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Setting The Agenda For STEM Literacy In Higher Education: A Content Analysis Of The Chronicle Of Higher Education

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SETTING THE AGENDA FOR STEM LITERACY IN HIGHER EDUCATION: A CONTENT ANALYSIS OF THE CHRONICLE OF HIGHER EDUCATION

by

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ABSTRACT

Enhancing achievement in Science, Technology, Engineering, and Mathematics (STEM) is a long-standing national concern. The current national agenda, to instill an "all hands on deck" approach to creating a STEM literate citizenry, calls for broadening the scope of inclusion in STEM efforts. A critical population, higher education administrators, faculty, and staff are a valuable resource to advancing this agenda. Under the proposed Agenda Setting Communication Theory (ASCT) model developed for this study, their level of exposure to needed information is an important indicator of their potential participation in this agenda. As the leading news medium for the higher education community, the *Chronicle of Higher Education* was examined, through Content Analysis, to identify the frequency of reporting on STEM education from January 2001 to December 2015, to discern the themes in STEM education which appear in the *Chronicle of Higher Education* from January 2001 to December 2015, and to determine the frequency of reporting on the need for collaboration in STEM education in the *Chronicle of Higher Education* during that same period. The results of the Content Analysis indicate that there has been a significant increase in the *Chronicle's* reporting on STEM education in the past five years. Also, matters relating to the recruitment and retention of underrepresented populations were reported on most frequently. Further, reporting on the need for collaboration did not emerge as a primary theme. These results indicate that while the *Chronicle* is somewhat participating in reflecting aspects of the national STEM education agenda, it is not yet functioning to advance the breadth of that agenda within the higher education community.

For every dream there is a dreamer.

As much as I would love to take credit for *this* dream, it was instilled in me by someone who, not only exhibits all that is good and pure and selfless in this world, but also does so with an elegance and joy that shall never be matched. Mother, without your vision and dedication I could never even imagine being half the person I am today. Thank you for all that you are and thank you for helping me achieve my greatest dream of all, motherhood, without having to sacrifice this achievement.

To my daughters, my life began with you!

May you always find the courage and strength to follow your dreams and give all that you are to this world for nothing shall remain but the memory of your contribution. The world is an infinitely better place every time you smile.

And always remember, the past is history, the future is a mystery, but today is a gift, that's why it's called the present ~Kung Fu Panda, 2008.

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LIST OF ABBREVIATIONS

ASCT: Agenda setting communication theory

CA: Content analysis

CHE: *The Chronicle of Higher Education*

NAS: National Academy of Sciences

NS: National Science Board

NSF: National Science Foundation

NSTC: National Science & Technology Council

STEM: Science, technology, engineering and mathematics

TIES: Teaching Institute for Excellence in STEM

TIMSS: *Trends in International Math and Science Study*

CHAPTER 1
INTRODUCTION

Background

In their 5-year strategic plan report, commissioned by president Obama, the Committee on STEM Education at the National Science and Technology Council (2013) states "President Obama believes that now is a time of opportunity—that we can build a true "all hands on deck" effort to move America forward and address this challenge" (preface letter to Congress). This statement, as part of the Educate to Innovate campaign the President began in 2009, represents the nation's drive to bring STEM to the forefront of educational reform ("Educate to Innovate," n.d.).

A 2012 Congressional Research Service report to congress, which addresses trends in funding for STEM education at the National Science Foundation (NSF), highlights:

> Federal policymakers have a long-standing interest in science, technology, engineering, and mathematics (STEM) education that dates to at least the 1st Congress. In its contemporary construct, this interest largely focuses on the connection between STEM education and the U.S. science and engineering workforce, which, in turn, is often perceived as instrumental to national security and the U.S. economy. (Gonzalez, 2012, p. 2)

The Soviet Union's launch of Sputnik in 1957 dramatically increased the U.S. frenzy over global competition for innovation (Gonzalez, 2012; National Science Board [NSB], 2010). The awareness invigorated the nation's investment in education, tripling the NSF's budget to address STEM education (National Science Foundation [NSF], 1994). The connection between STEM education and the production of human capital emphasizes the central role of higher education to this mission. It is clearly depicted in reports such as "Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital" (NSB, 2010). While efforts to recruit and retain talented STEM students proved valuable in early years (NSB, 2010), the rapid funding decline, from around 1968-1978 (NSB, 2010; NSF, 1994), is a likely contributor to stifling this effort and the looming concern over our nation's production of a STEM literate citizenry (NSB, 2010).

A resurgence of the nation's focus on STEM education slowly began in 1980s, highlighted by reports such as "A Nation at Risk" (1983), and exploded in the 21st century as demonstrated by the formation of the STEM Education Caucus in 2005, National Academy of Sciences in 2007, the America Competes Act in 2007, the Educate to Innovate campaign in 2009, and other such efforts. According to The White House Office of Science and Technology Policy (2014), these efforts are working but there is a need to continue to focus efforts and collaborate in order to raise the number of underrepresented populations such as women and minority groups in STEM fields, better prepare students in secondary school for the rigor of STEM education, and increase the number of skilled STEM educators. Due to the vastness of this effort and the importance of collaboration, the President has called for an "all hands on deck approach" (Committee on STEM Education, 2013, n.d.). This approach is critical to addressing the breadth of the current mission, the formation of a STEM literate citizenry. The goal, in part, is to leave no stone unturned in the recruitment and retention of a skilled STEM workforce.

Historically, the nation has always turned to higher education to meet the demands of production in human capital, whether it be the development of educated clergymen and leadership dating back to the earliest universities such as Harvard in 1636 (Brubacher & Rudy, 1997), the establishment land grant colleges for agricultural and mechanical research following the industrial revolution and Morrill Acts of 1862 and 1890 (Brubacher & Rudy, 1997), the 1960's focus on research and development for defense after the launch of Sputnik (Gonzalez, 2012; NSF, 1994), or the current focus on innovation and technology for global competiveness. This current focus has the largest agenda, emphasizing the involvement and responsibility of all citizens. Once again, the higher education community, that is faculty, staff, and administration, are being called on to forward our nation. However, unlike ever before, this agenda will require the involvement of the entire higher education community and not only those members who are specialized. The American higher education system is unique around the world primarily for its diversity of sectors. Now, these sectors will need to collaborate at some levels to meet, what has been declared, the nation's best interest. It is through collaboration between the STEM specialized population and the entire higher education community that best practices are being modeled and effective change is being recognized. As such, it is now critical to determine the extent to which the higher education community feels a need for orientation toward STEM education, that is, has a need to understand the STEM education environment, in order to effectively participate in this endeavor (McCombs, n.d.). As the leading source of news on higher education to the higher education community, the *Chronicle of Higher Education* is an ideal news medium from which to determine the salience of STEM education news to the higher education community.

Why the Chronicle of Higher Education?

It is more than coincidence that the *Chronicle of Higher Education* (CHE) shares its beginnings with the nation's focus on STEM education. Both beginnings reflect the response of members of the nation to a perceived deficit, one in information and the other in human capital. The *Chronicle of Higher Education* was born form the perceived need for higher education news coverage among university alumni. The need was validated by the overwhelming response to the first issue, then the "Moonshooter Report," and it was quickly realized, primarily due to their interest in reading the reports, that the need also existed among faculty and administrators. The *Chronicle of Higher Education* is now the leading news medium for the higher education community. According the Carnegie Corporation of New York (2006):

> The impact of the *Chronicle* on the world of higher education is documented by a range of factors that are not reflected merely by the number of people who read the paper. In the decades since the first issue appeared, the *Chronicle* has covered many topics such as cold fusion, plagiarism and evolution that its readership intrinsically seeks at a depth that most of the daily press does not provide. Even today, many newspapers do not often cover higher education from a national perspective, and, when they do, their articles usually follow a *Chronicle* story on the same subject. (p. 2)

Purpose Statement

The higher education community, that is, faculty, administration, and staff, is at the frontlines of higher education policy, direction, initiatives, and student success. Given the growing emphasis on a collaborative approach to addressing the STEM education national agenda of creating a STEM literate citizenry, it is pertinent to determine the degree to which the higher education community is oriented toward STEM education. A STEM ‘literate’ citizenry would entail all or most members of society having a basic understanding of what STEM is and what the nation’s investment in STEM is, and perhaps most importantly, having a sense that they are able to contribute to advancing that investment. For educators, the idea of STEM literacy transfers into every classroom for every child. Carley (2013) points out the following:

> Every subject is a S.T.E.M. subject, making every teacher a S.T.E.M. educator. Taking just a moment in each class to bring the S.T.E.M. applications being used to the attention of your students makes the connection complete. That is where we start and that alone will propel us into the future of more advanced S.T.E.M. awareness. (p. 3)

This notion parallels that of integrated STEM education and the idea that STEM skills can be honed in every learning experience. Larson (2013) offers his notion of a STEM literate citizenry by speaking of necessary everyday applications of STEM skills:

> Why do I speak about such a “non-academic” thing in a STEM newsletter? Because this is an academic issue: Our ability to reason properly with numbers and statistics. We need to be knowledgeable interpreters of data-informed situations. We need to read statistics-laden reports with appropriate skepticism. Becoming knowledgeable about STEM is not about the 0.01% who might become Ph.D. researchers or the 2% who might become engineers. In this data-informed technology intensive 21st Century, the entire populace needs to become STEM literate. We all need STEM thinking skills. Many apparently non-STEM jobs have become STEM jobs, especially in the trades. Do you know that the average new car has about 50 microprocessors? Forget about crawling under it with a

few of your Dad's tools to fix it! And Moore's Law of computers has affected most other trades as well. But perhaps the most important reason for everyone to become STEM literate is to build a more informed citizenry. In that way we individually and collectively become better decision makers about all the options that a democracy faces. STEM is not only for Ph.D. researchers. It's for all of us! (pp. 5-6)

Successfully creating STEM literacy will rely mainly on the perceptions, actions, and skills of educators. As the leading news medium for the higher education community, understanding the degree and nature of orientation that the *Chronicle of Higher Education* facilitates helped uncover the perceived importance of STEM education to the higher education community, its exposure to needed information, and the degree to which these are in line with the perceived importance at the national level, as demonstrated by the scope of recent initiatives. As a newspaper, the *Chronicle of Higher Education* attempts to comprehensively report all significant news on higher education to the higher education community. The Chronicle's stated role of disseminating needed information is what makes ASCT an ideal lens. Here, the media is not as concerned with setting the agenda, but with reflecting the agenda that is perpetuated by engaged professionals, key actors, and the national interest. The scope of news to be covered is large and the selection of news to be reported represents the perceived importance of that news, this is where the agenda setting effect occurs. With such a broad national agenda as creating an "all hands on deck approach to STEM education," the *Chronicle of Higher Education* must effectively reflect news pertinent to this agenda. The salience, or frequency, of the CHE's reporting on STEM education can highlight the degree of orientation, or need for information, and relevance to the higher education community. If effective, the level of uncertainty, that is a lack of knowledge or familiarity with a topic, should decrease allowing engagement with the agenda to increase. The current study developed and used a modified model of Agenda Setting Communication Theory (ASCT), which paralleled the Content Analysis framework to gage the significance of the CHE in engaging the higher education community in the national STEM education agenda.

Significance of the Study

The recent focus on an "all hands on deck" approach to the nation's agenda of maintaining its leadership in a global innovation and technology marketplace through a STEM literate citizenry calls for an inclusion of the entire higher education community in STEM initiatives. The recent broadening of the STEM education agenda makes involvement at all levels more prescriptive than descriptive. As such, an examination of leading journals in STEM education, such as *The International Journal of STEM Education* or *The Journal of STEM Education: Innovations and Research*, does not provide an account for the dissemination of knowledge past those who may already be oriented towards STEM education. However, an examination of news reporting provides this information due to the breadth of readership under this medium. Also, the review of a newspaper will allow for a gauge of how important one area of coverage is in relation to others. The more salient something is in the news, the more likely that it is perceived important by the public (McCombs, 2005). As the leading newspaper for higher education, with a readership of more than 315,000 ("About the Chronicle," 2015), an analysis of the *Chronicle of Higher Education*'s reporting on STEM education allowed a realization of the salience of STEM education to the higher education community. Further, analysis of a news medium, rather than a journal, allowed the researcher to analyze the ‘pulse’ of the community in relation to STEM education and not just the scholarly literature in the field.

> In 2007, the *Chronicle* was ranked in the 10 most credible news sources by Erdos & Morgan, a widely used survey of thought leaders in the United States. The *Utne Reader* that year named the *Chronicle* for ‘best political coverage’ among independent newspapers. (“About The Chronicle”, 2015, para. 8)

The educational system in general and higher education in specific will be chiefly responsible for meeting the demands of producing a STEM literate citizenry, it is pertinent to determine the extent to which they have been, and are, informed of the issues. This study provided a unique view of communication from the national to public level through the development and use of a modified model of the Agenda Setting Communication (ASCT) framework, which paralleled the Content Analysis framework to discern the extent to which the CHE is participating in setting the agenda for STEM education among the higher education community.

Agenda Setting Communication Theory (ASCT)

Born from a need to explain the effect of mass media on the general public, agenda-setting theory underscores the relationship between the salience of information in the media and public thought (Shaw, 1979; McCombs, Shaw, & Weaver, 1997; McCombs, 2005). Ghanem (1997) confirms the following: “what is covered in the media affects what the public thinks about” (p. 3). Prior to agenda-setting hypothesis the media was seen as “pervasive but not particularly persuasive” (Shaw, 1979, p. 96). Following the significance of early research suggesting the persuasive power, the transfer of the media's agenda to the public agenda, it became important to clarify the mechanism by which this may be occurring and differentiate it from effective deliberate manipulation. Shaw (1979) does just that by stating, "the media are persuasive in focusing public attention on specific events, issues, and persons and in determining the importance people attach to public matters" (p. 96). This is accomplished through the salience of issues in the media. The more something is emphasized, the more likely the public is to think about it.

Although early research centered on the need for information and orientation during political campaigns, the concepts of 'orientation,' 'relevance,' and 'uncertainty' have become hallmarks of agenda-setting research in many domains (McCombs, 2005). Since its introduction in the early 1970s, agenda setting hypothesis has been used in a plethora of diverse research and has matured "into a rich theory" (Ghanem, 1997, p. 3). In his 2005 review of agenda setting theory, McCombs (2005) recalls the first agenda-setting research effort involving a group of Chapel Hill, North Carolina's undecided voters. McComb states:

> Since that election, the principal finding in Chapel Hill-those aspects of public affairs that are prominent in the news become prominent among the public-has been replicated in hundreds of studies worldwide. These replications include both election and non-election setting for a broad range of public issues and other aspects of political communication . . . as the news media have expanded to include online newspapers available on the Web, agenda-setting effects have been documented for these new media. All in all, this research has grown far beyond its original domain-the transfer of salience from the media agenda to the public agenda. (p. 543)

Given the nature of the current study, it is important to further highlight the role that agenda-setting theory attributes to the media in forming public perception, which made it the best fit for use in this study. ASCT allows for a consumer driven approach with its emphasis on transmitting needed information and the function of orientation. Shaw (1979) discusses the basic dynamic between the media and public as viewed through the agenda-setting lens:

> Agenda setting does assume a direct, though not necessarily an immediate, impact of the media on their audiences. But it also specifies that the impact is not on people's attitudes but on their cognitions, and it attributes these cognitive changes to be the result of the media performing a gatekeeper, or channel, role in western democracies. The agenda-setting hypothesis does not say the media are trying to persuade- it does not charge them with adopting a prescriptive, or advocacy, role in American society. No, media effects on people are seen as the principal result of the day-to-day work of the press in informing its audiences of the opportunities and warning them of the dangers, real or imagined, in their environment and in the rest of the world. The media, by describing and detailing what is out there, present people with a list of what to think about and talk about. (pp. 96-97)

Tenets of ASCT

First and Second Level: Objects and Attributes

Like most theories, ASCT has grown from its original scope. Although it took some time to create formal differentiations, ASCT now recognizes two levels of agenda setting. The first level, the agenda of objects, dominated the theory for over twenty-five years (McCombs et al., 1997). The second level, the agenda of attributes, began to take shape in the early 1980s and has become a main tenet of the theory. The ways in which the addition of a second level has broadened ASCT applications is discussed in great detail for the first time in 1997 in *Communication and Democracy: Exploring the Intellectual Frontiers in Agenda Setting Theory* (Ghanem, 1997). Objects "are the things on which the attention of the media and the public are focused. In turn, each of these objects has numerous attributes, those characteristics and traits that describe the object" (McCombs, n.d., p. 5).

