operation. At this time students can practice by entering their essential profile information and by also any pretest related to prerequisites in background material. The data entry information can be used as a reference for data keying speed, data entry error rate, and metrics that assess the operational level of the student that can be used by the system to correct for individual student challenges and for underrepresented groups.
	3. This class entry period can also prepare the instructor for the features of the system’s response displays and analytics. The spreadsheet display of the student responses, grades, question analysis (% correct, avg. time, and other question analytics has questions organized in columns with students listed in rows. The upper rows list the question numbers, questions, and associated metrics. The leftmost columns give the students ID#, name, and performance metrics on the questions.
4. **Artificial Intelligence (AI) analysis of questions and class responses5:**
5. The AI software estimates the probability of correctness of each response to each question and is given in another spreadsheet of the class’s responses. The AI’s selection of the correct response is the one that is most probable, but if that probability is not sufficiently high, the question is flagged as being potentially too difficult, ambiguous, or misleading in some way allowing the instructor to make future corrections or changes in question weighting (automatically suggested by the software). The spectrum of responses with their probabilities of correctness are important to understanding what is being understood or misunderstood.
6. The AI software can also identify potential cheating from the student seating chart as is included with the test data as question “0”. This is done by comparing highly unlikely erroneous responses with seating proximity and other metrics.
7. **MetaNumber (MN) Software on the Server:**
8. Except for pure numbers, (a) numerical value is meaningless unless it has (b) units of measurement, (c) its level of accuracy (uncertainty), and (d) its meaning as represented in descriptive metadata all attached. We have developed software for evaluating expressions that have all four of these items attached in each object which we call a MetaNumber (MN). The MN software will perform all arithmetic operations with these MN objects while automatically managing unit conversions, uncertainty analysis, and tracking of the meaning of values that are combined. This tracking is done with a log of submitted expressions along with the resulting simple MN result. The software has over 700 units, prefixes, and scientific constants that can be used in the expressions. The output defaults to metric (SI) units but if “!units\_desired” follows the expression, then the output is given in those units.
9. For Example: What is the acceleration of a car that goes from 15.3mph to 74.22mph in 1min and 4 seconds and give the answer in units of acceleration due to gravity? Enter> ((74.22\*mph – 15.3\*mph)/(1\*minute + 4\*sec))!ag. Another example is to add: (14.3\*ft + 18.3\*yard -75.2\*inch) and the answer will by default be returned in meters.
10. The software also allows the computation of any algebraic numeric expression without units so that students can enter expressions in response to a problem using it as a calculator. Python expressions in logic can be evaluated.
11. Thus, this software allows the student to submit the correct form of their calculation on one line and the software will do all the work that would take half a page of calculation. The added feature is that an instructor can see what mistake the student is making because they can optionally see the exact input expression.
12. MN is based upon the metric system of the following basic units: length in meters: *m* or *meter*; time in seconds: *s*, *sec*, or *second*; mass in kilograms: *kg* or *kilogram*; electrical current in amperes: *amp*, *a*, or *ampere*; temperature in kelvin: *k* or *kelvin*; and luminosity in candelas: *cd*, or *candela*.
13. We have extended the metric system in MN by seven new fundamental units: quantity of information: *bit* or *b*; processing units of floating point double precision operations or FLOPs: *flop* or *op*; a person (living human): *person* or *p*; a unit of value as the U.S. dollar as: *dollar, usd, d*.; baryon number: *bn*; lepton number*: ln*; and a quantum of anything as designated in the associated metadata (an orange, a table, or a galaxy): *q.* Notice that MN always uses the singular form in lower case for units to avoid certain conflicts and ambiguities.
14. MN also contains all prefixes and one can enter 3.5\*kilo\*mega\*micro\*mile as well as 33\*dozen. It also contains all of the primary scientific constants such as the speed of light c, Planks constant, h, the Stephen Boltzmann constant, bc.
15. MN also allows users to create private tables (spreadsheets) of values such as the properties of the chemical elements or the values of all other currencies at a given time for financial conversion. These are accessed in the format: “TableName\_RowName\_ColumnName” and can be used in that form in any calculation. Other features and aspects of their use are contained in the MN home page section of the course home page which also has all available unit names sorted by type such as length, time, and energy.
16. **Conclusions:**
17. It is an important aspect of this design that all grades are computed automatically whether from supplied correct answers or from AI optimized answers. Our AI method of using random class peers to give credit (0 to 10) for extended responses is computed automatically. This makes the system neutral and immune to bias and discrimination in any form, a feature that will make many students much more comfortable.
18. There is a tendency for instructors today to assign inflated grades such as giving all their class an “A”. That is up to the instructor and the school and district policies. But this system will show exactly the percent achieved along with each student’s class rank. We believe that it is important for every student to understand exactly how well they are performing relative to their peers and to know that there is no favoritism in grading. Also, it is an extreme disservice to any student to constantly get high marks that they do not obtain naturally. Rather the system here proposed, identifies everyone’s success and weakness and opens the door for additional instruction and work to make up identified problems. This way we can eliminate disparities and persistent inequalities.
19. We seek to implement our design of this system and test it in multiple domains of education: K-12, University, and eventually corporate training.
20. **Historical Motivation – Make Learning and Teaching as Easy as Possible**:
