AC 2012-3344: PREPARING MIDDLE AND HIGH SCHOOL STUDENTS FOR CONDUCTING POSTSECONDARY ACADEMIC RESEARCH

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Abstract

Recent times have shown a remarkable increase in focus towards teaching science, technology, engineering, and mathematics principles both within and outside the classroom environment. Collaboration amongst academic researchers and educational practitioners has yielded exceptional opportunities for students to increase technological literacy through participation in structured formal and informal learning activities. This paper outlines a resource for students to display their creativity and independent learning skills by presenting a journalistic approach to publishing student-initiated research projects. Comparable in format to professional technical journals, the establishment of a peer-reviewed, online and open-access journal geared for the 7-12 grade audience is presented. This concept is currently being explored within the Springfield, Illinois public school district, coupled with the organization of a biannual workshop dedicated to teaching a systematic and ethical approach to performing academic research. Future performance indicators are discussed for capturing the effectiveness of this project-based learning methodology, and to show how this method might help students realize the significance of today’s challenges, understand the use of a systematic approach to problem solving, and create a pathway for achieving their academic endeavors.

I. Introduction

The future welfare of the United States relies heavily on the intellectual capabilities of its population, to become a worldwide leader in innovation, provide sustainable solutions for the global environment, tackle economical, health, and energy concerns, and extend the technology horizon to realize undiscovered capabilities. The past and present generations of scientists, engineers, and mathematicians have made, and are continuing to make enormous strides in propelling the human race through industrial, technological, and social revolutions, while educators are striving to establish new learning techniques to capture our youth’s enthusiasm and guide them through the next phase of innovative solutions.

On March 3, 1863, President Abraham Lincoln signed a congressional charter founding the National Academy of Sciences (NAS) for the purpose of serving the government to “investigate, examine, experiment, and report upon any subject of science or art”.

This enactment was catalyzed by the outbreak of the civil war, when the number of military warfare inventions submitted by private citizens to the government increased considerably. In today’s increasingly complex nature of terrorist threats, new strategies for preventing malicious attacks are of great importance, particularly those involving research surrounding the advancement of technologies designed to detect threats (e.g., improvised explosive devices) and intent (e.g., behavioral attributes). Likewise, future environmental disasters may transpire if the emission levels exhausted from coal burning power plants and vehicles, among others, are not significantly reduced. To address these and other problems of national and global concern over the long term, it is essential that our youth are aware, understand, and become educated about these issues by addressing these real world scenarios all whilst being taught the existing school curriculum.
The United States government, as well as governments of other foreign countries, realize this growing concern, and consequently, on November 23, 2009, the White House Press Secretary announced the creation of the “Educate to Innovate” campaign (in response to a call made at the NAS) through which President Barack Obama is “committed to making the improvement of STEM (science, technology, engineering, and mathematics) education over the next decade a national priority”. Here, partnerships between industries, foundations, non-profit corporations, and science and engineering societies are asked to contemplate new methods for motivating our youth to attain academic degrees in STEM fields. Also in 2009, the President’s Council of Advisors on Science and Technology made several recommendations for improving STEM education in the United States. These recommendations focused on improving the quality of education by preparing the teaching workforce to instruct students on acquiring the necessary skills for building “a strong foundation in STEM subjects”, and inspiring students to be “motivated to study STEM subjects” throughout their academic life and careers. Further spurred by President Obama’s “Change the Equation” campaign in 2010, STEM education continues to be explored through various avenues, including research in academia, museum programming, and competitive events.

The consensus amongst educational practitioners indicates the future of K-12 education to be strongly technology-driven, particularly in the use of cyberlearning techniques. Presently, many university institutions offer online courses, while a subset of these institutions provide the opportunity for enrolled students to earn online degrees. Curriculum designers can, and most likely will, adapt this web-based learning technique to K-12 education in some form, through the creation of digital instruction materials and interactive software, with particular effort focused towards the use of tablet computing platforms. By creating a digital resource network of information and learning materials, STEM educational practitioners, policymakers, researchers in academia, and industrial partners would have the ability to contribute multifaceted aspects and real-world examples depicting modern technological practices. Evaluation of the popularity and success of these digital resources can be performed by monitoring website usage statistics to provide valuable feedback for establishing the redesign or refocus of the digital content and presentation on a continual basis, while surveys can be offered to students and instructors to gain their perspective of its impact on teaching and learning effectiveness.