This extension of the theory from objects to attributes does not change the central tenets. As Ghanem (1997) states, "This shift emphasis does not negate the basic agenda-setting hypothesis, but rather builds on what already exists. It is one highway linking up with another major thoroughfare" (p. 4). In essence, the expanded focus from an object agenda to an attribute agenda was necessary because communication about issues naturally involves details, elaborations, and omissions. It is their salience that determines the agenda of attributes just as it would for the agenda of the object. McCombs (n.d.) states, "for each object there also is an agenda of attributes because when the media and the public think and talk about an object, some attributes are emphasized, others are given less attention, and many receive no attention at all" (p. 5). Ghanem (1997) states, "the agenda of objects and the agenda of attributes can be looked at as two concentric circles with the agenda of issues being the outer circle and the agenda of attributes imbedded within that circle" (p. 5). In this sense, the attributes are all the possible clusters of details regarding the object. Ghanem further describes the effect that the addition of a second level has had on the designation of variables within a study:

> For the first-level agenda setting, the independent variable is considered in terms of objects, the topics or issues discussed on the media agenda. For the second level, the

> media agenda (the same independent variable as at the first level) is considered in terms of attributes or perspectives. The dependent variable for both levels of agenda setting still remains the public agenda. However, in the case of the first level, the public agenda is operationalized in terms of issue or topic salience, whereas at the second level the salience of the attributes of the issue or topic are measured. (p. 4)

Orientation, Relevance, and Uncertainty

According to McCombs (n.d.), when people are faced with an unfamiliar situation where information is needed in order to form a perception or behavior, they experience a need for orientation. He states that this is an innate need that allows people to "understand the environment around us" (p. 9). Hence, it would first be necessary to perceive that the environment is 'around us.' This is where the concept of relevance plays a central role in determining the level of interest and the media's ability to impact cognitions and behaviors. McCombs states, "The media set the agenda only when citizens perceive their news stories as relevant" (p. 8). The highest need for orientation exists when both relevance and uncertainty are high (McCombs, n.d.). Further, McCombs states:

> Because it is a psychological trait, the degree of need for orientation varies greatly from one individual to another. For some individuals in any situation, there is a high need for orientation. For other individuals, there is little or no need for orientation at all. They just aren't interested . . . If a topic is perceived as irrelevant-or very low in relevance-then the need for orientation is low. Individuals in this situation pay little or no attention to news media reports and, at most, demonstrate weak agenda-setting effects. For individuals among whom relevance of a topic is high, their degree of uncertainty about

> the topic determines the level of need for orientation . . . Finally, among individuals for whom both relevance and their uncertainty about a situation are high, need for orientation is high. (pp. 9-10)

When discussing first and second level agenda-setting, orientation, relevance, and uncertainty follow the same function. That is, the need for orientation is a function of relevance and uncertainty for both objects and attributes. When the need for orientation results in information seeking regarding an object, the relevance may either increase or decrease depending on the information obtained. If the information increases relevance, then the information seeking will continue and agenda effects will be relatively high until uncertainty is low and individual opinion takes shape. During that process, exposure to attributes, the second level agenda, will determine the level of relevance and uncertainty for those attributes through a similar mechanism.

Framing and Priming

According to Entman (1993), frames "call attention to some aspects of reality while obscuring other elements, which might lead audiences to have different reactions" (p. 55). Whatever process is used, the result is that some content becomes salient while other matters are not addressed or are minimally addressed. Although framing and second-level agenda setting are often regarded together, some researchers, such as Weaver (2007), do not agree. There is also some disagreement about the definition of framing (Weaver, 2007). For the purposes of this study, framing was understood as the pattern with which attributes of an object or one object with another are presented to create a presumed relationship between them in the perception of the public. In this way, framing becomes somewhat similar to priming in that it links two or more thoughts together so that they are more likely to occur together than apart. Weaver states priming as the process of "making certain issues or attributes more salient and more likely to be accessed in forming public opinions" (p. 145).

The Ability of ASCT to Advance an Agenda

The tenets of ASCT, depicted in Figure 1, allow communication flow to be enhanced or stifled based on the function of relevance through priming and framing. Depending on how an audience is primed to pay attention to a topic, using such things as tone, association, and communication channel, the relevance of the topic will increase. Increase in relevance also allows people to be more susceptible to the effects of priming, hence the two-way relationship. As relevance increases, the need for orientation increases in relation to the level of uncertainty regarding a topic. This point is somewhat mute in the ASCT framework because uncertainty tends to only be low if relevance is high. It is uncommon to find instances of low relevance and low uncertainty. People tend to collect information about things that are relevant to them and not those which are irrelevant. As the need for orientation increases, people gather information on the object and its attributes based on priming and framing effects. The result is a decrease in uncertainty. This cycle can be repeated many times for one object or attributes of an object. It could also be said that the resulting decrease in uncertainty feeds right back into the loop, as the object and attributes will have increased in relevance based on the information gained and people will again seek to alleviate the need for orientation.

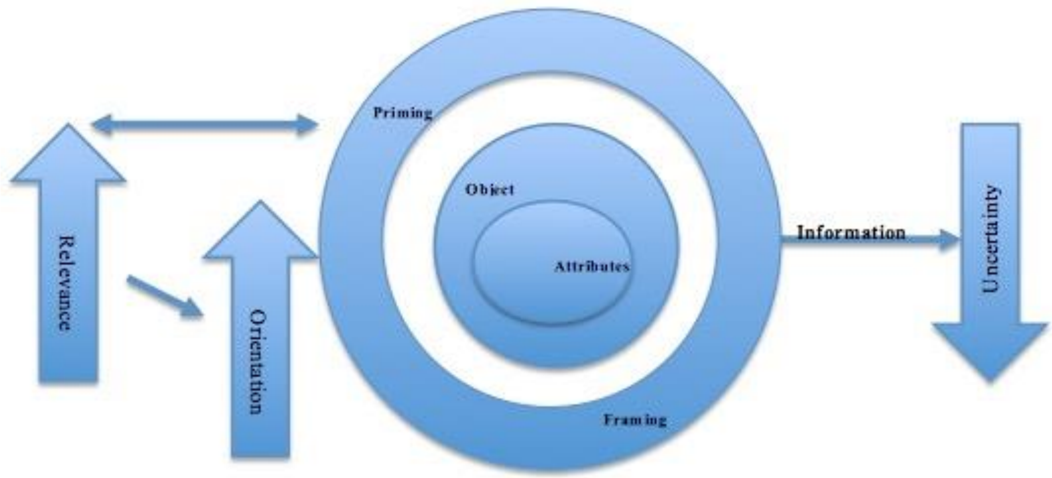

Figure 1. ASCT advancing agendas. Copyright 2016 by M. Abdallah.

Setting the Agenda for a STEM Literate Citizenry

The tenets of ASCT can easily be applied to many areas of communication primarily because they are a natural function of a psychosocial system. As such, the system can be viewed with or without purposeful manipulation or intervention. In the case of political campaigning, agenda setting is subject to higher levels of purposeful intervention. These acts include things such as deliberate framing, one-directional communication, and a focus on the media as the central agent. In the case of agenda setting for STEM engagement, there exists a need that is driven more by organic human and global processes than by the adopted stance of any one group, sector, or population. Instead, intertwined and interdependent goals at varying levels of society have created a perceived need and assumed social good which has been adopted by the masses. At this point, it is not a question of whether there is a STEM agenda and who it setting it; it is more a question of who is effectively participating in advancing an existing national agenda. Figure 2 overlays the tenets of ASCT as they may apply to communication flow in the current state of the STEM agenda. It was specifically developed for use in this study to conceptualize how the tenets of ASCT may serve to highlight the effectiveness of communication flow in advancing the STEM education agenda. Its practical application was gaged after data analysis.

Under this model, national interest is the ultimate agenda setter. That agenda is then advanced at various levels and to various degrees by different sectors of the population. Here, the STEM agenda is advanced primarily by the political and STEM engaged sectors, partly because of their heightened awareness of the global agenda and their access to resources, and partly because they are likely to be the most immediate beneficiaries of advancing the agenda. The four outer boxes represent the four sectors, political, STEM engaged, public, and professional. Within each box, of the ASCT tenets, the larger circle represents the object and, within it, the orientation function. The ellipse within the circle represents the object's attributes. Further, the letter "R" stands for relevance and the letter "U" stands for uncertainty. Each circle contains a thick line, the orientation gauge. If the gauge is on the left, then there is little relevance and high uncertainty regarding both the object and its attributes. As the gauge moves from the left to the right, relevance increases and uncertainty decreased for both the object and its attributes. Depicted in the model, the political sector has a high degree of relevance and low degree of uncertainty making them well oriented toward this agenda. The STEM engaged sector is the most oriented because they have the highest degree of relevance and very little uncertainty regarding the object, which, in this study, was STEM education, and its attributes. Attributes under STEM education include, but are not limited to, teacher preparation, retention of minority students, lack of skilled graduates, special programming, and global standing in math and science.

The media's role in the current model is as a disseminator of needed information. Its orientation gauge is highly in flux moving slightly back and forth from the midpoint. It is fairly oriented on the object and attributes but remains less reciprocally engaged than necessary for optimal communication flow. Whereas in traditional applications of ASCT, the media's role in framing and agenda setting is undesirable, under this model, an engaged media would be able to transfer necessary relevance through deliberate framing. This is not a true difference between the models; it is just an alternate use of the same function. In traditional models, the media is a gatekeeper, allowing only certain information to get through. In a democratic society, this is undesirable because people have a right to know and it is the media's job to remain unbiased in the delivery of information. However, in a natural model, the media can use its agenda setting power to engage the public and professional sectors and then channel information back to the political and STEM engaged sectors. The results would be more circular and less linear.

The public and professional sectors represent the greatest concern as they have low levels of relevance and high levels of uncertainty. Under ASCT, the need for orientation is a function of relevance and uncertainty. Relevance is necessary in order to seek information. Uncertainty decreases as the need for orientation leads people to seek information. People must first perceive something to be relevant at which point their level of uncertainty gauges how much information they seek and how susceptible they are to agenda setting effects. In order to accurately represent this function under the current organic model, it is important to first distinguish between different types of relevance. This model does not suggest that the public or professional sector finds STEM education irrelevant. It suggests that these sectors perceive their engagement in STEM education discourse as irrelevant. This perception is often a function of presumed helplessness. For example, people may very well know that the views and disposition of the elected president will have a direct impact on their lives and the future of the nation. However, that relevance may not translate into their need for orientation because they do not perceive that their engagement with issues will have any significance to the outcome.

Perceived significance is likely to be one of the key factors in mobilizing the call for an “all hands on deck” approach to STEM education. It is not until the communication flow, depicted with arrows in Figure 2, establishes functional significance through relevance amongst all sectors that more meaningful and progressive ways of advancing the national agenda will take shape. The model shows both one-directional and two-directional arrows, signifying the direction of information flow. There exists triangular communication flow between the political and STEM engaged sector and the media. There is also triangular communication flow between the media and the public and professional sector. However, communication flow is one directional between the political sector and the public and professional sector. The same exists between the STEM engaged sector and the public and professional sector. Communication between the professional and public sector is also one-directional. For example, a science teacher may speak to a parent teacher organization regarding the importance of a STEM program. However, as will later be discussed, very few teachers know what STEM is, or more importantly, what the programs are meant to accomplish.

In this proposed model, one-directional arrows are meant to depict a lack of reciprocal engagement in STEM education discourse. Such discourse is necessary for an all hands on deck approach because it allows for policy, programming, innovation and other initiatives to effectively permeate the system. Reciprocal communication from the professional and public sectors would mean things such as, more engaged and informed parents and students or increased collaboration and synergy between departments of higher education and between sectors of higher education. It would also mean more teachers seeking integrated learning strategies and professional development opportunities and administrators' increased awareness of the essential role the arts have in stimulating critical and creative thinking. As a result, it would mean more effective programming and less wasted human and financial capital. When communication flow is as it should be, agenda setting would allow for reciprocal relationships to exist, to some degree, between all sectors. This would result in Figure 2 showing two-directional arrows between all sectors and orientation gauges that are, at least, at or beyond the half waypoint of the object/attribute circles. Such an image would be uninformative. Hence, a more symbolic model, Figure 3, was created to provide a better mental illustration of the dynamic under which agenda setting would serve to promote engagement.

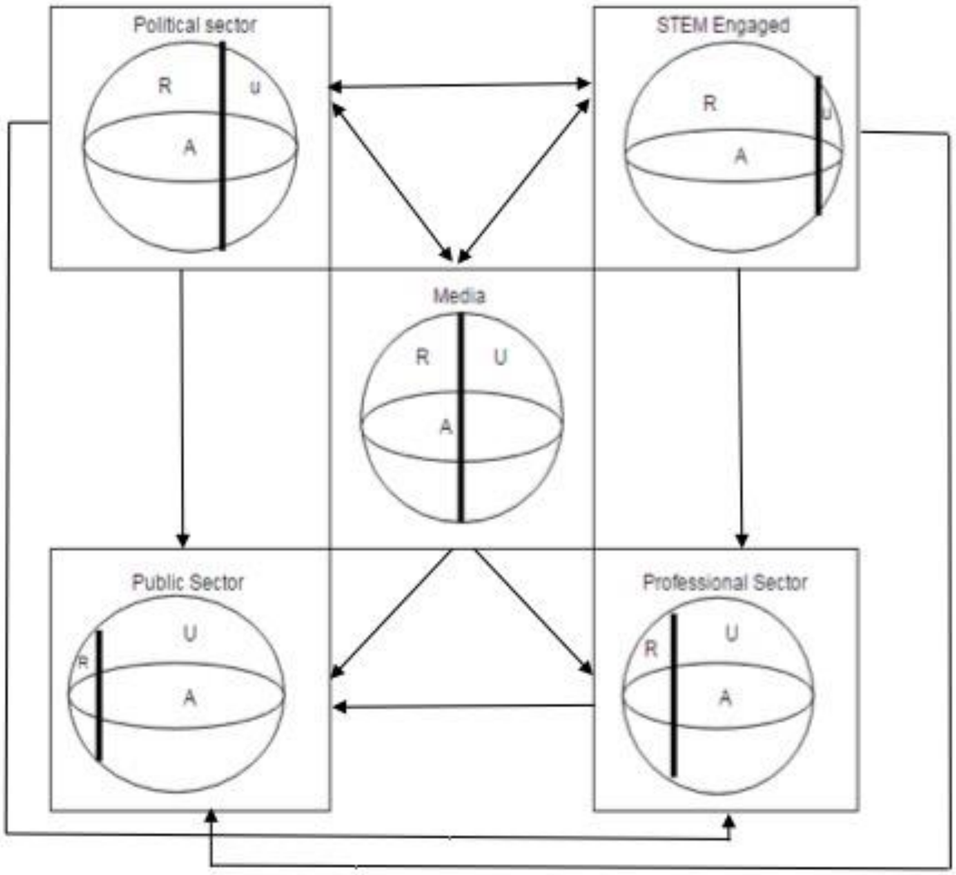

Figure 2. Agenda setting for a STEM literate citizenry. R=Relevance, U=Uncertainty, A=Attributes. Copyright 2016 by M. Abdallah.

<u>Setting the Gears in Motion: A Model for a STEM Literate Citizenry</u>

Figure 3 offers a mechanism for understanding the need for the synergistic relationship this model dictates. Depicted as the largest underlying gear, national interest is the organic function of a nation born from the need to preserve and advance national wealth in all resources. This study focuses the lens on STEM education as a vital resource item on the national agenda. Current legislation and initiatives have highlighted STEM education as a critical matter of state and emphasized communication at every level. This study investigated the salience of communication in STEM education in specialized media, such as the *Chronicle*, to establish whether talk about STEM education is setting the gears in motion for the President's call for an all hands on deck approach to developing a STEM literate citizenry.

By virtue of its natural function, communication involves, to some measure, all sectors within a democratic system. Analogous to gears in a machine, communication sectors interlock and activate one another to disseminate information within the system. Research in agenda-setting theory, targeting the salience of communication of public affairs, suggests that for communication to enact change, the flow and relevance of information must be targeted, emphasized, and elaborated upon. In this study, targeted information was evaluated in terms of the salience of STEM education topics or attributes as it generates from the CHE to its intended readership. Further evaluation included an examination of the degree of emphasis placed on each topic in relation to others, a function of framing, to heighten orientation by increasing relevance and decreasing uncertainty amongst CHE readership.

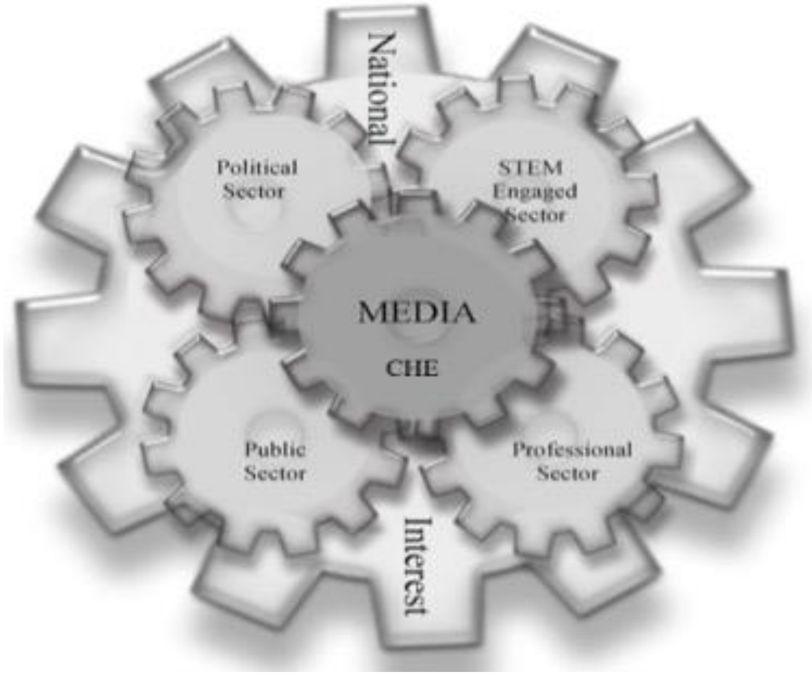

Figure 3. Setting the gears in motion for a STEM literate citizenry. Copyright 2016 by M. Abdallah

Setting the Gears in Motion: A Model for a STEM Literate Citizenry illustrates the critical role of each sector in engaging, as a gear would in a machine, to enable participation amongst all sectors. Figure 3 illustrates, in the large all-encompassing gear, the national interest, in terms of STEM education's value in producing human capital as a national resource for economic and technological sustainability and advancement in order to compete in the global arena. The sectors within national interest are illustrated through interlocking gears. These gears must operate in synergy to produce the necessary energy for communication flow to yield momentum. These sectors are identified in Figure 3 as the political sector, the STEM engaged sector, the professional sector, and the public sector.