21. **Syllabus:** The first thing that I put on the course home page was a course syllabus that gave the schedule for topics in lecture, four exams & final exam and homework requirements. This also covered the required textbook and how the final grade would be computed.
22. **Past Exams**: Next I put about two years of past exams on the course web site so that students could practice for exams and knew the exact expectations for the course.
23. **Homework**: Sometime later, I used these exams as required homework that had to be turned in for grading.
24. **Textbook:** There are perhaps a dozen excellent texts for introductory college courses and the best ones are truly outstanding, well written, with excellent color graphics and images. But they are massive and overwhelming having about 1,000 to 1,200 pages. The student feels overwhelmed. The text is very useful for reference, so it is required.
25. **Class Notes:** I decided to condense the best four texts into a set of lecture notes that contained every critical term and its definition as well as every core equation along with the associated scientific constants that it contains. I basically condensed each chapter of about 50 to 60 pages down to about 2 typed pages. These were refined over 2 or 3 years as I used them for lecture notes. Then I put them on the course home page so that everyone could download them and print them out. They are the core of the course. One of the main reasons is that many students come to class just try to write down everything that the instructor discusses – they can’t do it and they did not hear what I was really saying because their attention was diverted. And when they begin to “cram” for exams, it is a disaster because their notes contain errors and are hard to read. This way, the correct definitions and correct equations are typed out for them to follow as the lecture proceeds and since they have printed them out, then the students can just make a few notes on those pages and listen to the lecture!
26. **Course Video Lectures (CVL):** As technology advanced, I decided to make a complete series of video lectures and put them on the web. Some students may miss some of the lectures because of illness, jobs, or other issues, and this way they can keep up with the class. Also, especially for the more challenged students, and those with poor backgrounds, they can play the lectures several times as needed. In later classes, I required students to watch the lecture units for the next class ahead of time and make notes on their printed class notes. Then when they came to class, they had already seen the essence of the lecture and I could delve more deeply into the subject as well as answer questions that they had identified.
27. **Student Response System (SRS):** Still later as “smart” phones, tablets and laptops were able to log onto the web in class, (as the University had wireless connections over the whole campus), I realized that I could transmit questions or problems to students during class and capture their responses. I worked with a programmer, and we built a classroom response system that allowed me to ask 2 or 3 questions during class to see how many students understood a topic. Then later I used this same system to give exams and to collect homework via the internet. I then made question “0” each day “What is your seat number?” and the response not only showed me the name of each student and where they were sitting but also took attendance which was required. For the first time I was able to lecture to 30 up to 340 students and address each student by name and see, in a matrix on my screen, the responses that everyone gave. I made attendance, daily questions, and homework as well as the exams all a part of the grade. We here will rebuild the SRS in Google Forms.
28. **MetaNumber (MN)**: During these decades of teaching, I realized more and more that about half of the errors that students made were due to unit conversions in the equations – a laborious tedious process that perhaps could be done by a computer. Over time I devised an algorithm for adjoining a numerical value to its units, uncertainty, and descriptive metadata and designed a program that would automatically convert units and track the computations in a log. Originally, I programed this in the Basic language on my PC but later we put this on our server so that students could access it online when entering the response to a problem. This was highly successful, and it allowed the students to concentrate on the concepts involved and not the details of unit conversion. This is like how we no longer require students to do arithmetic with pen and paper but allow the use of calculators which now are contained in their phone! The program would also catch errors such as when incompatible units were added or subtracted such as 2 gallons + 5 meters. Over the years I improved this program and more recently extended the foundational units of the metric system to include 7 new units for information theory (bit, byte, flop..) and socioeconomic problems (a person and value as measured in US dollars), then finally two more for isotope and ion identification (baryon number and lepton number). I presented this at a national meeting of the American Physical Society. The system now has over 700 units, prefixes, and core scientific constants. I have now rewritten the program in Python software and continue to expand its functionality.
29. **Automatic Grading with Artificial Intelligence (AI**). The last component of teaching is the problem of grading all the responses. I originally used mark sensor forms that were computer graded by the University. My research in information theory designed a collection of AI modules that could grade the simplistic multiple choice responses. But for obvious reasons, the actual answer, whether numeric or text, is far more informative and does not allow guesswork. I have now extended the algorithm to work with general numerical responses and even short answer text material. It is based upon some rather complex equations in probability theory. The software estimates the scores of each student then uses them as probabilities for “voting” for the correct response. The system constantly iteratively solves the complete set of non-linear equations and optimizes the grading. We are now programing this system.
30. **Proposed Plan Overview:**
	1. Create the system web page with instructions, instructor and student roles, and PW login,
		1. Create the Student Response System in Google Forms on a Google web server.
		2. Load Introductory Physics as a test system and operational example (videos, class notes, exams).
	2. Move MN to server with access from the response entry when preceded by a “=”
		1. Improve MN features
	3. Design and implement the AI system for automatic grading.
	4. Test system with both 12 grade AP physics and university freshman honors physics
	5. Expand system to other K-12 and university freshman courses