This paper presents a journalistic approach to STEM learning by exploring the creation of a “technical”, online research publication intended for the middle and high school audience. The intention of the journal is to feature articles that depict a variety of STEM related issues, learning practices, research activities, and industrial careers, and is designed to increase the awareness of modern engineering and science practices currently ongoing within both academia and industry. Currently within its beginning phase of inception, the scope of the journal is to comprise a combination of student-initiated research projects, university research activities, and industrial engineering white papers to both actively engage students in problems of national concern and prepare them for advanced careers in science or engineering fields. Furthermore, this journalistic approach aims to transform STEM learning by tying together all aspects of the recognized aptitude achievement tests, including reading, English composition, science, and mathematics, along with promoting the understanding of technology and engineering practices.
Techniques for capturing the effectiveness in building technological self-efficacy and inspiring the future generation of scientists and engineers are proposed for future evaluation through the inclusion of online surveys and interactive features for students to post specific questions and seek answers concerning their proposed research projects and the publication process. The conduciveness of using published articles to supplement classroom instructional material can also be investigated through survey questionnaires designed for teachers to evaluate the publication’s usefulness in delivering effective instruction. Ultimately, through continual evaluation and improvement, the objective is to provide a nationwide resource covering STEM related research activities, that would serve to improve the awareness of existing academic and career opportunities, share intellectual information, and promote the understanding of technology design in a cost-effective way.

This paper is organized as follows: Section II details the purpose, goals, and objectives of the online STEM journal, while Section III outlines its aims and scope. Section IV presents a series of workshops organized to teach students the process of conducting academic research. Section V outlines a future evaluation plan used to rate the journal’s performance. Section VI discusses the journal’s potential impact on STEM education, and Section VII provides concluding remarks.

II. Purpose, Goals and Objectives

This section discusses the purpose, goals, and objectives of creating an online, open-access STEM journal for the 7-12 grade audience. The journal is designed to enhance middle school and high school students’ and teachers’ awareness of modern engineering and science practices currently ongoing in academia and industry, and to inspire students to research, experiment, and publish articles on topics pertaining to STEM related issues. It is intended to serve as an intellectual and informative resource portraying a spectrum of STEM related issues through a combination of articles contributed by students, faculty, and professionals alike. In addition, articles submitted to the journal for publication follow specific author guidelines to allow the material to serve as supplementary classroom instructional material, by detailing real world scenarios and the solution methodologies employed. Specifically, the establishment of this journal aims to provide a readily accessible resource for all students to download, read, and learn about scientific and engineering achievements, enhance the ability of teachers to provide high quality STEM education for all students, institute an innovative educational model in a cost effective manner, and provide the next-generation of scientists and engineers with intellectual material to inspire their interest in STEM fields.

This journalistic approach to STEM learning encompasses the solicitation and review of engineering white papers and current scientific research activities from academia and industry – written at a level of understanding for the middle and high school audience – while also documenting student-initiated projects exploring patent publications, issues of national concern, and posing an assortment of mathematical problems. In the latter case, students partner with experienced mentors (e.g., educational instructors, industry professionals) to investigate self-motivated research projects and gain practical experience through reverse engineering, testing and measurement, and concept validation experiments. Articles contributed from industrial and academic institutions serve indirectly as a source of advertisement for their products and research activities, and also serve as an opportunity for recruiting future employees.
The goal of the journal is, ultimately, to increase students’ awareness of the role of research in academia prior to entering their collegiate stage of life. Naturally, the pursuit of a STEM related career is not the desired path for everyone (and appreciatively so), and hence, the formulation of core curricula that is heavily STEM based might not be the best approach for secondary schools nationwide. The introduction of additional (perhaps elective) courses that focus primarily on basic engineering principles and technology, taught alongside the traditional science and math curricula, is a feasible and a well-explored solution. Alternatively, this journal aims to integrate material into existing science and math curricula by providing the public, and in particular, teachers, open-access to an online archive of research articles, available to view or download free of charge and without imposing membership obligations. This cyberlearning approach provides the opportunity for all students to learn STEM principles at no additional expense. The promotion of scientific and engineering research at the middle and high school levels encourages students to learn about the type of problems scientists and engineers encounter, and how the resulting solutions help improve our “health, happiness, and safety”.