The political sector represents the political personnel accountable for the evaluation and enactment of STEM education policies. The STEM engaged sector represents the members of current lobbies, councils, organizations, academe, and industry that are actively engaged in STEM education discourse and evaluation and propose initiatives in STEM education. The professional sector represents the members of academia and other organizations and industry that have a level of awareness related to STEM education but lack necessary levels of relevance and certainty for orientation to lead to engagement in the development of STEM education discourse. The public sector represents the general public who are affected by STEM education but have little to no perceived need for orientation in STEM education discourse. The public sector has the lowest levels of relevance and the highest levels of uncertainty. The media reflects the national interest and prescribes a need for orientation by disseminating information throughout the sectors.

These sectors communicate with each other via both natural and systematic channels. For example, the political sector and the STEM engaged sector communicate STEM education initiatives and legislation with each other through joint policy revision and evaluation of STEM education issues. These communications constitute more systematic channels. The same sectors' communication with the professional and public sectors may depend on personal, situational, or environmental variables that influence variations in the perceived need for orientation. These communications constitute more natural channels. Although some communication exists organically amongst the sectors, it is not until there is sufficient continuity and reciprocity between the sectors that the movement can operate to advance the national interest. Presently, there exists a more active engagement between the political sector and the

STEM engaged sector. This is implied in the policies targeting STEM education and the efforts to emphasize the vital role that STEM education plays in the national interest. Setting the Gears in Motion: A Model for a STEM Literate Citizenry parallels the President's all hands on deck approach by providing a mechanism that engages all gears/sectors necessary for effective discourse in STEM education to enact the kind of change that aligns with the national interest. This model was used in this study to evaluate the salience of STEM education communication in specialized media, such as the CHE, and the dissemination of information to the higher education community, within the professional sector, to determine the nature and degree of STEM education discourse to which the higher education community has been exposed.

Research Questions

Guiding this study were three main research questions:

1. What is the frequency of reporting on STEM education in the *Chronicle of Higher Education* from January 2001 to March 2015?
2. What themes in STEM education appear in the *Chronicle of Higher Education* from January 2001 to March 2015?
3. What is the frequency of reporting on the need for collaborative in STEM education in the *Chronicle of Higher Education* from January 2001 to March 2015?

Definition of Terms

Higher Education Community: All faculty, administration, and staff of postsecondary education.

Integrated STEM Education: Approaches that explore teaching and learning between/among any two or more of the STEM subject areas and/or between a STEM subject and one or more other school subject (Sanders, 2008, p. 21).

Traditional STEM Education: The disconnected study occurring in each separate and distinct subject area (Sanders, 2008).

Organization of the Study

Chapter 1 of this study consists of an introduction to the study including a brief background on STEM and the CHE, purpose and significance statements, and a discussion of the conceptual framework and model. Chapter 2 provides a review of the literature related to STEM education, the *Chronicle of Higher Education*, and content analysis. Chapter 3 provides a discussion of Content Analysis and a description of the methodology used in this study. Chapter 4 presents the results of the data analysis. Lastly, Chapter 5 provides a discussion of results and their implications, as well as recommendations for future research.

CHAPTER 2
LITERATURE REVIEW

The Field of STEM Education

STEM Education History

"Perhaps since the fist time since Sputnik, educators broadly agree on the value of STEM education for ensuring America's edge in the global economy" (Barakos, Lujan, & Strang, 2012, p. 2). While it may be no surprise that America's educational system has become occupied with efforts to increase student knowledge and skill related to STEM areas, the recent focus is markedly different in its breadth. Historically, STEM education efforts are commonly attributed to two reports: "A Nation at Risk: The Imperative for Education Reform" (National Committee on Excellence in Education, 1983) and "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future" (NAS, NAE, & Institute of Medicine, 2007). Taken together, the reports highlight two main historical agendas of the STEM movement; to ensure a more STEM literate society and to create more STEM graduates. The central concern of both is the underachievement of America's educational system, predominantly in comparison to global competitors. Since the 1983 National Committee on Excellence in Education report, a host of initiatives emerged in response to American educational shortcomings in science, technology and innovation (Barakos et al., 2012; Committee on STEM Education, 2013, NSB, 2010). In their evolution, they spawned an educational reform movement that now focuses on integrated STEM education.

Over the past two decades, the serious challenges that face STEM education have not been lifted (Sanders, 2008). Some suggest that the lackluster effect of the breadth of initiatives is due, in part, to the multiple conceptualizations of STEM (Bybee, 2010; Sanders, 2008). It has been reported that, while academicians can easily explain what the acronym stands for, few to none are comfortable with their knowledge of the term (Barakos et al., 2012; Bybee, 2010; Sanders, 2008). Perhaps the most telling account for the evolution of disparity that has transpired is in the definition of the term STEM. "The disparity of what STEM education is can be seen in the many different definitions of STEM education" (Brown, 2012, p. 7). Prior to 2001, when Judith A. Ramaley, the former director of the National Science Foundation's Education and Human Resources Division, rearranged the acronym, STEM was known as SMET (science, math, engineering, technology) (Koonce, Zhou, Anderson, Hening, & Conley, 2011; Sanders, 2009; Teaching Institute for Excellence in STEM, 2015). Although it now rolls off of the tongue much easier, this change was the most discernable the term would undergo.

From isolated learning in each separate field under the acronym, that is, science, technology, engineering, and mathematics (US Department of Education, 2007) to finding connections between the disciplines (Sanders, 2008) to relating and integrating the disciplines to other areas of study (Stohlmann, Moore, & Roehrig, 2012), to extracting the fundamental principles of creative problem solving and inquiry and integrating the skill of these areas for continuous learning (Zollman, 2012), STEM education is now about the integration of knowledge for the development of 21st century skills for innovation (White House Office of Science and Technology Policy, 2014). The current conversation is one of 'integrated STEM education' and no longer simply STEM education. In an effort to explain and advance the integrated STEM education movement, Sanders (2008) discusses the effort within Virginia Tech's Integrative STEM Education graduate program:

> A pedagogy we refer to as "purposeful design and inquiry" (PD&I) is a seminal component of integrative STEM education. PD&I pedagogy purposefully combines technological design with scientific inquiry, engaging students or teams of students in scientific inquiry situated in the context of technological problem-solving—a robust learning environment. Over the past two decades of educational reform, technology education has focused on technological design, while science education has focused on inquiry. Following the PD&I approach, students envisioning and developing solutions to a design challenge might, for example, wish to test their ideas about various materials and designs, or the impact of external factors (e.g., air, water, temperature, friction, etc.) upon those materials and designs. In that way, authentic inquiry is embedded in the design challenge. This is problem-based learning that purposefully situates scientific inquiry and the application of mathematics in the context of technological designing/problem solving. Inquiry of that sort rarely occurs in a technology education lab, and technological design rarely occurs in the science classroom. But in the world outside of schools, design and scientific inquiry are routinely employed concurrently in the engineering of solutions to real-world problems. (p. 21)

Concepts of integration now abound within talk of STEM education. "The goal of STEM education is developing interdisciplinary thinkers" (Figliano, 2007, p. 1). The Teaching Institute for Excellence in STEM (TIES) mentions, "TIES always views STEM instruction and the STEM resources that support the instruction with a transdisciplinary lens" (TIES, 2015). The California Department of Education (2015) states:

> STEM education can be an interdisciplinary or trans-disciplinary approach to learning where rigorous academic concepts are coupled with real-world problem-based and performance-based lessons. At this level, STEM education exemplifies the axiom 'the whole is more than the sum of the parts.' (p. 21)

Although Sanders (2008) mentions that integrated STEM education is not to be thought of as "a new stand-alone subject area in the schools" (p. 21), but rather a pedagogy by which students can best develop the necessary skills to be successful in STEM, there is perhaps as much variance in integration as there is in traditional STEM education. The confusion is likely to be compounded when taking into account the large variance between which disciplines are included under the STEM umbrella.

There is a vast disparity in the parameters of which disciplines are included under STEM. The NSF has wide parameters, which include the social sciences. In a brief produced by the US Department of Commerce, Economics and Statistics Administration, Langdon, McKittrick, Beede, Khan, and Doms (2011) note "the acronym STEM is fairly specific in nature-referring to science, technology, engineering and math-however, there is no standard definition for what constitutes a STEM job" (p. 2). In their list, depicted in Table 1, they exclude education and social scientists. In 2011, following President Obama's initiatives to expand STEM access to foreign students, Immigration and Customs Enforcement (ICE) expanded their list (Appendix A) of STEM disciplines to include neuroscience, medical informatics, pharmaceutics and drug design, mathematics, and computer science, among others (United States Immigration and

Customs Enforcement, 2011; Department of Homeland Security, 2012). This is important because, under initiatives such as the Optional Practical Training program (OPT), foreign students in STEM disciplines can extend their stay in the US for up to seventeen months following their graduation. Efforts have been made to somewhat alleviate the confusion by conceptualizing the specific terms under the acronym rather than listing the specific fields each discipline represents. As indicated by Honey, Pearson, and Schweingruber (2014):

> *Science* is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.
>
> *Technology* comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves.
>
> *Engineering* is a body of knowledge about the design and creation of products and a process for solving problems. Engineering utilizes concepts in science and mathematics and technological tools.
>
> *Mathematics* is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics.

Table 1

Sample STEM Undergraduate Majors

Sample STEM Undergraduate Majors: Computer Science	
Computer Administration Management & Security	Computer Programming & Data Processing
Computer & Information Systems	Computer Science
Computer Networking & Telecommunications	Information Sciences
Sample STEM Undergraduate Majors: Engineering	
Aerospace Engineering	General Engineering
Architectural Engineering	Geological & Geophysical Engineering
Biological Engineering	Industrial & Manufacturing Engineering
Biomedical Engineering	Industrial Production Technologies
Chemical Engineering	Materials Engineering & Materials Science
Civil Engineering	Mechanical Engineering
Computer Engineering	Mechanical Engineering Related Technologies
Electrical Engineering	Military Technologies
Electrical Engineering Technology	Miscellaneous Engineering
Engineering & Industrial Management	Miscellaneous Engineering Technologies
Engineering Mechanics	Petroleum Engineering
Engineering Technologies	Physics & Science
Environmental Engineering	
Sample STEM Undergraduate Majors: Mathematics	
Applied Mathematics	Mathematics & Computer Science
Mathematics	Statistics and Decision Science

Sample STEM Undergraduate Majors: Physical Sciences	
Animal Sciences	Microbiology
Astronomy & Astrophysics	Miscellaneous Biology
Atmospheric Sciences & Meteorology	Molecular Biology
Biochemical Sciences	Neuroscience
Biology	Nuclear, Industrial Radiology, & Biotechnologies
Botany	Nutrition Sciences
Chemistry	Oceanography
Cognitive Science & Biopsychology	Pharmacology
Ecology	Physical Sciences
Environmental Science	Physics
Food Sciences	Physiology
Genetics	Plant Science & Agronomy
Geology & Earth Science	Soil Science
Geosciences	Zoology

Note. Adapted from "STEM: Good Jobs Now and For the Future," by D. Langdon, G. McKittrick, D. Beede, B. Kahn, and M. Doms, 2011, Retrieved from http://www.esa.doc.gov/sites/default/files/stemfinalyjuly14_1.pdf. Copyright 2011 by the US Department of Commerce, Economics and Statistics Administration.

STEM Student Success

Reporting data on student success in STEM is problematic because, as mentioned earlier in a review of STEM education, there is no agreement of which disciplines to include and exclude when conducting research. Hence, every research effort relies on its own designation of 'STEM students' (United States Department of Education, 2011). While this does not essentially indicate that the results are incomparable, it does suggest that they *may* not be comparable. However, according to the US Department of Education (n.d.), "only 16% of American high school seniors are proficient in mathematics and interested in a STEM career" and only half of those who major in STEM work within a related field. Further, The US ranks 25th in mathematics and 17th in science when compared to other industrialized nations. Taken together these is an alarming state as the projected percentage increase in STEM jobs from 2010 to 2020 is 16% for mathematics, 22% for computer systems analysis, 32% for systems software developers, 36% for medical scientists, and 62% for biomedical engineers (USDE, n.d.).

K-12 Student Success in Math & Science

Due to the focus on global competitiveness when referring to the deficit in STEM education, it is pertinent to expand on this discussion. The following information on the TIMSS administration was summarized from the TIMSS website (National Center for Education Statistics, 2015a). Since 1995, The International Association for the Evaluation of Educational Achievement (IEA) has been collecting data on mathematics and science achievement of 4th and 8th graders with around 57 countries represented in the most recent administration, which took place in 2011. The Trends in Mathematics and Science Study (TIMSS) has been administered five times with the sixth administration coming up in 2015. The 1995 and 2007 administration included data on 12th graders. Of the 520,000 students that took part in the 2011 study, 20,000 are from the US. The following data on student achievement in math and science was summarized from the TIMSS 2011 results (National Center for Education Statistics, 2015b). According to the TIMSS data (Tables 2 and 3), there were seven foreign educational systems that had average mathematics scores which were above the U.S. average: Singapore, Hong-Kong, Chinese Taipei, Japan, Northern Ireland, and Belgium. For 4th graders, the U.S. was among the top 15 educational systems. However, for 8th graders, the U.S. was in the top 24 educational systems in mathematics. Korea, Singapore, Chinese Taipei, Hong Kong, Japan, the Russian Federation, and Quebec were the foreign systems with averages higher than that of the U.S.

Table 2

2011 TIMSS Analysis Results

Grade	Subject	Rank	Educational Systems Above the U.S. Average (Foreign & Domestic)
4	Math	Top 15	Singapore, Korea, Hong Kong, Chinese Taipei, Japan, Northern Ireland, North Carolina, and Belgium
8	Math	Top 24	Korea, Singapore, Chinese Taipei, Hong Kong, Japan, Massachusetts, Minnesota, the Russian Federation, North Carolina, Quebec, and Indiana.
4	Science	Top 10	Korea, Singapore, Finland, Japan, the Russian Federation, and Chinese Taipei.
8	Science	Top 23	Singapore, Massachusetts, Chinese Taipei, Korea, Japan, Minnesota, Finland, Alberta, Slovenia, the Russian Federation, Colorado, and Hong Kong.

Note: Adapted from "Trends in International Mathematics and Science Study: TIMSS 2011 Results," by National Center for Education Statistics, 1997, Retrieved from https://nces.ed.gov/TIMSS/results11.asp. Copyright 2015 by National Center for Education Statistics.

In science, the U.S was among the top 10 educational systems for 4th grade with Korea, Singapore, Finland, Japan, the Russian Federation, and Chinese Taipei outperforming the U.S. For 8th grade science, the U.S. was in the top 23 educational systems with Singapore, Chinese Taipei, Korea, Japan, Finland, Alberta, Slovenia, the Russian Federation, and Hong Kong outperforming the U.S.

Table 3

TIMSS Average US Score Year Comparisons

U.S. Average Score by Year	1995	2007	2011
Math			
4^{th} grade	518	529	541
8^{th} grade	492	508	509
Science			
4^{th} grade	542	539	544
8^{th} grade	513	520	525

Note: Adapted from “Trends in International Mathematics and Science Study: TIMSS 2011 Results,” by National Center for Education Statistics, 1997, Retrieved from https://nces.ed.gov/TIMSS/results11.asp. Copyright 2015 by National Center for Education Statistics.

Undergraduate Enrollment and Graduation

According to the NSF (National Science Foundation, 2014b), The overall number of undergraduate enrollment in U.S. was 18.3 million in 2010 and declined to a little less than 18 million in 2012. Enrollment for both women and men decreased approximately 2% between 2010 and 2012. Since 2010, women made up more than half of the undergraduate student population. The rate of women undergraduate stabilized at 57% through 2012. The Cooperative Institutional Research Program (CIRP) at the Higher Education Research Institute at UCLA which asked freshmen students at a large number of universities and colleges about their intended major in science and engineering (S&E) fields (National Science Board, 2014). In 2007, the data showed about 30% of freshmen students intended to major in S&E fields. This number grew to 39% by 2012, with freshmen intending to major in biological and agricultural sciences accounting for most of the growth. The intended major distribution are as follows: 13%

biological and agricultural sciences, 10% social and behavioral sciences and engineering, approximately 3% for each major in physical science, mathematics, statistics, and computer science. Data of intended major in S&E fields by race in 2012 yielded the following: more than 50% of Asian American freshmen, followed by 42% for Hispanic or Latino freshmen, 37% for white freshmen, 36% for black freshmen, and 33% for American Indian or Alaskan Native. In every racial group, men had higher proportions than women intending to major in S&E fields.