**Special Needs Issues:**

**Encrypted Identification of Need (EIN)**

1. Marginalized and underrepresented students often are dealing with adverse circumstances: lack of physical and mental health care, lack of adequate food, lack of safety either in their home where abuse may occur or in their neighborhood where there are threats of different forms. Things normally taken for granted such as adequate clean clothing, regular meals, personal hygiene infrastructure, and many other circumstances are not reported from embarrassment or fear of retribution. Mental health issues have greatly increased during the isolation of the COVID lockdowns and physician’s offices now are taking a simple survey of patients with ratings for responses 0 to 10 about depression, anger, hopelessness, and other conditions. The survey should be given to ALL students as even those who are successful can be dealing with adverse circumstances. A special confidential phone number can be given to the class and students can be counseled on personal problems without giving their name.
2. Consider this SRS educational environment, where each student can confidentially send responses to the secure cloud server to register concerns about their well-being (physical health, mental health, safety, lack of infrastructure- food, housing, and abuse/bullying) in a simple survey. The data would be treated statistically, and no identity could be traced to the student. A private phone number could be provided so the student could confidentially speak with a school health professional about their circumstances. Such an opportunity to seek help could truly help the underserved and marginalized student and in fact all students.
3. It is also important also to identify the gifted and talented students. Special projects can be given to these students, so they do not become bored. These students also may suffer problems with their environment and their determination to succeed in spite of adversity needs to be recognized.

**Instructor Evaluations:**

1. Another sensitive topic is that of instructor evaluations. It is natural that instructors do not want to be evaluated and at most allow a rating by students of simple questions such as “Did you enjoy this course?” and “Did you find it profitable?”. Knowing that these are the primary means of evaluations from a student survey and knowing that their job is on the line results in a popularity contest where they seek to be well liked by students which is not the core issue but is important for learning. Assessing whether an instructor is achieving the goals and objectives of teaching STEM courses is very important and can be cast in ways that can help instructors realize their shortcomings and know that the staff, other instructors, and administrators are there to help them improve.
2. The AMASE system metrics includes powerful means to evaluate instructors:
	1. The primary evaluation by administrators is to look at the course objectives: (a) What is the quality and level of the questions and problems that are being asked and (b) how well the students have been able to answer the questions. Such evaluations should be done in the same manner as the evaluation of students by having the appropriate technical administrative staff do this using the SRS. This is the core of the issue as to whether they are achieving the goals and objectives of the course.
	2. The second evaluation for administrators is to evaluate the (a) syllabus and class notes on the web, (b) the online videos made by the instructor, (c) the results of the evaluation by the students (which should be required, and which should keep student identities obfuscated, and (d) the past exams that are to be used as homework and the success rate by students in answering the questions. The homework is basically a “take home test” and complements the student performance on true exams.
	3. The third evaluation is done by the Artificial Intelligent software where it identifies questions that are ambiguous, too difficult, or too simple, and questions that do not pertain to the core material. Such questions can be identified as those which are not answered correctly by the best students. The software contains exacting metrics to measure such aspects. It can also measure the time taken to answer the standard questions and compare this to previous classes on the subject.