Furthermore, the goal of the journal is to increase the technological literacy of our youth by encouraging the use of these articles within the classroom setting, through the engagement of classroom discussions or project-based activities. Specific guidelines set for publishing articles aid teachers to select and adapt certain material within these publications to standard concepts in existing curriculum, thereby enhancing the quality of STEM education. Moreover, by involving students directly in research-oriented projects, and through the publication of these projects, the students gain the ability to question, hypothesize, explore, observe, and draw conclusions by applying methods currently taught in standard science and math curricula. Extracurricular projects, mentored by science and mathematics teachers, allow the individual student to strengthen his or her work ethic skills through self-motivated research, in addition to strengthening communication skills amongst a group of peers.

Over the past decade, the growing issues of national priority have evolved to become more technically oriented, and require advanced knowledge of science, engineering, and mathematics to produce viable solutions on issues such as improving healthcare, homeland security, energy systems, environmental sustainability, and transportation efficiency. These and future issues of national and global concern will continue to evolve, and will require the next generation of professionals to be proficient in creating new technologies and solving complex problems. However, to achieve such solutions, it is first necessary to inspire our youth to pursue careers in STEM fields by introducing exciting and highly rewarding activities within the educational learning environment.

Consequently, an important objective in establishing the online STEM journal is to clearly convey the incentives for students to investigate research projects and publish articles. Such incentives include receiving public recognition, bolstering college application resumes, and, depending on the journal’s long-term success and financial support through corporate sponsorship, offering prizes for “best” publications (e.g., most viewed, most commented, editorial board’s paper of the year, etc.) or award grants towards covering partial college tuition expenses. The ever-expanding growth and accessibility of the World Wide Web provides an
excellent pathway for communicating with and inspiring students, where the creation and sustainability of this STEM learning resource can be accomplished in a cost-effective manner.

III. Aims and Scope

The primary aim of the online journal is to produce an intuitive educational approach to STEM learning by creating an open-access publication designed for spotlighting middle and high school students’ independent or collaborative research efforts. It is important to state that this journal is not intended to achieve the stature of a typical professional academic journal, since the technically focused nature of the works published in these journals are considerably more advanced than the level of understanding of high school students. Rather, the aim of this journal is to obtain a balance between the editorial rigor exhibited in a professional journal and the thought provoking journalistic approach found in news and scientific magazines to create an “intellectually entertaining” series of articles related to enhancing the awareness of modern STEM disciplines.

Designed to inspire the direct involvement of students in STEM learning, the journal, entitled Schematics (citeri.org/journals/schematics), is devoted to increasing the awareness of science, technology, engineering, and mathematics principles within secondary education environments. Based on the notion of illustrating science and engineering problems through drawings and sketches, the scope of its articles includes discussions and reviews of modern engineering and scientific practices currently ongoing in academic institutions and industrial facilities – including current technological advancements – and geared towards informing and educating the middle and high school audience. Topics of interest cover a wide range of disciplines, including mechanical, electrical, civil, environmental, computer, and chemical engineering, as well as biology, physics, and mathematics. Articles typically focus on spotlighting current academic research activities and innovative product design, detailing issues of national concern, exploring patent publications, and posing insightful mathematical problems.

Currently in a call for papers mode (i.e., a research work-in-progress), Schematics aims to publish informative articles used to supplement standard educational curricula, and to encourage student participation in conducting independent research projects. Articles may be contributed by middle and high school students on STEM related issues, by university students and faculty outlining current research activities, and by professionals detailing standard industrial practices. Articles are expected to encompass both experimental and theoretical analyses pertaining to interesting and/or novel aspects of product design, technology, and scientific breakthroughs, written to captivate individuals at secondary institutions. The aim is to publish articles that inspire students to solve real world problems, actively engage students in problems of national concern, and prepare them for advanced careers in science or engineering fields, in addition to indirectly providing a comprehensive overview of future career opportunities. This combination of learning and teaching helps students realize the significance of today’s challenges, outlines the use of a systematic approach to problem solving, and creates a pathway for achieving their academic endeavors.