According to the National Science Foundation (2014), data showed 63% of students who enrolled in S&E six years earlier in academic year 2003-04 earned Bachelor's degrees in stated or other S&E fields. Science and engineering degree completion is higher for agricultural, biological and social sciences than physical and computer science and mathematics. In general, for the past 10 years NSF data shows that bachelor's degrees in S&E fields account for approximately 33% of all degrees earned. Of those, women U.S. citizens and permanent residents earn about 50% of all S&E majors (NSF, 2014a). However, it is important to note the inclusion of social sciences as S&E majors in this data. Women show a track of earning more degrees in S&E fields relating to agricultural sciences, biological sciences, psychology, and other social sciences fields, in contrast, men show a track of earning more degrees in computer science, engineering and physics.

According to the NSB (2014), data of students earning bachelor's degrees in S&E by race has changed over the years. The data, shown in Figures 4 and 5, is adjusted based on population changes and the rate of minority groups attending college. By race, S&E bachelor's degree trends from 2000 to 2011 are as follows: white students decreasing from 71% to 63% but still the majority; Hispanic students increasing from 7% to 10%; Asian and Pacific Islanders increasing from 9% to 10%; Black students remain constant at 9%; and American Indian or Alaska Native students remain constant at 1%. Students of unknown or undeclared races tripled in the same period. Since 2000, the overall S&E degrees earned by minority groups have risen. However, as figures 4 and 5 demonstrate, the gap in Bachelor's degree attainment in S&E and other fields is still very wide between underrepresented minority students and white students. According to NSF this is due to the following factors: high school completion rates, college enrollment rates, and college persistence rates. The data suggests that legislation and initiatives to bridge this attainment gap is not having the intended effect.

STEM Initiatives & Legislation

Since the 1950s, the national legislation and initiatives have advanced the STEM education agenda to its current status. Efforts have been more pronounced during the beginning of the space race and last fifteen years of the digital revolution clearly demonstrating the nation's response to global competition. Of the 28 most notable STEM education related highlights (Table 4) since the 1950s, half have occurred in the New Millennium. The list certainly is not exhaustive, however, it accurately reflects the timeline trends that have propelled the STEM education agenda into its current, all-encompassing focus, which is reflected in the most recent mutation of the acronym, STEAM, to include the arts.

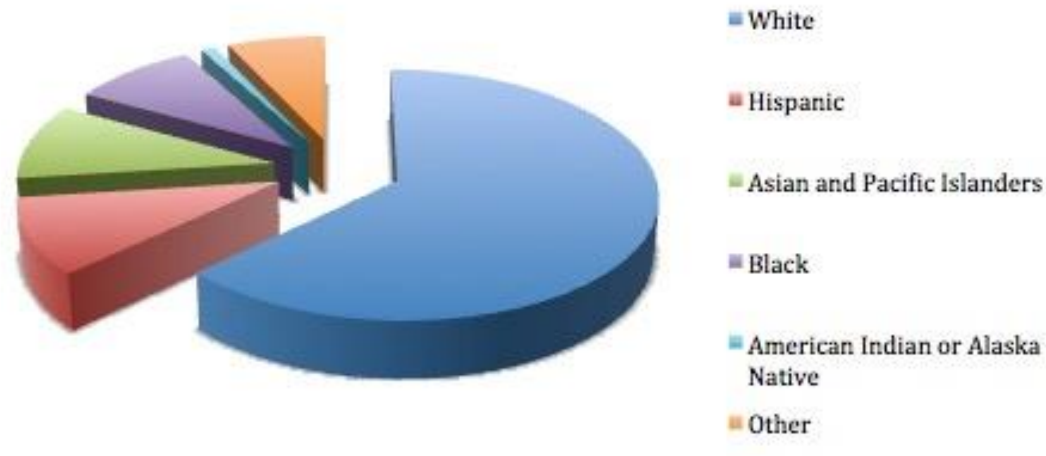

Figure 4. Science and engineering bachelor's degrees earned by ethnicity in 2011. Adapted from "STEM Education Data and Trends: How Many Undergraduate Students," by National Science Foundation, 2014b, Retrieved from http://www.nsf.gov/nsb/sei/edTool/data/college-02.html. Copyright 2014 by National Science Foundation.

Tying these efforts together is the intent to create a consorted effort toward the nation's prosperity. Whether it is national defense, research and development, environmental sustainability, the space race, innovation, or any other national concern, the inherent common theme in all these initiatives is a focus on comparative standing. What is important to global competitors is important to the nation and vice versa. This notion suggests that the national agenda is in fact a reflection of the global agenda. Also inherent in most efforts is the bringing together of specialties to form a group or task force with a mission of either oversight or action planning and development. These efforts highlight the collaborative strategies long used to increase quality and productivity.

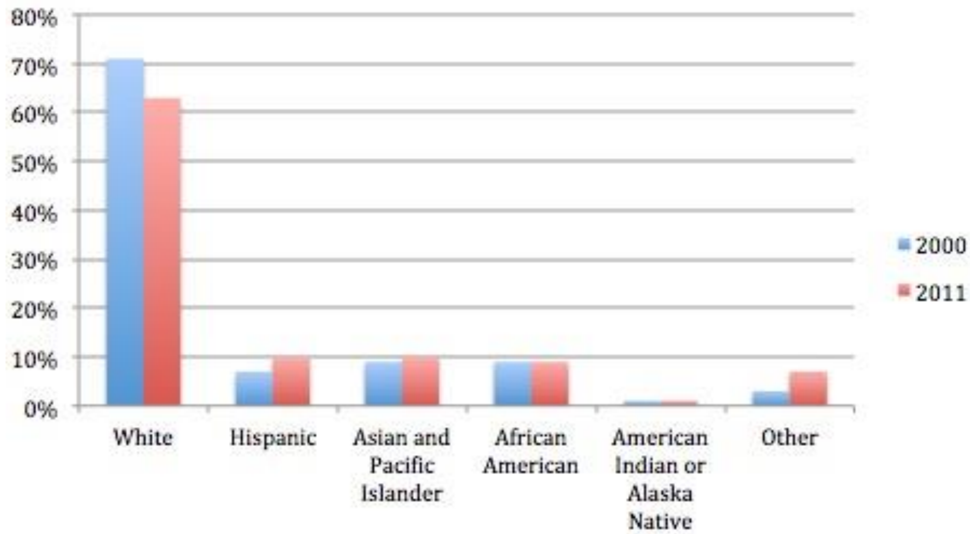

Figure 5. Difference in S & E bachelor's degrees earned by ethnicity from 2000 to 2001. Adapted from "Science and Engineering Indicators", by National Science Foundation). Copyright 2014 by National Science Foundation.

The most common view of collaboration involves 'working together toward a shared goal.' However, some researchers such as Hansen (2009) have suggested that there are varied forms of collaboration and that collaboration can be bad if not properly directed and executed. Collaboration in STEM has, prior to the new millennium, been limited to politicians and highly engaged STEM specific professionals. The more recent focus on collaboration in STEM education parallels Hansen's first step of disciplined collaboration, which focuses on evaluating opportunities for collaboration. Evaluating opportunities for collaboration in STEM education has enhanced the need for collaboration by expanding the pool of valuable collaborators.

Table 4

Legislation and Initiatives Forwarding the STEM Education Agenda

Date	Event
1950	The National Science Foundation (NSF) and National Science Board (NSB) were founded by congress
1957	Bureau of the Budget requested a Federal Financial Support of Physical Facilities and Major Equipment for the Conduct of Scientific Research report to examine the conditions and capacities of higher education laboratory facilities (in anticipation of the large Baby Boom college student enrollment)
1958	The National Aeronautics and Space Administration (NASA) was created
1958	National Defense Education Act of 1958 emphasizing science education administered out of the US Office of Education
1959	Sputnik-sparked competition resulted in tripled NSF budget
1962	President Kennedy appointed an Office of Science relieving the NSF from Federal Science Policy coordination
1965	Elementary and Secondary Education Act (ESEA)
1968	Rapid funding decline for NSF & related programs lasting until around 1978
1983	*A Nation at Risk: The Imperative for Education Reform* published by President Ronald Reagan's National Commission on Excellence in Education
1985	Triangle Coalition for STEM Education formed
1988	The National Center on Education and the Economy (NCEE) created
1990	US Ranked #1 in Four-Year Degree Attainment for 25-34 year olds
1993	NSTC established by executive order
2000	Alliance for Science & Technology Research in America (ASTRA) founded. Publish ‘report cards’ for STEM by state
2001	STEM Education Coalition formed
2001	No Child Left Behind Act (NCLB)
2002	Institute of Education Sciences (IES) created as part of the Education Sciences Reform Act of 2002. Houses National Center for Education Statistics (NCES), which conducts The Nation’s Report Card.
2005	STEM Education Caucus Founded by Rep. Vernon Ehlers (Senate)
2007	*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* published
2007	America Competes Act becomes law
2008	21st Century Partnership for STEM Education (21PSTEM) created
2009	Educate to Innovate introduced President Obama’s campaign supporting STEM
2009	Connect A Million Minds (CAMM) created to inspire student interest in STEM
2011	America Competes Reauthorization Act of 2010 becomes law
2011	100kin10 Organization formed between 28 organizations to improve STEM education by increasing the number of qualified STEM educators by 100,000 over the next 10 years
2014	US Ranked #12 in Four-Year Degree Attainment for 25-34 year olds
2014	As part of the Educate to Innovate initiative, the Obama administration coordinated with over 200 organizations, as part of the 100k in10 Initiative, to raise $28 million
2015	STEM Coalition Supports Passage of the STEM Education Act, which will broaden the definition of STEM subjects, increase NSF research capabilities, and increase extracurricular programs.

Growing Emphasis on Collaboration for Best Practice

STEM 2.0-An Imperative for Our Future Workforce is a publication by STEMconnector's Innovation Task Force (2014) that looks to connect stakeholders for the future success of STEM. Among the stakeholders identified are the education community and industry. In addressing the current state of STEM, it highlights that:

> Across government, industry, the non-profit community, and educational institutions, a consensus has been reached; the United States must develop a sustainable system that develops human capital equipped with knowledge and expertise in the fields of science, technology, engineering and mathematics (STEM). The commitment and passion for STEM transcends both political party and state lines, as it is the one public-policy issue Americans can generally agree upon. There is a unique opportunity to seize upon the momentum built in recent years and transform discourse into solutions. (Klelnbach-Sauter & Fraser, 2014, p. 5)

Within the discussion of higher education's role in meeting the STEM 2.0 objectives, Denson and Kanter (2014) state:

> We in higher education are judged by the quality of our graduates. We are also accountable for educating students in K-12, through our teacher preparation programs. For STEM 2.0 to become our new reality, we must ensure that students at every level can succeed and, in doing so, we will expand the "zone of opportunity" for students and businesses. We must lead in tackling these challenges and contributing solutions for success! (p. 27)

As a national leader in STEM education, Massachusetts also launched a collaboration focused STEM Plan 2.0, Expanding the Pipeline for All: Massachusetts' Plan for Excellence in STEM Education, which “provides policymakers, educators, businesses, and parents with a common vision on how to move forward together to create a STEM literate citizenry that is informed and prepared to fill the needs of a new and ever changing innovative economy” (Massachusetts Department of Higher Education, 2013, para. 2). Also emphasizing the need for collaboration, the STEM Education Caucus states that:

> Effective science, technology, engineering and mathematics (STEM) education is critical. The STEM ED Caucus seeks to strengthen STEM education at all levels (K-12, higher education, and workforce) by providing a forum for Congress and the science, education and business communities to discuss challenges, problems, and solutions related to STEM education. (STEM Education Caucus, n.d., Why Was section, para. 7)

According to the Caucus:

> Science, technology, engineering and mathematics (STEM) education is responsible for providing our country with three kinds of intellectual capital: scientists and engineers who will continue the research and development that is central to the economic growth of our country, technologically proficient workers who are capable of dealing with the demands of a science based, high technology workforce; and scientifically literate voters and citizens who make intelligent decisions about public policy and who understand the world around them. (STEM Education Caucus, n.d., Why Was section, paras. 5-6)

The value of collaboration has been echoed by research on student success. A policy report developed by members of the ACT (2004) to examine non-academic and academic factors that effects postsecondary retention found that non-academic factors were more significant than was represented by programming efforts. "Our findings indicate that the non-academic factors of academic-related skills, academic self-confidence, academic goals, institutional commitment, social support, certain contextual influences (institutional selectivity and financial support), and social involvement all had a positive relationship to retention" (Lotkowski, Robbins, & Noeth, 2004, p. vii). The main tenant of the report being the allocation of resources toward efforts that effectively retain students to degree completion, it went on to emphasize the importance of addressing non-academic factors in policy decisions and program design.

> Our findings have significant implications for designing effective retention programs. Although many programs rely on traditional academic factors to identify students at risk of dropping out, our findings suggest that this approach may be limited and may miss students who are at risk due to other, non-academic factors. Students who master course content but fail to develop adequate academic self-confidence, academic goals, institutional commitment, and social support and involvement may still be at risk of dropping out. (Lotkowski, et al., 2004, p. vii).

The success of initiatives is increasingly being observed through changes, not just in areas of curriculum and instruction, but as campus-wide efforts involving collaboration from many departments to affect campus culture. This is especially important for minority student and faculty retention.

> If the changes are to be effective and sustained, institutional leaders must be involved . . . Doing so means evaluating student access, diversity, and learning and successfully recruiting and supporting faculty and administrators from diverse backgrounds. For

> faculty and administrators, several questions need to be asked: Are we helping them to network? Have we identified strong mentors and highlighted effective mentoring practices? Have we identified what they need to do to succeed in their positions? Institutions must also use valid and reliable measures-such as focus groups, questionnaires, and conversations among people--to help assess the progress of institutional transformation and inclusive excellence. (Hrabowski & Maton, 2009, Fundamentals section, para. 3)

Ohland and Anderson (1999), two chemical engineers under a NSF funded postdoctoral fellowship, demonstrate the need for cross campus collaborations when they referenced Tinto, Astin, and Chickering in their research on program contribution toward student success. The types of programs they included are mentoring programs, summer residential programs, and engineering orientation programs. "College and university personnel must answer questions such as, "does this program help students? Or does this program help students better than the one we used to use" (Ohland & Anderson, 1999, Motivation section, para. 2). Questions such as these cannot be answered in isolation, it is increasingly being noted that collaborations between student and academic services as well as faculty and higher administration need to pool their intellectual, financial, and personnel resources in order to achieve lasting and meaningful results. Hence, the current STEM education agenda will require the participation of diverse and knowledgeable administration, faculty, and staff. In a response to the NSF's call for the new generation of STEM research by 2020, Roth & Van Eijck (2010) discuss the meaning of STEM learning for the lifespan.

When a person facing a problem does not know what to do, s/he orients to engage others

> so that collectively they may learn, produce knowledge ability (an ability to learn) and thereby a solution. This means that it is more important to be able to participate in conversations in which STEM knowledge is available and mobilized in and through collective endeavors. (p. 1028)
>
> Knowlegeability, creative coping (debrouillardise), and productive contribution to collective endeavors were the key ingredients to successful mobilization of knowledge and STEM learning. (p. 1033)

With the steady realization that collaboration is the key to success in such a vast undertaking as developing a STEM literate citizenry or even opening access channels for success in STEM fields, many college and universities have set the stage by publishing and reporting on their successful collaborative initiatives. Anzalone (2014) describes one such effort in the UB Reporter, The University of Buffalo's faculty and staff newsletter. The article, titled "Collaborations' Key to UB's STEM Education Success," details the university's Graduate School of Education's collaboration with the Niagara Falls City School District to advance their STEM education reform. "The Niagara Falls STEM classrooms - part of a nearly $67 million district-wide, three-year capital project called "Inventing Tomorrow" - are evidence of the university's strong commitment to work with the local community in education context that cross grade levels, campuses and disciplines" (Anzalone, 2014, para. 14). A similar effort put forth by the UC San Diego called the CREATE STEM Success Initiative also demonstrates the need for multi-level collaborations.

> In the CREATE STEM Success Initiative, we at CREATE (The Center for Research on Educational Equity, Assessment, and Teaching Excellence) are exploring with hundreds

> of colleagues, students, and community partners how a university can be a resource hub for leveraging local opportunities to learn for high-need student and teachers (K-20) in Science, Technology, Engineering, and Math (STEM). This campus wide effort, launched in July 2013 by chancellor Khosla, synergized months of input from UCSD faculty, staff, and students, and San Diego STEM educators, on strategies for collective local impact on the k-20 STEM pipeline (CREATE, n.d., p. 1)

These initiatives and their outcomes highlight the importance of the President's call for an "all hands on deck" approach to meeting the national agenda of producing a STEM literate citizenry.