**What has worked well for me in teaching:**

1. First, I believe that it is critical to base decisions in concrete metrics that measure exactly what the student is learning and not learning and some indication of what mistakes they are making. This can only be achieved by (a) presenting material, then (b) testing the student with well-formed problems and questions that can verify their comprehension. This must be done with a SRS so that one can look at their grades to see what they are mastering, and when they are in error to look at their submitted erroneous responses to understand their mistakes. (c) Then to ascertain whether this was a fault of mine in the presentation (which would be discernible when several students had the same errors and misunderstanding) or the students lack of effort, extenuating circumstances, or lack of adequate preparation for this course. In the first case where the fault is mine, I try to alter the presentation and explain things a different way or use alternative materials. The SRS is ESSENTIAL because it allows me to collect keyed responses that are easy to read, and it is easy to manage the data with analytics – an impossible task with poorly written material on hundreds of sheets of paper that do not allow computer analysis. In the second case when the student has a lack of effort, I try harder to inspire the student and explain why they need to master this. In the last cases of extenuating circumstances and lack of prerequisite knowledge for the course, I try to head this off by using the SRS to ask preliminary questions on the student’s background at the beginning of the course. If they do not know algebra, it is impossible to teach them calculus, so I encourage them to drop the course and master the prerequisites. Also, by polling students with the SRS, I can identify other extenuating problems the student is having and meet with the student to seek an optimal solution. In conclusion, proper testing with SRS can uncover both my exact inadequacy in teaching and their exact lack of comprehension in learning.
2. Second, I constantly try to motivate the students by explaining why each concept is important with everyday examples. When I discuss heat transfer and explain that it “dead air spaces” in insulating materials will prevent both conduction and convection of heat from inside a house to the outside. Recently I was explaining why in my old house we use shear curtains on all windows because they let light in, increase privacy, and most of all reduce our heat bills by insulating the windows. I had one person come to me and thank me for that explanation because they had been trying to talk their spouse into having shears put up. When we discuss kinetic energy, (KE = (1/2)mv2 ), I explain that in a car accident if they are going twice the speed then there will be four times the damage and the probability that they will die! I do the same thing for all of my subjects and interject ways they can save money or understand the world around them. I make a great effort in trying to instill passion for learning and curiosity for comprehension.
3. Third, I make a great effort to create an environment where it is easy for students to learn. I typed up the exact class notes that I use in class that contains the essence for excelling in the course with every equation with a worked example and every term exactly defined. I also created tutorial videos that covered every topic in the class notes in units of about 10 to 15 minutes of talking about a particular coherent concept. That way they could review a specific concept without spending a whole hour on it. Next, I posted my last two years of exams and required that they work one year as homework prior to the associated exam. This way they knew exactly what to expect in the testing. All of these items were on the class web page for them to download and study and the homework had to be answered online by 24 hours before the associated exam. That way they had one day to study and properly review their notes.
4. Fourth, by using the SRS to collect GRADED daily questions, homework, and exams, I am able to grade these and return their grades to them within 24 hours or usually less so that they know exactly which questions they missed, how they missed it, and what the right answer was. Very rapid feedback is essential to motivate students.
5. Finally, the most difficult thing to teach is a passion for knowledge. Passion and curiosity are the energy that drives one to master knowledge and to truly understand to the maximum depth. I give them examples of my research in physics, mathematics, computer science, and information theory. I tell them what drives me and how I solve very hard problems that sometimes take years or decades of work. I try to share my energy and excitement and passion for problem solving in my in-person lectures.

**JEJ Notes**

1. NSF seeks proposals to address “persistent and vexing problems in STEM education:
	1. Disparities and persistent inequalities:
		1. At Risk, Underrepresented, and Challenged students are identified within the first few days based upon initial testing of math and science correlated questions and past courses in math and science.
		2. All underperforming students are continuously tracked and both shortcomings and possible solutions are identified. Daily class questions and homework responses are used to identify how to best guide the student
	2. Understanding the impacts of remote instruction on all students:
		1. The system is fully operational for both distance and classroom instruction.
		2. Utilizing complete course material online, we can compare functionality between remote and classroom performance.
	3. Aligning curriculum with the work of the future and studying its effects
		1. The system also lays a foundation for corporate training and instruction.
	4. Grappling with AI and other advanced technologies for STEM leaning.
		1. The system incorporates extensive AI analysis of continuous daily, homework, and exam responses of students
2. USC Proposal Emphasis Seeks:
	1. Proposals that highlight communities of practice
	2. Improving elements of the STEM learning ecosystem
	3. \* Conduct discipline-based education research (DBER) to extend knowledge of successful and effective teaching methods through communities of practice (CoPs)
	4. \* Secure consistent eternal funding to update and increase professional development opportunities for science and mathematics instructors.
	5. \* Establish a nationally renowned Center with opportunities for science and mathematics instructors to grow in their pedagogical methods.
3. Current grants:
	1. Sean Yee: $180K: Collaborative Research: Improving the Preparation of College Mathematics Instructors to Implement Student-centered, Inclusive…
	2. Katherine Ryker $93K: Exploring How Geoscience Inquiry Labs Influence Graduate Student Teaching Beliefs and Undergraduate Student Learning….