The types of articles that fall within the scope of this journal arise from a multitude of fields lying beneath the umbrella of STEM related disciplines. Articles are sought from industry and
academic research groups, as well as from middle and high school students where teachers and/or professionals serve as mentors to provide oversight and encourage the use of a systematic approach to defining and addressing the design problem. Articles submitted from industry typically provide details pertaining to the design of innovative technology, or provide insight into common measurement, analysis, or quality assurance techniques used within the design cycle. Article contributions from postsecondary academia typically provide an overview of an interesting aspect of their research activities, and discuss how these activities may be used to envision technology in the future. Most importantly, middle and high school students are encouraged to pursue either independent or collaborative student projects on topics such as the

- Discussion of issues of national concern, including environmental problems, power generation and distribution, transportation security, and the economy, among others, including those listed as the 14 Engineering Grand Challenges of the 21st century,
- Exploration of existing patent publications and applications, detailing the fabrication, testing and performance evaluation of the patented device or concept,
- Investigation of laboratory and so-called “workshop” projects that detail experimental setup, measurement, and test procedures, and provide results that are novel, entertaining, and motivate replication or further investigation,
- Characterization of mechanisms, their applications, and the dynamics governing their behavior,
- Formulation of thought provoking mathematical puzzles or problems, where the solution methodology is shown to relate to solving real world problems.

To assist students with generating a potential project, a shortlist of research topics is made available on the journal website, which is periodically refreshed as the “hot topics” of national concern evolve.

The purpose of these articles is threefold. First, they serve to motivate and inspire students to expand their knowledge about issues pertaining to STEM fields and to pursue academic degrees related to science and engineering disciplines. Second, specific formatting guidelines are set forth to maximize the articles conduciveness as supplementary educational material within existing science and math core curricula. Here, it is believed to be beneficial for all students to experience engineering and technology related education within the formal classroom setting, rather than the select number of students willing to engage in informal research projects. Third, the opportunity to publish articles on STEM related issues provides students with a highly engaging and rewarding activity for advancing their skills in independent research, composition, and of the associated STEM methodologies. Studies have shown that a large part of the learning process takes place in informal settings, and is a critical component of inspiring interest in STEM learning. The plan for achieving such results includes investigating the appropriate structure of these articles through interactions with secondary education teachers, academic faculty, and conducting “field experimentations” within local middle and high school classrooms. Since most secondary education science and math teachers have not acquired engineering degrees, it is essential that the article is structured to provide sufficient background information on the related STEM disciplines, the problem addressed, the methodology employed, and the solution results.

Mirroring that of professional journals, a published article provides author information (names and affiliation only to give credit but not jeopardize privacy through email disclosure), a brief abstract, and a systematic review of the problem addressed, including an introduction and
background of the problem or technology, an overview of the methodologies used, any experimental procedures or measurement techniques, a discussion and interpretation of solution results, and provide concluding remarks, along with citing all relevant references. The intention of using this predominant format is to help educate and prepare students for the process of publishing quality research in postsecondary academia. Most importantly, however, is a clear portrayal of the problem, methodology, and solution in such a manner that the article can be used to supplement aspects of existing science and math curricula by highlighting standard concepts used to solve real world problems. Articles accepted for publication appear on the journal website in pdf format, and are accessible for the public to view and download at no charge.

To provide oversight of the technical content and relevance of published work, articles submitted for publication in the journal undergo a unique review process consisting of two high school student/teacher combinations (including math, science, and English teachers), and by an individual from academia or industry who demonstrates expertise in the associated field. The student/teacher combinations serve as sources for judging the impact the submitted content may have on stimulating self-motivated learning and its usefulness for integrating within the educational curriculum. Thus, an opportunity exists for students to understand the editorial process through this unique “peer-review” process. The academic/industrial reviewer serves to ensure accuracy of the publishable content, and to provide constructive recommendations for conducting further experimentation, analysis, and narrative revisions.

An editorial board consisting of academic faculty and school administrators provides oversight of the STEM journal and regulates the content published on the website to handle cases of unacceptable journalistic behavior, such as plagiarism and falsification of information. Clearly, since the research and publishing experience of middle and high school students is at an early stage, mistakes are commonplace, and in fact are an essential part of the learning curve. The structure of the editorial review process is designed to capture and correct the majority, if not all, of these errors prior to publication. Mindfully, the philosophy of the editorial process is to not frighten students away from performing research and publishing their results with the possibility of receiving negative reviews. Rather, the students (and professionals alike) cooperate during the review and revision process to help hone the students’ skills in performing academic research and improve the overall quality of their content presentation.