The Chronicle of Higher Education

History

The Chronicle of Higher Education shares it beginnings with STEM education agenda. It was after headlines revealed the launch of Sputnik in 1957 that Corbin Gwaltney, the first chief editor the CHE, along with the Editorial Projects board developed a plan for "a publication that would make a lot of the existing reading material unnecessary" (Baldwin, 1995, p. 4). The CHE did not begin as a newspaper, instead it was a supplement, the "Moonshooter Report," that was bound into existing university alumni magazines with the first issue titled U.S. Higher Education 1958 with circulation over one million (Baldwin, 1995). Due to the success and interest in the report, circulation tripled by the third year and Gwaltney left John's Hopkins to work full-time for what then became the Editorial Projects for Education (EPE) (Baldwin, 1995). Following a survey of the higher education community on its need for information, a newsletter for trustees called the 15-Minute Report was created (Baldwin, 1995). Once it was apparent that not only trustees but also administrators were reading the reports, the team decided that higher education needed a publication to call its own. It was this realization that led to the launch of the *Chronicle of Higher Education* in November of 1966 (Baldwin, 1995; Carnegie Corporation, 2006).

Funding

Funding began with a pledge from each of the initial alumni magazine editors for the Moonshooter. With interest in the supplement higher than they originally thought, they sold over 1 million copies, which allowed them to return a $12,500 grant from the Carnegie Corporation (Baldwin, 1995). The Carnegie Corporation later contributed $25,000 for Ronald Wolk's (volunteer chairman of EPE) trip around the county to survey educators about the need for information. The resulting report from the survey led to a $68,000 grant from the Carnegie Corporation for the publication of the 15-Minute Report for trustees (Baldwin, 1995). As the EPE team learned of the high readership among administrators, they took the idea for the *Chronicle of Higher Education* to the Carnegie Corporation. It was agreed that there was a need and the *Chronicle* was backed with a $120,000 two-year grant in 1965 (Baldwin, 1995), which was renewed at $100,000 in 1967 (Carnegie Corporation, 2006). This was followed by a $300,000 grant by the Ford Foundation in 1969 and a $152,000 grant by the Carnegie Foundation in 1973; the *Chronicle* went from being non-profit to for-profit in 1978 (Carnegie Corporation, 2006).

Circulation and Readership

"Ask any group of academic administrators what publication they consider the essential current-awareness tool for events in academe, and the answer is bound to be the *Chronicle of Higher Education*" (Rice & Paster, 1990, p. 285). This sentiment is echoed by any account of the *Chronicle's* readership (Carnegie Corporation of New York, 2006; Baldwin, 1995; Groennings, Griswold, Wyatt-Woodruff, & Gregg, 1991; Boyles, 1988). "The *Chronicle's* market penetration extends well beyond top academic levels to include department chairs, computer center directors, student service personnel, development officers, professors of education, faculty job-hunters, and librarians (to name just a few)" (Rice & Paster, 1990, p. 285). Further, since it early years the *Chronicle* has evolved its awareness to bridge the gap and expand its dedicated readership. In an interview with Connell and Yarrington, editor Philip Semas stated:

> When I came here the *Chronicle* was very much an administrator-oriented publication. Over the years we've tried to move more and more in the direction of covering the intellectual, academic discipline type of issues, with mixed success, I'd say. We're not going to try to compete with the New York Review of Books or the scholarly journals, but the *Chronicle* has always operated partly on the theory that the guy over in the history department might have some interest in what's going on in the physics department, or might at least want to know . . . enough to be able to sit in the faculty club with somebody besides the people in (his) own department and carry on an intelligent conversation. (as cited in Rice & Paster, 1990, p. 290)

The *Chronicle* has a readership of over 315,000 and over 64,000 academics are subscribers ("About the Chronicle," 2015). It is published in both print and digital formats. The print format contains two sections, one with news and jobs and the other with the *Chronicle Review*. In the digital format, only the latest issue is fully available with a selection of archived information from previous issues. The digital format contains a selection of articles that are available to the public and a selection of articles that are only available to subscribers. "The *Chronicle's* web site features the complete contents of the latest issue; daily news and advice columns; thousands of current job listings; an archive of previously published content; vibrant discussion forums; and career-building tools such as online CV management, salary databases, and more" ("About the Chronicle," 2015). There are "more than 70 writers, editors and international correspondents" ("About the Chronicle," 2015) that are responsible for its coverage. Currently, 45 issues of the *Chronicle* are published every year ("About the Chronicle," 2015), comparing historically to 22-49 issues per year (Baldwin, 1995). Online, the website has an audited traffic of more than 12.8 million pages per month with "more than 1.9 million unique visitors" ("About the Chronicle," 2015).

The website features the following sections: Home, News, Global, Opinion & Ideas, Facts & Figures, Blogs, Advice, Forums, and Jobs. There is also a search tool that allows readers to filter searchers by publication date, content type, topic, or section and an Events section which features professional development opportunities that readers can register for through the website. It further features an online store from which publications such as *Careers in Academe*, *The Trends Report*, and *Great Colleges to Work for* among others. The *Chronicle* is also active on Twitter and Facebook. The *Chronicle's* Facebook page, started in 2008, currently has around 90,000 'likes' and over 4,000 'people talking about this.' Their Twitter account, also started in 2008, currently has over 145,000 followers.

Content Analysis of the Chronicle of Higher Education

"We can readily see how the technique of Content Analysis may be applied to selected aspects of historical research in education" (Cohen, Manion, & Morrison, 2007, p. 197; Cohen & Manion, 1980, p. 56). Content Analysis has been used to analyze trends and themes in the *Chronicle of Higher Education*. Groennings et al. (1991) conducted a Content Analysis of the CHE to uncover trends in foreign policies of U.S. higher education institutions. Groennings et al. (1991) were primarily concerned with the intentionality of policy decisions and their basis as reactive or proactive. Groennings et al. (1991) state:

> In general, campus decision-makers have not thought systematically about the extent of their institutions' international involvements. They have not conceived of themselves as makers of foreign policy, facing issues and making policies pertaining to their relationships with foreign governments, institutions and individuals. (p. 117)

Similarly, it is the broader purpose of this study, through the agenda-setting lens, to assert that making STEM education relevant and certain to the general higher education audience may allow for innovation in initiatives through inclusion and therefore advance the national agenda. Groennings et al. (1991) go on to state, "At present this foreign policy decision-making is piece-meal, lacking coherence as it reacts to financial, political, and social pressures" (p. 117). Their analysis uncovered four policy areas including research, students, investments, and academic programs. Studying only a six-year time frame (1984-1989), they advised:

> Whenever an institution is dependent upon an external body for funding, or for favorable legal or political consideration, it becomes vulnerable to both real and perceived pressures. Failure to anticipate international issues leads to overreaction, inconsistency, and decision-making without the benefit of carefully considered options. (Groennings et al., 1991, p. 125)

Groennings et al. (1991) concluded, “there is a growing need to incorporate foreign policy into the institutional strategic planning process, linking international decisions to the overall mission and goals of the institution” (p. 125). The ability to reach this conclusion from a Content Analysis of the CHE aligns with the purpose of the current study. Through categorization of themes and their presentation in this medium, a conclusion about the salience of issues and the possible effects of underrepresentation or isolation of information is discussed.

Boyles (1988) conducted a Content Analysis of the CHE from 1970-1985 to profile the field of institutional research. Focusing on only the “Bulletin Board” section now known as the “Jobs” section, the researcher analyzed over 700 ads for institutional research positions. Through a comparison between information in the CHE ads and an analysis of the literature in the field, he concluded that, “literature has presented a fairly accurate portrayal of institutional research. However, the academic community outside institutional research is still in the dark as to what IR does and what it can do for them” (Boyles, 1988, p. 213). He discusses two potential reasons for this “institutional research offices may not do a good job of public relations to inform potential users of their existence…the exposure to institutional research literature is limited outside the field” (Boyles, 1988, p. 213). He goes on to highlight the implications of this disparity:

> The education of the individuals being sought for the positions in the recent past indicates that the field has become narrower in scope . . . There may be resistance to individuals with different and unusual educational backgrounds in the profession . . . Individuals with educational training in institutional research, higher education, or education may have an advantage over their competition with training in other fields . . . institutional research as a profession may be skewed toward individuals with backgrounds in certain fields. (Boyles, 1988, p. 213-214)

Boyles (1988) suggests that institutional research offices may not be using all their human capital and other resources to fulfill their purpose 'in house' and often end up using consulting firms at high prices to do the thinking and planning that follows the research. The conceptualization of this research parallels the current study in that it suggests that broad exposure to key information is critical to expanding the pool of diverse knowledge and experience that can be capitalized on for more effective functioning.

Rice and Paster (1990) conducted a Content Analysis of the *Chronicle* to determine the extent and quality of library news coverage, specifically, "to address the adequacy of its library news coverage" (p. 285). They state, "The *Chronicle of Higher Education* is a unique source for news information about current events and trends in academe" (Rice & Paster, 1990, p. 285). An initial survey of librarians revealed a dedicated and extensive readership of the *Chronicle*. However, when the same professionals were asked to rate the quality of the *Chronicle's* reporting on their profession, "the academic library scene" (Rice & Paster, 1990, p. 285), their response signified that they were less than satisfied. Following an analysis of the following:

> 661 library-related articles published by the *Chronicle* between 1966 and 1988. They found that, although coverage has increased dramatically over the past two and a half decades, the *Chronicle's* focus tends to be elitist. Nonetheless, it remains a significant source of academic library information for the higher education community. (Rice & Paster, 1990, p. 285)

As part of their analysis of 'adequacy', the researchers give an account of the growth in library-related events that may have contributed to their observation of the growth in the *Chronicle's* reporting. Rice and Paster (1990) note:

> Although some critics of the modern scene like to say that news is a fabrication of the media, only the most cynical would deny a close relationship between events and what gets reported. Thus it is reasonable to ascribe part of the surge in library-related coverage to things that were happening at the time. (p. 287)

Further, their conclusion highlights some important parallels with the aim of the current study. For example, in their explanation of the *Chronicle's* elitist focus they state "elitism, inattention to the people who provide services, and an apparent lack of excitement about current developments in technology constitute the down side" (Rice & Paster, 1990, p. 289), the up side being the *Chronicle's* growth in reporting and expected level of attention to happenings in "Washington, the Library of congress, and ARL libraries" (Rice & Paster, 1990, p. 289). They further state:

> What is needed, however, is more attention to the broad spectrum of academic libraries, including the professionals who staff them. In its automation coverage the *Chronicle* should acknowledge the CD-ROM revolution-a genuine library hot topic for at least two

> years now. Also needed is some insightful analysis (as opposed to straight reporting) of networking, plus discussion about the effect that all the bells and whistles are having on scholarship and instruction. (Rice & Paster, 1990, p. 289)

After discussing the alignment of the *Chronicle's* growing attention to the broadening of its readership and their suggestion for inclusion of, what seem to summarize as application or professional trends, they close by saying:

> We obviously do not expect the *Chronicle* to cover academic libraries to the same depth or with the same attention to nuance that is possible in our own professional literature. But we hope that, with our help, the *Chronicle* can expand its already significant effort at bringing academic library news to the broader higher education community. (Rice & Paster, 1990, p. 290).

CHAPTER 3
METHODS

Study Design Overview

This study used both qualitative and quantitative Content Analysis methods to uncover and interpret the presence or absence of themes and report their frequencies of occurrence. A sample of text was chosen to best answer the proposed research questions and meet the research study goals. The sample was chosen according to the detailed steps outlined below. Further, the Content Analysis steps and procedures developed by Zhang and Wildemuth (2009) are described below and were adhered to so that the research method may be deemed sound and appropriate conclusions may be drawn.

Sampling

This study used relevance sampling, also called purposive sampling. Relevance sampling "aims at selecting all textual units that contribute to answering given research questions" (Krippendorff, 2013, p. 120). In relevance sampling, the researcher conducts a surface or multilevel analysis of text units in order to include those that relate to the research questions (Krippendorff, 2013). This study entailed a multilevel analysis for relevance sampling with the following steps and their rationale:

1. A news medium was selected instead of an academic journal. As this study focuses on the represented salience of STEM education to the higher education community, an analysis of an academic journal may not yield results past those who are already 'engaged' in STEM education. That is, a sample of academic journals would be useful to

determine the salience of STEM education academic literature. However, it would not be useful to determine the salience of the STEM education agenda as it is presented to the higher education community/audience and as it relates to the ASCT framework used in this study.

2. The CHE was selected instead of a non-audience specific newspaper, such as the *New York Times*, or STEM education audience specific newspaper, such as Triangle Coalition for STEM Education. The *Chronicle* was selected for its broad readership, long history, and recognition. Since the *Chronicle* was created as a response to the scarcity of comprehensive reporting on higher education news, it is an ideal venue for narrowing in on the readership intending to further knowledge of current events in higher education. Also, since the *Chronicle* is recognized as the leading source of news for higher education, an analysis of the salience of STEM education in its reporting speaks to the general orientation of the higher education community towards STEM education. A STEM education specific news medium may not yield results past those who are already oriented toward STEM.
3. Only STEM education news was selected instead of all published articles. The research questions target the CHE's orienting capacity toward STEM education and are not attempting to capture the nuances of the CHE's agenda.
4. Articles published between January 2001 and March of 2015 were selected. These data were chosen to parallel the national STEM education agenda in the New Millennium.
5. Only articles that arise from a search for STEM, and include any word under the acronym (science, technology, engineering, mathematics) were selected.

6. After an analysis of each article, only articles relating to STEM education will be selected. An example of an article that was excluded is “Judge Rejects Stem-Cell Challenge” (June, 2006).

<u>Content Analysis</u>

“Content Analysis is perhaps the fastest-growing technique in quantitative research” (Neuendorf, 2002, p. 1). Although beginning in journalism and communication research, the methodology has branched out to many academic areas including the social sciences, law and health-care (Krippendorff, 2013; Neuendorf, 2002). According to Neuendorf (2002), “Content Analysis may be defined as the systematic, objective, quantitative analysis of message characteristics” (p. 1).

> The term Content Analysis is not reserved for studies of mass media or for any other type of message content. So long as other pertinent characteristics apply (e.g., quantitative, summarizing), the study of any type of message pool may be deemed a content analysis. (Neuendorf, 2002, p. 17)

According to Zheng and Wildemuth (2009), “many current studies use qualitative content analysis, which addresses some of the weaknesses of the quantitative approach” (p. 1). As with quantitative content analysis, there is more than one definition of qualitative content analysis. According to Hsieh and Shannon (2005), qualitative Content Analysis is “a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (p.1278). Zheng and Wildemuth (2009) state, “qualitative Content Analysis goes beyond merely counting words or extracting objective content from texts to examine meanings, themes, and patterns that may be manifest or latent in a particular text" (p. 1).

Quantitative vs. Qualitative

Due to the nature of content analysis, the distinction between qualitative and quantitative studies becomes imperfect. While there are some researchers who hold that it is possible to conduct a true qualitative content analysis, others disagree. "Although some authors maintain that a non-quantitative (i.e., "qualitative") Content Analysis is feasible, that is not the view presented in this book" (Neuendorf, 2002, p. 14). "A Content Analysis summarizes rather than reports all details concerning a message set" (Neuendorf, 2002, p. 15). The debate over qualitative vs. quantitative Content Analysis is long lived. Some researchers have held firm to their view that it is one or the other. Whereas, others have suggested that the nature of Content Analysis allows for a blend of the two approaches (Smith, 1975; Weber, 1990). They discuss that for Content Analysis to reach meaningful and significant conclusions, it uses aspects of both qualitative research and quantitative research. Simply stated, there seems to be a qualitative mechanism that naturally underlies the inferences that lead to the decision of which communication units should be quantified. Further, qualitative methods can provide context that enriches the research and allows more meaningful conclusions to be drawn.

There are, however, key differences in the two approaches that are important to identify early in the research. Quantitative content analysis usually

> Requires that data are selected using random sampling or other probabilistic approaches, so as to ensure the validity of statistical inference. By contrast, samples for qualitative

> Content Analysis usually consist of purposely selected text which can inform the research questions being investigated. (Zhang & Wildemuth, 2009, p. 2)

Another important difference is tin he results that are produced by each method. Quantitative content analysis "produces numbers that can be manipulated with various statistical methods [whereas] the qualitative approach usually produces descriptions or typologies, along with expressions from subjects reflecting how they view the social world" (Zhang & Wildemuth, 2009, p. 2).

Given the goals of the current study, the best approach was a combination of both methods to produce results that account for the emergence of themes and categories, their frequencies and their meanings. The reported frequencies of themes were better understood when accompanied by descriptions of interferences that will made throughout the research process. Further, the mere fact that themes were inferred from varying chucks of text, yet data will also be reported using frequencies and statistical testing, required that this research study employ both quantitative and qualitative methods.

Steps in Content Analysis Design

This research study used the Content Analysis design steps identified by Zhang & Wildemuth (2009)

1. Prepare the data: Involves turning any non-text data into text and justifying choice of text data. This step is usually most informed by the research questions.