IV. Teaching and Learning Workshops

Historically, the educational aspects contained in science and math curricula have been well addressed. Unfortunately, less focus has been placed on adapting learning techniques to account for modern practices, on the assessment and evaluation of new instructional techniques, and on advancing the professional skills of the teaching workforce. For the purpose of formalizing the role of engineering in the educational curriculum, the National Academy of Engineering and the National Academies’ Center for Education’s Committee on K-12 Engineering Education completed, in 2009, a study of the interconnections among science, technology, and mathematics within the proposed creation of a K-12 engineering curricula. Despite their recommendations, the Committee still remained uncertain about the proper approach to teach basic engineering principles in the K-12 environment. They concluded that at least three options exist for teaching these engineering principles: i) through ad hoc infusion, by introducing engineering projects
within existing science and math curriculum, ii) by introducing standalone courses, and iii) by creating a fully integrated STEM educational curricula, combining aspects of science, technology, engineering, and mathematics into several concept specific courses. The latter option is currently being addressed through the foundation of various STEM oriented public, private, and magnet schools. However, this does not currently address the deficiencies of STEM education for students in public school systems. The introduction of standalone courses, similar to those offered in first year university engineering institutions, is a viable option, but requires a tiered structure (base level, honors, and advanced placement) or offered as elective courses, since a large number of students will continue to pursue careers in areas other than science or engineering despite the projected increase in level of understanding of these principles.

While the introduction of STEM education within existing curriculum may be viewed as the least complicated option, it demonstrates excellent benefits for implementation within public schools, where budgetary limitations constrain the support of offering additional, engineering-specific courses and the appropriately trained teaching personnel. Thus, a cost-effective solution for integrating STEM activities into existing science and math curriculum is highly coveted by administrators in public secondary institutions. Furthermore, opportunity for teachers to learn how to instruct STEM principles is detrimental to the success of integrating STEM activities into the classroom setting.

As part of the initial local implementation of this journal, middle and high school teachers within the Springfield public school district met to discuss the role of STEM learning in today’s educational philosophy, the importance of inspiring students to perform research projects, the process of writing articles for publication and integration within the classroom environment, and how to form a connection between the real world scenarios presented in the resulting articles, as well as from those published in leading technical journals, and the standard middle and high school science and mathematics curricula.

To assist the students with learning the process of conducting academic research, a single day, three-hour workshop session was organized for four high school teachers and administrators to present students with a set of guidelines on how to investigate a relevant issue and publish findings in Schematics or similar (future) journals. The workshop was subdivided into six thirty minute segments: i) an introduction to the academic research model and the role of STEM fields in society, ii) a discussion on potential research topics, iii) information on how to a conduct literature review and the associated ethical considerations, iv) perform an analysis of results and draw conclusions, v) present a set of guidelines covering the publishing and review procedures, and vi) a segment devoted to questions and open discussion.

Difficulties surrounding the operation of these workshops are that they are offered only on a local level, require extra time commitment from the teaching workforce, and often conflict with students’ busy weekend schedules. Plans to overcome these challenges include offering the material covered in this workshop on the journal website, so that students may access the information at any time, while also making the information available to other school districts nationwide. Future plans also include dividing the material into a series of two workshops, offered annually, where a fall workshop teaches students about the research process and potential research topics, while a spring workshop focuses on the publication and review process. This
approach can help reduce the time commitment to at most two hours per workshop, and hence, may then be offered weekdays during after school hours.