2. Define the unit of analysis: “The unit of analysis refers to the basic unit of text to be classified during content analysis” (p. 3). The unit of analysis may be themes, word utterances, sentence, paragraph, etc. “An instance of a theme might be expressed in a single word, a phrase, a sentence, a paragraph, or an entire document” (p. 3).
3. Develop categories and a coding scheme: Involves deriving categories and coding schemes using the data or other sources. “Coding schemes can be developed both inductively and deductively” (p. 3). When inductively forming categories from data, the constant comparative method should be used. “The essence of the constant comparative method is (1) the systematic comparison of each text assigned to a category with each of those already assigned to that category, in order to fully understand the theoretical properties of the category; and (2) integrating categories and their properties through the development of interpretive memos” (p. 4).
4. Test coding scheme on a sample of text: Involves coding a sample of the data according to the developed coding scheme and then checking for consistency, using more than one coder to establish inter-coder agreement. This process repeats until coder agreement is reached and the coding scheme is consistent.
5. Code all the text: Involves using the developed coding scheme to code the entire data sample. Consistency should be checked continuously. New themes and categories may be added and checked as they emerge.
6. Assess coding consistency: Involves a final recheck of the coding consistency for the possibility of human error or change in the understanding of the coding rules.

7. Draw conclusions from the coded data: "This step involves making sense of themes or categories identified, and their properties. At this stage you will make inferences and present your reconstructions of meanings derived from the data" (p. 5).
8. Report methods and findings: This step is guided by the research questions and goals. A "balance between description and interpretation" (p. 5) should be present. For quantitative methods, counts and statistical significance are presented. Whereas, qualitative methods will "uncover patterns, themes, and categories" (p. 5). Further, "interpretation represents your personal understanding of the phenomenon under study" (p. 5).

Data Analysis

The following is a description of data analysis by research question.

- What is the frequency of reporting on STEM education in the *Chronicle of Higher Education* from January 2001 to March of 2015?
- Data answering RQ 1 was reported with frequency tables and charts for all years and a Chi-square to discern significant differences between the years. This research question involved the 'object,' STEM education, under the developed ASCT model.
- What themes in STEM education appear in the *Chronicle of Higher Education* from January 2001 to March of 2015?
- Data answering RQ 2 was reported with frequency tables and charts for each theme by year and a Chi-square test will be conducted to discern significant differences between the frequencies of themes by year. An over-time trend was depicted to show changes in

frequencies for each theme between the years. This research question involved the set and emerging ‘attributes’ under the developed ASCT model.

- What is the frequency of reporting on the need for collaborative ein STEM education in the *Chronicle of Higher Education* from January 2001 to March 2015?
- Data answering RQ 3 was reported using frequency tables and charts for each year as well as a Chi-square to discern significant differences between the years. This research question aimed to target the ‘need for orientation’ as a function of ‘relevance’ under the proposed ASCT model.

Limitations

Content Analysis as a research method is consistent with the goals and standards of survey research. In a content analysis, an attempt is made to measure all variables as they naturally or normally occur. Just as the self-report nature of most surveys calls into question the objectivity and validity of their measures, so, too, the involvement of human decision makers in the content analysis process calls into question the validity of the coding or dictionary construction. In short, the content analysis enjoys the typical advantages of survey research and usually suffers its drawbacks as well. (Neuendorf, 2002, p. 49).

This limitation represents the subjectivity that was used when deciding both which articles were relevant to include in the sample and also to determine the coding scheme used for data analysis. As discussed in detail in Chapter 4, although measures were taken to ensure that the data reflected the research questions and that the coding was representative of the sample characteristics, this qualitative part of the Content Analysis was still subject to the researcher’s subjectivity. This study is further limited by use of a purposive sample as only select years were examined within a specific publication, the *Chronicle of Higher Education*. The publication was central to the research purpose and the years were chosen to parallel the STEM national agenda efforts. Further, only articles that were found using the UCF library database search engine were included in the sample. Thus, they may not be an exhaustive representation of the *Chronicle's* reporting. Other limitations include the ability to statistically analyze the data. However, these limitations are discussed at length in Chapter 4.

Institutional Review Board

This study does not pose any risk to human participants. However, approval was still obtained from the University of Central Florida's Institutional Review Board (IRB). The approval letter is provided in Appendix B.

Originality Score

To ensure the originality of this work, this manuscript was submitted to iThenticate by my dissertation chair. The results were discussed with the dissertation committee members on the date of the defense.

CHAPTER 4
RESULTS

Introduction

This study involved a content analysis of articles published in the *Chronicle of Higher Education*. Prior to reaching the data collection phase of the study, only articles published through March of 2015 were available. However, since all articles published in 2015 were available at the point of data collection, to accurately represent the year 2015, articles published between January 2001 and December 2015 were included in the sample. The articles were found electronically using the University of Central Florida Library's database search tools. Initially, a search was conducted using ERIC (EBSCOhost) for articles with *Chronicle of Higher Education* as the source and STEM as the second search term. Approximately 38% of the articles found were in reference to stem cells. Stem cell articles refer to the medical/biological term and not the acronym STEM standing for Science, Technology, Engineering, and Mathematics and are not relevant to this study research. A second search was conducted, removing the term 'cell/s' from the results. This search limited the results to 30 articles. The researcher conducted a final search, selecting all 91 databases available through the UCF library while keeping the *Chronicle of Higher Education* as the source, STEM as the second search term (excluding the terms cell/s). This search returned 499 articles. After removing all 359 exact duplicates (some articles were present more than twice), 140 articles remained for review. Of these articles, 63 were relevant and were included in the data analysis. Relevance was determined by the article's focus on STEM or Science, Technology, Engineering, Mathematics. The 63 articles included in the sample are detailed in Appendix C. The remaining 77 articles excluded from the sample are detailed in Appendix D.

Steps of Analysis

Every measure was taken to adhere to the steps of content analysis design detailed in Chapter 3. The following is an explanation of the specific procedures for each of the eight steps.

1. Prepare the data: The data used in this study were taken from the *Chronicle of Higher Education*. The *Chronicle* was chosen because it is the primary news source for the higher education community and, as such, is the optimal source of data for answering the research questions stated in Chapter 1.
2. Define the unit of analysis: Each selected article was, in its entirety, a unit of analysis. Although articles were selected through the use of key words, STEM, Science, Technology, Engineering, and Mathematics, they were examined as a whole in order to derive the themes presented in this study.
3. Develop categories and a coding scheme: A constant comparative method was used in order to inductively arrive at the themes presented in this analysis. Upon reading an article, a descriptive category was assigned and reasoning notes were taken. An example of notes includes: briefly discussing legislation but primary focus is retention of minorities and tone is descriptive, author's main intent is to highlight the diversity gap and efforts to reduce it. For each following article, either a new category was created or the article was assigned to an established category based on a comparison of its content with the articles already in that category. Once categories were created for all of the

articles, the properties of the categories were examined, compared, and integrated in order to arrive at the final overarching themes and coding scheme presented this analysis. Thus, the themes were inductively created by first categorizing specifics of each article and then comparing those categorizes for commonalities and integrating them into larger overarching themes. Deductive reasoning was then used to break down the theme to represent each of the articles within it to assure that the progression was logically sound. An example of inductive reasoning includes first categorizing recruitment and retention of women, African American males, students with disabilities, and then combing those categories under the theme Diversity. Then, deductive reasoning was used to examine whether the category of Diversity was truly representative of the articles within it. For example, progressing from STEM education to Diversity to minority retention and recruitment to gender-gaps in recruitment and retention and so forth. The analysis and reporting of frequency of articles and themes constituted the quantitative part of this content analysis. The use of deductive and inductive methods to arrive at the themes and coding scheme constituted the qualitative part.

4. Test coding scheme on a sample of text: Due to the relatively small sample size, instead of checking for consistency among only a sample of the data, all articles were rated by both the researcher and an independent rater and the inter-rater reliability was analyzed to ensure the consistency of the coding scheme.
5. Code all the text: After a thorough examination of each of the six instances of disagreement between the raters, the researcher determined that sufficient consistency was reached in order to move forward with the analysis.

6. Assess coding consistency: The coding rules were reached following an examination of the rationale behind the integration of categories into themes. The themes were examined four times for consistency and representation of every article in the sample. A codebook was created (Appendix E) to ensure that each article was fully represented and the coding rules were clearly stated.
7. Draw conclusions from the coded data: Conclusions were drawn at several points of analysis. First, conclusions regarding categories were made, this was followed by conclusions regarding themes and, as presented in the codebook, the development of rules governing article placement. Finally, the conclusions presented in Chapter 5 were drawn following the integration of the quantitative and qualitative analysis of the data.
8. Report methods and findings: The descriptive quantitative findings appear in this chapter using frequencies, statistical analysis, and charts. The interpretative qualitative findings appear in Chapter 5, consisting of discussions and implications reached based on an integrated consideration of the data, research questions, and purpose of the study.

Inter-Rater Reliability

To evaluate and ensure the consistency of the coding scheme, both the researcher and an independent rater coded the sample of 63 articles and inter-rater reliability was determined. The researcher, following examination of the articles, developed the initial coding scheme and codebook. The codebook and instructions were then given to an independent rater in a STEM field. The rater was selected based on familiarity with STEM concepts and knowledge of STEM initiatives. The rater was provided with the codebook and instructions but was not given access to the researcher's coding. The rater was also advised to keep notes of any instance where article placement was difficult and to add any new categories or themes that emerged but were not represented by the coding scheme. Using IBM SPSS 23 statistical software, Cohen's *k* was run to determine the level of agreement between raters. There was substantial agreement between the researcher's ratings and that of the independent rater, k=.886, p<.0005 (Table 5). To determine if any changes to the coding scheme were necessary, the raters reviewed and discussed each of the six instances of disagreement. Disagreements were resolvable within the original coding scheme and the researcher's coding was used for the remainder of the analysis.

Table 5

Cohen's Kappa for Inter-Rater Reliability

Symmetric Measures					
		Value	Asymptotic Standardized Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	.886	.044	16.253	.000
N of Valid Cases		63			

<u>Research Question 1</u>

What is the frequency of reporting on STEM education in the *Chronicle of Higher Education* from January 2001 to March 2015?

Although the original research question addressed the *Chronicle's* reporting from January 2001 through March 2015, at the time of data collection, all of 2015 reporting was available for analysis. Therefore, the following results represent data collected from January 2001 through December of 2015. As displayed in Table 6, no articles were found for the years of 2001-2004 and only one article was found for 2005. Between 2006 and 2011, the number of articles ranged from 2-4. However, in 2012, the number of articles jumped to 19, representing 30% of the sample. While the number of articles decreased from 2013-2015, with a range of 8-9, they remained at least double what they had been in the first five years analyzed. Year-by-year frequencies and percentages are shown in both Table 6 and Figure 6.

Table 6

Frequencies by Year

Year By Year					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2005	1	1.6	1.6	1.6
	2006	4	6.3	6.3	7.9
	2007	2	3.2	3.2	11.1
	2008	4	6.3	6.3	17.5
	2009	2	3.2	3.2	20.6
	2010	3	4.8	4.8	25.4
	2011	3	4.8	4.8	30.2
	2012	19	30.2	30.2	60.3
	2013	9	14.3	14.3	74.6
	2014	8	12.7	12.7	87.3
	2015	8	12.7	12.7	100.0
	Total	63	100.0	100.0	

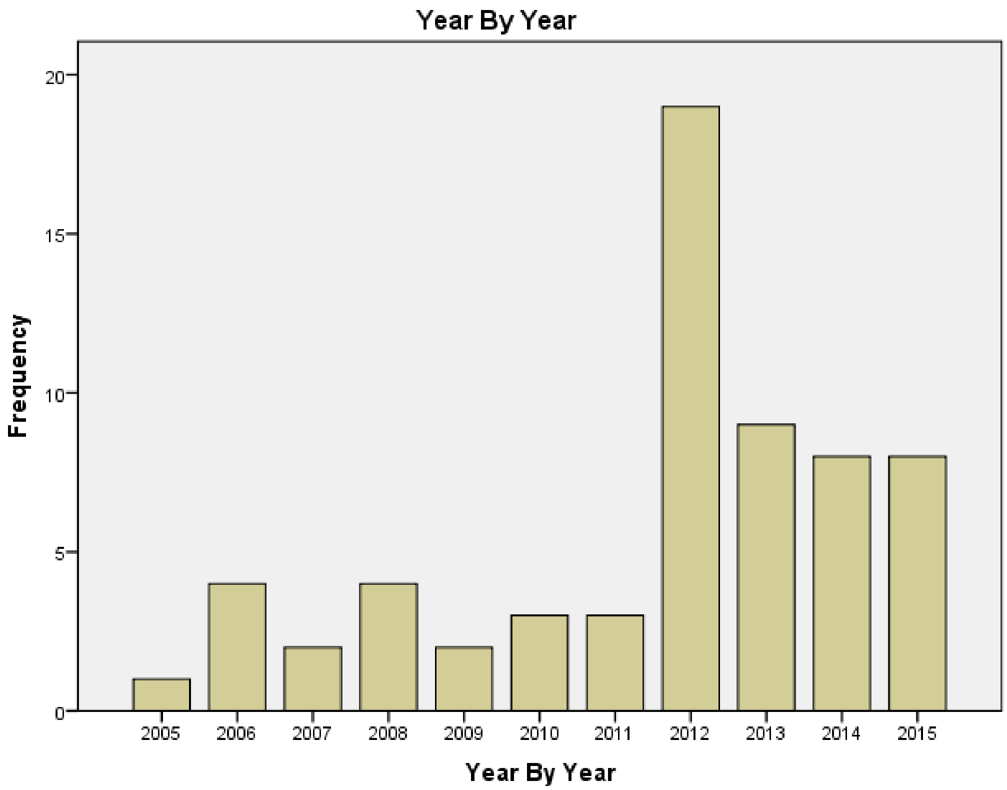

Figure 6. Year-by-year frequencies.

To determine if any significant differences exist between the article frequencies by year, the researcher originally stated that a Chi-square analysis would be conducted. However, the Chi-square goodness of fit test could not be run on the article frequency data by individual years because at least one of the assumptions of the test would be violated, making the results invalid. Based on the distribution of the data, it was possible to group the years without compromising the data, allowing for the test to be run without violating any of its assumptions. The groups that were created appropriately reflect the data trends with Group 1 between the years 2001-2005, Group 2 between the years 2006-2010, and Group 3 between the years 2011-2015. The year groupings are equal, with each group consisting of five years. The frequency of articles by groups appears in Table 7 and Figure 7. Consistent with the year-to-year data, there is only one article in the 2001-2005 group, 15 articles in the 2006-2010 group, and 47 articles in the 2011-2015 group with this group representing almost 75% of the data. A Chi-square goodness of fit test was then conducted to determine if there were significant differences between article frequencies by year groups. Table 8 shows that the expected frequency for each year group was 21, with residuals of -26, -6, and 26 respectively, showing how far the observed frequency for each group was from the expected frequency. As presented in Table 9, a significant difference was found between year groups with $X^2(2)=52.95$, $p<.0005$.

Table 7

Frequencies of Groups (Year)

Year					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2001-2005	1	1.6	1.6	1.6
	2006-2010	15	23.8	23.8	25.4
	2011-2015	47	74.6	74.6	100.0
	Total	63	100.0	100.0	

Because there is not an accurate post-hoc test for a Chi-square goodness of fit statistic, to further discern which groups differ significantly from one another, separate Chi-squares were run for each of the three possible combinations of year groupings. For Groups 1 (*N*=1) and 2 (*N*=15) the expected frequency was 8, leaving residuals of -7 and 7 respectively (Table 10). A significant difference was found (Table 11) between Groups 1 and 2 with $X^2(1)=12.25$, $p<.0005$.

Significant differences were also found between Groups 2 and 3, $X^2(1)=16.52$, $p<.0005$ (Table 13), and Groups 1 and 3, $X^2(1)=44.08$, $p<.0005$ (Table 15). Hence, there was a significant difference between each of the year groups within each progressive year, showing a significant increase in the frequency of articles relating to STEM education.

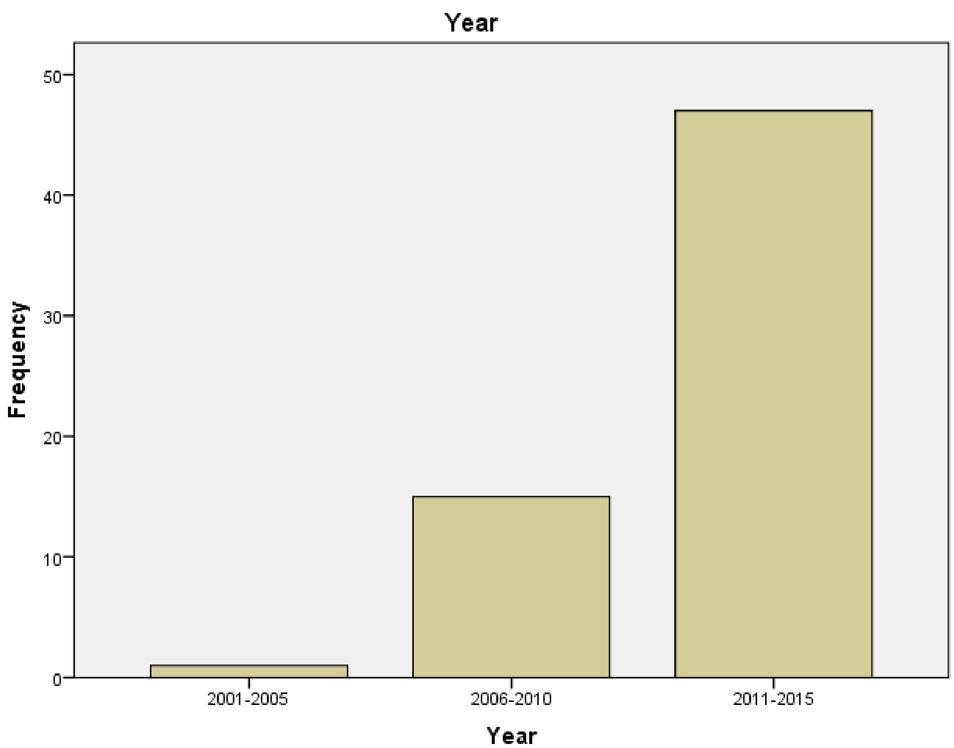

Figure 7. Year-by-year frequencies.

Table 8

Observed and Expected Frequencies by Year (Groups)

	Year		
	Observed N	Expected N	Residual
2001-2005	1	21.0	-20.0
2006-2010	15	21.0	-6.0
2011-2015	47	21.0	26.0
Total	63		

Table 9

Year Group Statistic

Test Statistics	
	Year
Chi-Square	52.952[a]
df	2
Asymp. Sig.	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 21.0.

Table 10

Observed and Expected Frequencies for Groups 1 and 2

	Groups 1 and 2		
	Observed N	Expected N	Residual
2001-2005	1	8.0	-7.0
2006-2010	15	8.0	7.0
Total	16		

Table 11

Groups 1 and 2 Statistics

Test Statistics	
	2001-2010
Chi-Square	12.250[a]
df	1
Asymp. Sig.	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.0.

Table 12

Observed and Expected Frequencies for Groups 2 and 3

Groups 2 and 3			
	Observed N	Expected N	Residual
2006-2010	15	31.0	-16.0
2011-2015	47	31.0	16.0
Total	62		

Table 13

Groups 2 and 3 Statistic

Test Statistics	
	2006-2015
Chi-Square	16.516[a]
df	1
Asymp. Sig.	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 31.0.

Table 14

Observed and Expected Frequencies for Groups 1 and 3

Groups 1 and 3			
	Observed N	Expected N	Residual
2001-2005	1	24.0	-23.0
2011-2015	47	24.0	23.0
Total	48		

Table 15

Groups 1 and 2 Statistic

Test Statistics	
	2001-2005 2011-2015
Chi-Square	44.083[a]
df	1
Asymp. Sig.	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 24.0.

Authorship

One of the main purposes of this study—to determine participation in setting the agenda for a STEM literate citizenry—was to identify trends in authorship for the data sample. Most pertinent to this study was the determination of the frequency of articles written by reporters versus those written by academic professionals; academic professionals who are STEM engaged to the point of reporting on matters of STEM education may demonstrate the ability to engage to other academic professionals. A large number of academic professionals reporting on STEM education would also contribute to an understanding of the level of orientation toward STEM education that exists among the higher education community. Of the 63 total articles, reporters wrote 42 articles (67%) while academic professionals wrote 21 (33%) articles. Academic professionals included three presidents, three provosts, one associate provost, two deans, one associate chair, seven directors, and nine professors. These numbers add up to more than 21 articles because five of the articles had more than one author.

Accounting for both reporters and academic professionals, a total of seven authors wrote more than one article, with only one of the seven being an academic professional, a university president, who authored two articles. Of the six remaining authors who wrote more than one article, one author wrote four articles, two authors wrote three articles, and three authors wrote two articles. Referring to Table 16, consistent with the article frequency trends for the entire sample, most of the articles by academic professionals were written in the past five years (*N*=17). Although a Chi-square could not be run to determine significant differences in authorship between groups by year, there were a greater proportion of articles authored by academic professionals versus reporters in 2011-2015 (36%) then in 2006-2010 (27%). Thus, reporting by academic professionals increased by a little more than 10% over the past five years.

Table 16

Authorship by Year Group

Year * Author Crosstabulation

Count

		Author		Total
		Reporter	Academic Professional	
Year	2001-2005	1	0	1
	2006-2010	11	4	15
	2011-2015	30	17	47
Total		42	21	63

In order to determine what academic professionals are writing about, trends in authorship by theme were examined. As illustrated in Table 17, the State of STEM was most reported on (*N*=6), followed by Diversity (*N*=5), and Curriculum & Instruction (*N*=4). Further, State of STEM and curriculum & instruction were the only two themes reported on more frequently by academic professionals than by reporters. There were no articles authored by academic professionals in the International and Study Abroad theme, while, Employment, Government & Politics, and Institutional Initiatives contained one, two, and three articles authored by academic professionals respectively. The highest proportion of articles written by academic professionals versus reporters existed in the Curriculum & Instruction theme (67%) whereas the highest proportion of articles written by reporters versus academic professionals existed in the International & Study Abroad theme (100%), followed by Employment (85%).

Research Question 2

What themes in STEM education appear in the *Chronicle of Higher Education* from January 2001 to March of 2015?

Once again, the following results represent data collected from January 2001 through December of 2015. As presented in Table 18, seven themes emerged from the data. Referring to Table 19 and Figure 8, articles relating to Theme 2, Diversity (*N*=17), were highest (27%), representing more than a quarter of the sample. State of STEM (*N*=11) came in second, representing 17.5% of the sample, followed by Institutional Initiatives (*N*=9) at 14.3 % and both Government/Politics (*N*=7) and Employment (*N*=7) at 11.1%. The two themes, International/Study Abroad (N=6) and Curriculum/Instruction (N=6), each represented the lowest proportions of the sample (9.5%).

Table 17

Authorship by Theme

Themes * Author Crosstabulation

Count

		Author		Total
		Reporter	Academic Professional	
Themes	Government/Politics	5	2	7
	Diversity	12	5	17
	Employment	6	1	7
	State of STEM	5	6	11
	International/Study Abroad	6	0	6
	Institutional Initiatives	6	3	9
	Curriculum/Instruction	2	4	6
Total		42	21	63

To detect whether there were significant differences between theme frequencies, a Chi-square goodness of fit test was conducted. As shown in Table 20, no significant differences were found between the theme frequencies, $X^2(6)=10.44$, $p>0.1$. Further, the data did not allow for a Chi-square test of association to be conducted between the theme frequencies by year, as at least one of the test assumptions would be violated, making the results inaccurate. Hence, it was not possible to determine if there were significant differences between the themes by year. This data driven statistical limitation could not be resolved by grouping years. Additionally, due to the sample size and distribution of the data, presenting theme trends by year groups instead of individual years was found to be more effective and representative of the data. The trends in theme frequencies by groups (year) are depicted in Table 21 and Figure 9. The only article found from 2001-2005 belonged to Theme 5, International/Study Abroad. From year group 2, 2006-2010, to year group 3, 2011-2015, both Government/Politics and International/Study Abroad showed the smallest change, decreasing by one, whereas Diversity and State of STEM showed the greatest changes, increasing by 11 and nine respectively. The theme of Institutional Initiatives was only represented by one article from 2006-2010 but jumped to eight articles from 2011-2015, showing an increase of seven articles. Finally, both Employment and Curriculum/Instruction showed increases of three and four respectively.

Research Question 3

What is the frequency of reporting on the need for collaboration in STEM education in the *Chronicle of Higher Education* from January 2001 to March 2015?

As with the first two research questions, the following data represents articles collected from January 2001 through December 2015. Collaboration did not emerge as an independent or primary theme; that is, none of the articles primarily focus or intend to convey the need for collaboration as their central message. However, since collaboration is a critical component in the conceptual design, there was a need to further explore this construct. Thus, all 63 articles were reexamined for collaboration as a secondary theme. Articles where messages regarding collaboration may resonate with the reader and articles that provided instances where collaboration may have been instrumental were determined to have collaboration as a secondary theme and are included in these results.

Table 18

Themes

Code	Theme	Description
1	Government/Politics	Articles that deal primarily with government initiatives and policies regarding STEM education.
2	Diversity	Articles that deal primarily with underrepresentation of specific populations and the recruitment or retention of underrepresented populations in STEM education.
3	Employment	Articles that deal primarily with the job outlook for STEM students/graduates and conditions affecting retention in the field.
4	State of STEM	Articles that deal primarily with highlighting the concerns and conversations in higher education as they relate to STEM education including issues of STEM and the liberal arts, the economy and economic competition, the STEM shortage, and data regarding enrollment and graduation trends.
5	International/Study Abroad	Articles that deal primarily with international developments in STEM education U.S./International collaborations, and U.S. study-abroad and research programs.
6	Institutional Initiatives	Articles that deal primarily with highlighting specific institutional initiatives regarding STEM education.
7	Curriculum/Instruction	Articles that deal primarily with matters relating to STEM curriculum and instructional methods or pedagogy.

Table 19

Frequency of Theme

Themes					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Government/Politics	7	11.1	11.1	11.1
	Diversity	17	27.0	27.0	38.1
	Employment	7	11.1	11.1	49.2
	State of STEM	11	17.5	17.5	66.7
	International/Study Abroad	6	9.5	9.5	76.2
	Institutional Initiatives	9	14.3	14.3	90.5
	Curriculum/Instruction	6	9.5	9.5	100.0
	Total	63	100.0	100.0	

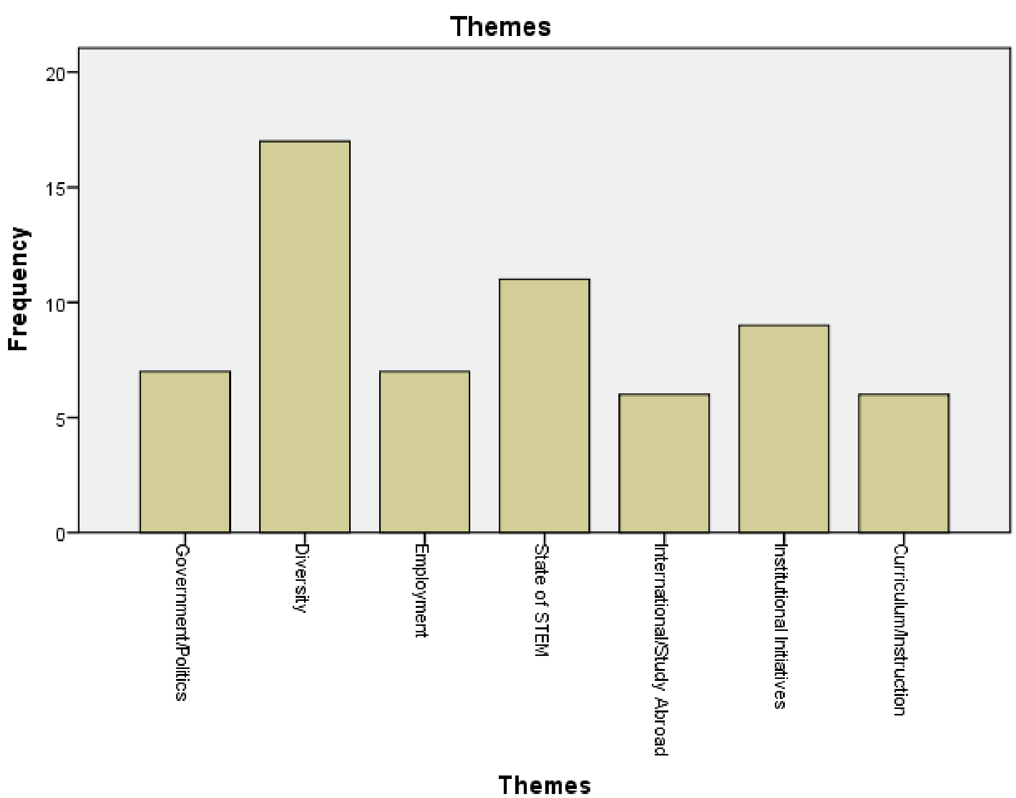

Figure 8. Frequency of themes.

Collaboration was found as a secondary theme in almost 35% (*N*=22) of the sample (Table 22). Referring to Table 24, a significant difference was found between articles determined to have a secondary theme of collaboration and those that were not (*N*=41), $X^2(1)=5.73$, $p<0.5$. A Chi square could not be run to determine significant differences between frequency of articles by year or year groups as at least one of the test assumptions would be violated. However, as shown in Table 23 and Figure 10, there were 3 times more collaboration articles from 2001-2015 (*N*=1) to 2006-2010 (*N*=3) and 6 times more from 2006-2010 to 2011-2015 (*N*=18). Thus, 82% of the articles found to have a secondary theme of collaboration were published in the last five years.

Table 20

Theme Statistic

Test Statistics	
	Themes
Chi-Square	10.444[a]
df	6
Asymp. Sig.	.107

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.0.

To further understand this relationship it was important to calculate the percentage of collaboration articles within each year group and compare. Only one article exists in Year Group 1 and the secondary theme of collaboration was present in that article thus representing 100% of the articles from 2001-2005. This data is not particularly informative. However, in Year Group 3, 38% of the articles included collaboration as a secondary theme versus the 20% in Year Group 2. This data was informative as the frequency of collaboration as a secondary theme nearly doubled in the last five years. Although statistical significance could not be calculated, reporting on STEM that includes indirect or implied messages of collaboration has greatly increased during the past five years.

Table 21

Theme Frequencies by Year

Themes * Year Crosstabulation					
Count					
		Year			Total
		2001-2005	2006-2010	2011-2015	
Themes	Government/Politics	0	4	3	7
	Diversity	0	3	14	17
	Employment	0	2	5	7
	State of STEM	0	1	10	11
	International/Study Abroad	1	3	2	6
	Institutional Initiatives	0	1	8	9
	Curriculum/Instruction	0	1	5	6
Total		1	15	47	63

Table 22

Frequency of Collaboration as Secondary Theme

Article					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Collaboration	41	65.1	65.1	65.1
	Collaboration	22	34.9	34.9	100.0
	Total	63	100.0	100.0	

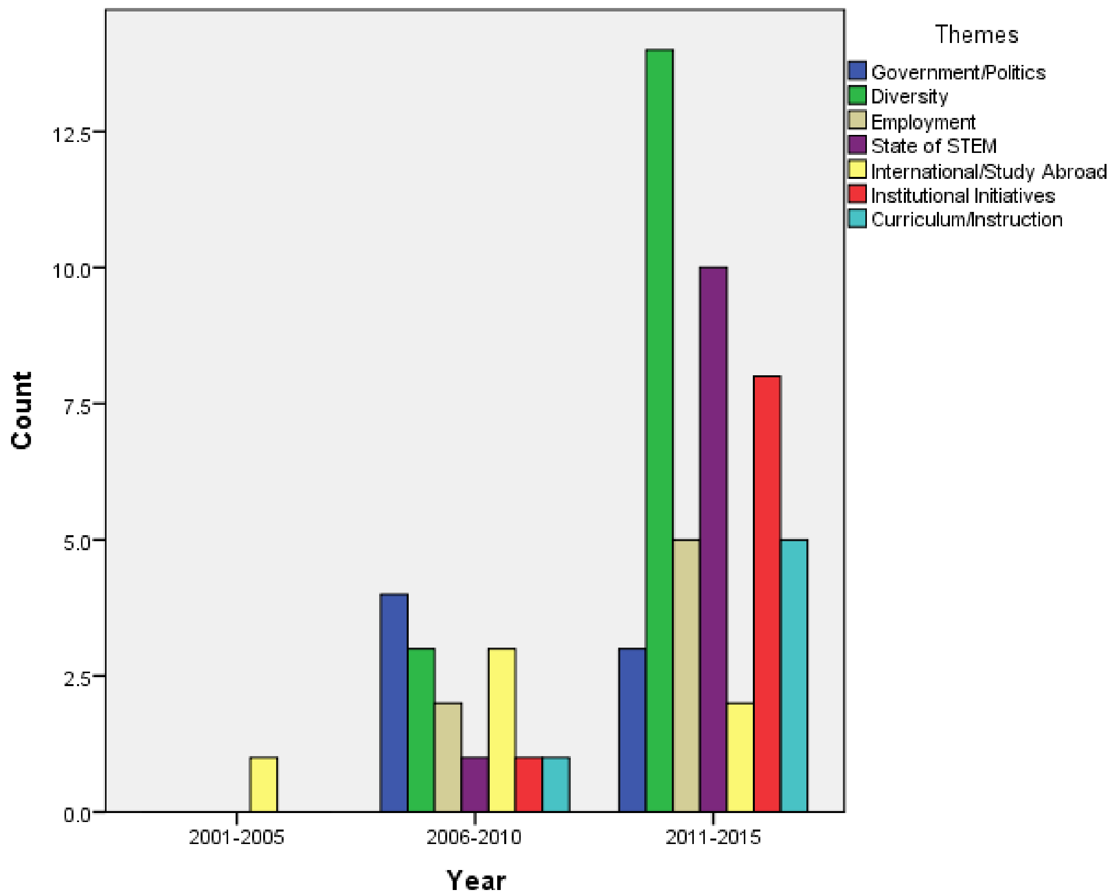

Figure 9. Theme Frequencies by Year.