V. Performance Evaluation

Over the past decade, tremendous effort has been devoted to teaching STEM principles, first to undergraduate students in post-secondary institutions, and more recently, to K-12 grade level students in primary and secondary schools. This effort is based in part by the educational requirements envisioned for achieving success over the next twenty years, and also from studies illustrating a decline in interest and achievement in STEM fields for students in the United States.9 For example, the American College Testing (ACT) high school achievement test reports that the national average ACT scores have remained constant for math and science, while those for English and reading have all decreased marginally (~1%).10 More noticeably, the average scores have declined by 10-15% for those students who partially completed a core curriculum while in high school. College readiness benchmarks for 2010 high school graduates are reported as 66% for English, 52% for reading, 43% for mathematics, a dismal 29% for science, and only 24% that met all four. These values are, on average, 10-15% higher for students of White and Asian American ethnicity, and are, on average, 10-20% lower for those of Hispanic, American Indian, and African American minorities. While the ACT reports that at least 89% of graduating students aspire to pursue a two or four year post-secondary degree, and roughly 45% aspire to attain a graduate or professional degree, the number of students interested in pursuing careers in STEM fields falls far below the projected number of job opportunities in those fields.

The long term evaluation plan for the online STEM journal aims to invoke the experiential learning process by utilizing evidence and inquiry-based methodologies, and by encouraging students to incorporate systems thinking and service learning principles within their research projects. Students are encouraged to collaborate with fellow students and mentors to strengthen their leadership skills, while also building their self-efficacy through early exposure to academic research. Considering the recent launch of the journal website, the success of this research effort will be based on the evaluation of students’ and teachers’ perception of the presentation, content, and quality of the website, through the quantitative analysis surrounding details of the website usage, and by capturing the impact that student-initiated research projects has on inspiring future scientists and engineers. Group discussions and online surveys are planned to provide continual assessment of the STEM journal in meeting its goals and objectives through multiple choice questions (for conducting statistical analysis) and open response questions (for basing continual improvement). The criteria for program success constitutes articles published from a diversity of STEM disciplines and author backgrounds, and the effective use of these articles as supplementary instructional material within the classroom.

One goal set forth by the National Science Foundation is to establish a metric characterizing a student’s level of STEM literacy.9 In addition to assessing the student’s understanding of various aspects of science, technology, engineering, and mathematics subjects, gauging a level of competence relating the four areas is also of critical importance. A technologically literate person is one who holds knowledge about technology and engineering concepts and constraints, understands the risks, costs, and benefits associated with technology, demonstrates thinking skills and ways of acting upon a hypothesis or design concept, and shows
the capability of using research, acquired knowledge, and skills to innovate solutions to various technical problems. Metrics that capture these characteristics are essential for determining the effectiveness of future pathways of K-12 STEM education.

Studies show that the “process of reasoning from evidence” is comprised of cognition (how students acquire competence in subject matter), observation (the assessment of what and how students learn), and interpretation (how the observations correlate to educational goals). The long-term goal involving the evaluation of this STEM journal is to gauge its effectiveness in increasing student and teacher awareness of modern scientific and engineering practices currently ongoing in the generation of new technology. The most straightforward approach to identifying this is to pursue a systematic approach to gathering, analyzing, and interpreting data surrounding the participation in and use of the online publication. This includes the qualitative evaluation of students’ and teachers’ perception of the presentation, content, and quality of the STEM publication, and the quantitative analysis surrounding details of the website usage, along with capturing the impact that encouraging student-initiated research projects has on inspiring future scientists and engineers.

The qualitative aspects planned are to involve the administering of group discussions and online surveys to provide a continual assessment of the journal in meeting its goals and purpose, and to provide information for improving the focus of its content. Surveys requested following the completion of the teaching workshop or a student project are designed to gauge the students’ initial and follow-up perceptions of the

- role of technology and engineering in society and the social perceptions of scientists and engineers,
- importance of studying technology and engineering alongside science and math curricula,
- importance of addressing social, environmental, educational, security, and ethical issues,
- level of interest in the material presented within the online STEM publication,
- conduciveness to learning STEM principles and engaging in self-motivated research projects,
- receptiveness of the publication as a source of learning material for classroom use, and
- impact the online resource has on guiding career ambitions.

A second type of survey will be made available on the journal website and is open for the public to complete, encompassing questions pertaining to the overall presentation and usefulness of the online STEM publication. The quantitative aspects of the evaluation plan involve the capturing of various website and journal statistics, including the number and origination of site visits, the number of visits or downloads of particular content, the number responding to the call for papers (along with the percentage who actually submit papers), and the number of participants engaged in forum discussions. Quantitative analyses using existing techniques can also be performed through data obtained from the online surveys comprised of a mixture of multiple choice and open response questions. Lastly, monitoring the number of students participating in research intensive projects, as well as monitoring the number of teachers engaged in these activities, provide an indication of the capability of 7-12 grade level students in systematically applying knowledge, skills, and methodology to reach solutions, and indicate the interest of teachers in building the interconnections among STEM disciplines.
Since the journal is currently a work-in-progress, and hence, in a call for papers mode, at this stage it is important to make the educational world aware of its existence and purpose. Figure 1 shows a screen capture of the journal homepage (website: citeri.org/journals/schematics). As previously stated, the goal is to create a balance between a “professional” and “entertaining” feel, where ideas to incorporate the latter into the website are currently being explored within student internship opportunities. The initial publication of papers is expected in June 2012, and will be released online in a continual format, but archived quarterly.

VI. Impact on STEM Education

This section discusses how the journal can help support the growth of students’ interest in studying STEM disciplines. Particularly, its ease of accessibility can provide the opportunity for all students to learn a variety of STEM content. By encouraging students to collaborate with teachers or professionals on their research projects, the journal provides the opportunity for teachers to practice the delivery of STEM education on an individual basis then extend their educational practices to the classroom environment. Also, an archive of STEM material can be
provided to the public in a cost effective manner by offering the journal online only and through an open-access format.

Students from diverse backgrounds in secondary institutions experience various instructional techniques within schools of varying degrees of the quality of education due to factors including academic and industrial support and the financial state of the school system, for example. A small percentage of students have the opportunity to enroll in elite private institutions, such as STEM curriculum based academies and magnet schools, while the majority of students enroll in public or private religious school systems. While several of these school systems have established a STEM based educational environment, many lack the funds, incentive, or properly trained personnel to offer such experiences. This journal is designed to provide an opportunity for all students to take part in learning STEM content by providing open-access to an online resource of related articles. Those who inspire to gain further knowledge can do so by exploring the opportunities to participate in independent study. Furthermore, teachers who use the published articles can provide the opportunity for all their students to learn advanced content through classroom discussions tailored to supplement regular instructional material. Teachers have the opportunity to enhance their ability to teach STEM content by serving as mentors to student-initiated research projects, integrating the online material within the classroom setting, and participating in the workshops on conducting academic research.

The structure of the internet enables the delivery of information in a cost-effective manner across a large audience. The journal creates a STEM learning resource that is fully accessible to the public at no charge. The majority of published articles can convey research activities, scientific and engineering practices, and mathematical problems are primarily literature-based, and can be accomplished at minimal cost. Student-initiated, hands-on projects, such as the exploration of existing patent publications, might incur personal expense, although the scope of these projects can be addressed depending on the participant’s available funds.

As the amount of information available over the internet continues to increase, along with the number of people gaining access to this information, the next-generation of learning materials will inevitably appear in electronic format. The journal provides a resource of current STEM learning practices to inspire students to pursue careers in STEM fields by motivating them to participate in self-initiated research projects, and to create an awareness of the opportunities that currently exist in academia and industry.

VII. Concluding Remarks

This paper presented the establishment of an online, open-access, STEM oriented journal intended to increase middle and high school students’ awareness of the role of science and engineering practices in today’s technological society. This journal aims to provide students with the opportunity to learn firsthand how to conduct research and disseminate their findings in a peer-reviewed publication. It is intended to prepare the students earlier for the rigors of post-secondary academic life, and to help shape future scientists and engineers by introducing real-world problems and the associated solution methodologies at an earlier stage in their learning curve.
The long-term plan of the journal is to build upon the success of the initial localized phase by expanding contact to academic and industrial institutions nationwide. Methods to accomplish this include using the journal itself as a form of advertisement within existing online journal search databases, direct contact with school administrators, teachers and parents, through offering the online workshops on conducting academic research, as well as presentation at technical and educational conferences. The plan for maintaining and re-designing the online content is to continually update the informational material provided on the journal website (articles, learning practices, conferences, activities, etc.) based on survey responses. The long-term goals are for this publication to serve as a nationwide resource for showcasing a wide spectrum of academic and industrial career opportunities, and to extend this STEM learning technique towards the K-12 audience by inspiring future online publications of a similar nature.

References

3. President’s Council of Advisors on Science and Technology (PCAST), 2010. Prepare and inspire: K-12 education in science, technology, engineering, and mathematics (STEM) for America’s future. Report to the President.