Table 23

Frequency of Collaboration as Secondary Theme by Year

Article * Year Crosstabulation

Count

		Year			
		2001-2005	2006-2010	2011-2015	Total
Article	Not Collaboration	0	12	29	41
	Collaboration	1	3	18	22
Total		1	15	47	63

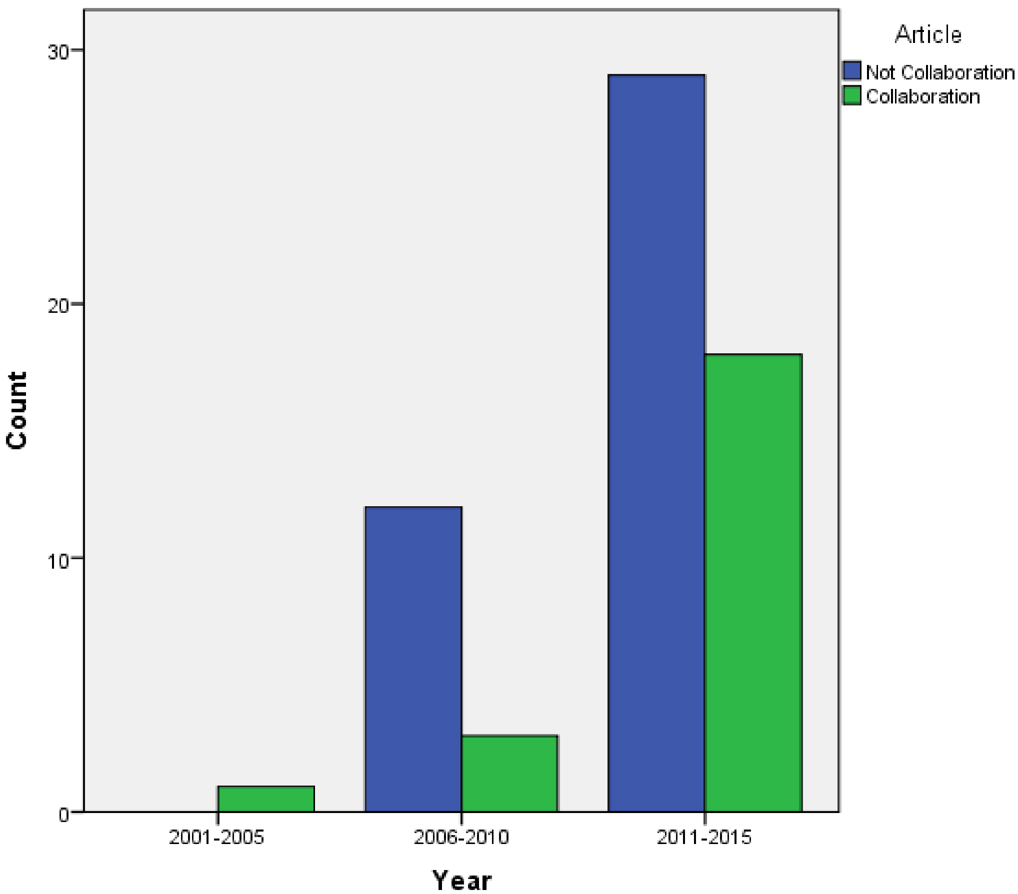

Figure 10. Theme of collaboration as secondary theme by year.

Table 24

Collaboration as a Secondary Theme Test Statistic

Test Statistics	
	Article
Chi-Square	5.730[a]
df	1
Asymp. Sig.	.017

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 31.5.

CHAPTER 5
DISCUSSION AND IMPLICATIONS

The conceptual design of this study assumes that a relationship naturally exists between the amount of information provided to an audience and their level of interest or subsequent involvement in the subject matter. In order to further understand this phenomenon, a theory was developed over 35 years ago and has been widely used in communication research ever since. This theory, Agenda Setting Communication Theory (ASCT), was used in this study to examine the role that the *Chronicle of Higher Education* may play in mobilizing the higher education community on matters of STEM education. Under this theory, STEM education was considered as an object or target of inquiry. Further, the themes or categories emerging under this object were considered and examined as attributes of the object. The following is a discussion of the study findings through the lens of the adapted model of ASCT developed for this study.

Research Question 1

The frequency of reporting on STEM education in the *Chronicle of Higher Education* was found to be significantly lower for the first 10 years investigated. Only 16 articles represent the years 2001-2010 compared to 47 articles over the last five years, 2011-2015. These numbers signify the salience and trend of salience of STEM education issues in the CHE. This is clearly demonstrated by the increase in articles found from 2001-2005 (*N*=1), to 2006-2010 (*N*=15), and to 2011-2015 (*N*=47).

This research study aimed to uncover whether the trends align with the national agenda. Given that 75% of the articles found were published in the last five years, the salience of STEM education issues in the CHE can be said to be a reflection of the national agenda. Under the ASCT model, the increase in reporting on STEM education may have the potential of signaling to the CHE's readership that STEM education is on the table for discussion. Because it is a specialized journal, readers of the *Chronicle* assume that it reports news that is deemed relevant to the higher education community. Hence, the increased salience or focus on STEM issues should, theoretically, relay a message of relevance to its readership. This is depicted in the ASCT model shown in Figure 1 (Chapter 1), where reporting on STEM education serves as 'information.' The information raises the level of relevance and orientation among the higher education community, which in turn allows for the effects of priming and framing regarding the object, STEM education, and its attributes. As knowledge is gained from reading the CHE articles, the level of uncertainty regarding this object should decrease. Thus, as demonstrated by the increase in salience, CHE participates in communicating the STEM education agenda to the higher education community.

Under the framework provided in this study, there are three possible outcomes of the agenda-setting effect; it can cycle the reader back into the loop to seek more information regarding the object or attributes to further decrease uncertainty, mobilize the reader into some sort of action relating to the subject, or help establish for the reader that the subject is of no personal interest. These effects occur as a relationship of the level of relevance produced. Although it has been established that the CHE is participating in communicating the STEM education agenda to its readership, suggesting that the subject is relevant to the higher education community, whether the subject is relevant to the individual reader is a function of the relevance produced by the nature of the information provided regarding the subject. Under this model, this process qualifies as the second level of agenda setting. Since, in serving the national interest, President Obama has called for an ‘all hands on deck’ approach to creating a STEM literate citizenry and if the CHE is to act as a gear in motion (Figure 3), it is important that its contribution to communicating the STEM agenda focus on establishing relevance to most or all of its readership to mobilize the higher education community toward STEM education.

One possible approach to accomplishing this may be to raise the number of academic professionals reporting on STEM education. Only 33% of the articles examined in this study were written by academic professionals. While reporters often quote professionals in their articles, articles that are authored by academic professionals may appear more credible and relatable. Reporters are ultimately outsiders and, while they maybe laboring intensively to disseminate the most accurate and pertinent information possible, the professionals are the source of that information. Determination of what is important to include and exclude when reporting may be more meticulous when performed by someone with a complete account of the information. Based on social psychology research, when people are given information by other members of their in-group, the likelihood that the information will seem credible, and thus resonate, may be higher than when given information by members of an out-group (Blumberg, Hare, Kent, & Davies, 2009).

Research Question 2

Diversity

The seven themes that emerged from the data represent what the CHE deems relevant or important to communicate to the higher education community. Although no significant differences were found between theme frequencies, matters relating to diversity were reported on the most, at a difference of at least six articles. Theme 2, Diversity (N=17), primarily represents articles that discuss matters of minority recruitment and retention. Breaking down the theme further, articles were found to discuss the following: (a) first-generation students, (b) the gender gap, (c) female undergraduate and graduate students, (d) undergraduate students with disabilities, (e) African-American undergraduate and graduate students, (f) African-American and Hispanic undergraduate and graduate students, (g) all undergraduate minorities together, (h) all minority graduate students, and (i) minority faculty. These articles mostly reflect the national concern over the disparity of minority students in STEM education and discuss possible causes and strategies or initiatives to address them. The presence of this theme and its relatively large frequency reflects the national STEM education agenda. In the sense that minority populations represent an untapped potential, diversifying the STEM workforce has been highlighted as critical to expanding innovation and competing in the global economy.

State of STEM

Among the other themes, State of STEM represents the next most reported (*N*=11). Under this theme, a reflection of the national agenda is also present, with articles that discuss the STEM shortage, the way in which STEM and the liberal arts are in a presumed competition, the effects of the economy on spending in higher education, the economic effects of STEM education and global competition, and data charts referencing enrollment and graduation trends. One facet of this theme that was not reported on and may have the potential to mobilize the higher education community toward STEM education was the amount of funding and grant opportunities available for programs and research that advance the national STEM agenda. Although this may have been inferred from brief mention in some articles, it was not discussed in a way that is representative of the degree of opportunities available, nor in a way that is prescriptive more than descriptive. Thus, none of the articles specifically aim to promote involvement in this effort. This suggests that while it is participating in communicating aspects of the national STEM agenda, the CHE is not yet purposefully participating in setting that agenda for the higher education community.

Institutional Initiatives

The same can be said for the other themes that emerged. Institutional Initiatives (*N*=7), represents articles that discuss programs, interventions, partnerships, and policies that institutions have implemented in order to address matters of STEM diversity or the STEM shortage. While these articles imply some sort of collaboration was undertaken, they do little to drive the message that anyone in the higher education community can or should be participating. Most of the articles were found to be descriptive in nature and include mostly brief mention of the intent, process and outcome of the initiatives. Interestingly, successes were often reported to include strengthening nonacademic support structures such as mentorship, engagement, campus culture, and bridge programs. These types of initiatives are often highly dependent on collaboration and involvement of many institutional departments. Thus, it would likely take very little to go one step further to directly prescribe broad participation.

Government and Politics

Reporting on political matters was lower than expected (N=7) given the breadth of action taken in the new millennium. Among the reported were, commission findings, the need for program oversight and program consolidation, the Enhancing STEM Education Act of 2008, the NSF Career-Life Balance Initiative, performance based models for funding, and tuition breaks for STEM majors. Articles were not found to detail such things as the America Competes Act and its reauthorization, the recent STEM Education ACT, Educate to Innovate, formation of a STEM caucus, the 100k in 10 initiative, the President’s call for an all hands on deck approach to STEM education, the intention to create a STEM literate citizenry, or the plethora of commissioned reports that span the time period under investigation. Thus, the CHE does not appear to be reflecting the national STEM education agenda in terms of its reporting on matters of public policy.

Employment

Articles under the Employment theme (*N*=7) involved concerns over the difficulty of attaining academic positions and competition for grants within STEM fields, the debate over the shortage of STEM graduates in relation to job outlook, the difficulties of work-life balance, poor pay for post-docs and the increase in adjunct teaching, addressing shortages with certificate programs, and career outlook for minorities in STEM fields. Reporting on this theme was found to align with the national STEM agenda in that it consistently reinforces the need for an effective system to meet national goals.

International and Study Abroad

Theme 5, International and Study Abroad (*N*=6), includes articles that discuss initiatives other countries are taking to keep STEM students in the country and spur research and innovation in math and science, effects of U.S institutions' overseas research and operations, international partnerships with US institutions, and international exchange programs. A message can be inferred from the fact that other countries are hard at work trying to keep their STEM talent at home, while the US is hard at work trying to produce STEM talent. Although some brief discussions of the need for home grown talent as opposed to international student talent was found in this and other themes, articles underscoring the underperformance of US students in math and science compared with specific performance levels of students in other countries were not found. This information is central to the national STEM education agenda and its lack of representation suggests that the CHE is not reflecting the national concern.

Curriculum and Instruction

The final theme, Curriculum and Instruction (*N*=*6*), houses articles relating to the need for teaching more spatial literacy, moving away from traditional lecture models to include student participation and engagement, training for STEM educators, lack of natural creative thinking skills in females as a reason why they choose not to enter or do not perform well in math and science, the need to teach more quantitative skills in general coursework, and the importance of emphasizing writing skills for STEM students. Once again, a central message of the STEM education agenda was not found. Integrated STEM education has been a rapidly evolving 'hot topic' in addressing the STEM shortage and the goal of a STEM literate citizenry. No articles were found to expose or explain this trend. This is important because the integrated STEM movement reinforces the benefits of teaching critical thinking and creative problem solving in all disciplines from K-12 to postsecondary education. Even those not on the STEM train agree that these skills are impetrative to student success both in life and in their disciplines. This is perhaps the essence of the call to produce a STEM literate citizenry. More creative thinking and problem solving ability propels innovation in every discipline not only those designated as STEM. Further, only one article was found that discussed teacher preparation. This issue is central to the many commissioned reports intended to identify ways in which to enhance STEM education. Thus the CHE does not appear to be reflecting the national agenda regarding matters of curriculum and instruction.

Implications of Theme Results

Referring again to the mechanism depicted in Figure 3 (Chapter 3), setting the gears in motion for a STEM literate citizenry, in order for the CHE to be an effectively moving gear, allowing the engine to turn, it must either have some force of its own or it must be allowing the force of the other gears to turn it. Referring to ASCT, the media does not have to be purposefully setting an agenda for agenda setting effects to occur. Hence, the CHE may be setting the STEM education agenda for the higher education community simply through the salience of reporting on the subject. However, the nature of that agenda would, in this case lack the force necessary for effective contribution to the system. In order for the CHE to act as an effective moving part, it must have a direction and a purpose. It would be fine for that direction and purpose to simply be an information channel, where no specific position is taken, however, in order for that to be true, it would have to report all information in the way it exists, allowing the reader to choose a position. Theoretically, when any decision is taken to include or omit any aspect of a subject, agenda setting effects can automatically take place. Since it is virtually impossible to communicate all messages all the time, the media must be aware of the agenda it is advancing and by what process. To mobilize the higher education community to contribute to producing a STEM literate citizenry, the CHE's direction and purpose would have to increase the need for orientation by establishing relevance. Here, reporting would be both descriptive and prescriptive and imply or directly call to action the higher education community. Such messages were not found, thus, while the CHE may be functioning to relay aspects of the national agenda, it is not functioning to advance that agenda.

Research Question 3

Reporting on the need for collaboration was designated its own research question because it is central to the mission to create a STEM literate citizenry and also central to the way in which the CHE can effectively participate in advancing that agenda. The need for collaboration did not emerge as a primary theme from the articles examined. This suggests that the CHE is not participating in advancing the national agenda. Because prescribing collaboration would likely be a highly effective way to transfer relevance to a broad readership, a focus on collaboration would mean that the CHE is a moving gear with its own force. This focus was not found.

As a secondary theme, collaboration was present in about 35% of the sample. In most instances the articles were describing an initiative or program and, in doing so, refer to the participation of several players. In some instances articles briefly made direct reference to the need for broad participation. One stated, “Boosting the proportion of STEM professionals among underrepresented groups—including ethnic minorities, the disabled and women—requires a national effort that begins in grades K through 12 and continues into the college years, experts say” (Leary, 2012, Early Interventions section). The author then goes on to quote Dr. Shirly M. Malcom, the head of education and human resources programs at the American Association for the Advancement of Science: "This is a systems problem that can't be solved by one thing, you have to manage a number of moving parts" (as cited in Leary, 2012, Early Interventions section). This statement by Dr. Malcom is analogous to the model depicted in Figure 3 (Chapter 1). Further, three articles were concerned with people in STEM disciplines collaborating with other disciplines, including History and English, as well as discovering similar diversity issues in other disciplines. One such article was also found to have the most reference to broad participation and collaboration. The article states:

> It is clear that diversity research and programs take place within specific academic disciplines, or "silos." We don't reach beyond our own silos enough to know that colleagues in other silos are wrestling with similar issues and ideas. Solving the growing problems of underrepresentation and lack of equity in higher education, and society in general, needs a multidisciplinary approach. Bringing together a diverse group of researchers and practitioners from law, business, STEM, education, the humanities, and so forth -- perhaps at a national conference -- would result in better ideas, programs, research agendas, and ultimately solutions. (Gilbert, 2008, para 7-8)

Since 82% of the articles discussing collaboration were published in the last five years, it seems that the CHE is reflecting the current trends in discovering the importance of collaboration to success. However, that type of reporting will only go so far to contribute to this knowledge. In order to mobilize the higher education community to engage with each other on matters of STEM education for the production of a STEM literate citizenry, the CHE would have to be representing the need for collaboration as a primary theme with a high level of salience. It would also require an understanding of the agenda being set by the inclusion and omission of certain information regarding collaboration. Thus, it would need to be purposeful in its reporting in order to increase the need for orientation by creating a sense of relevance to a broad readership. It is at that point that the CHE could be said to be an efficiently moving part of this particular system.

Application of ASCT

Agenda Setting Communication Theory proved to be a valuable framework though which to examine the *Chronicle of Higher Education's* participation in advancing the national agenda for a STEM literate citizenry. Although the *Chronicle* was found to be reflecting the national STEM education agenda through an increase in the salience of STEM education reporting over the past five years, their participation was not found to be sufficient for setting or advancing the national agenda to create a STEM literate citizenry. Further, referring to Figure 2, due to the omission of several key aspects of the current national STEM agenda, the salience of reporting was not found to be sufficient to move the professional sector's orientation gauge. That is, the CHE is not reporting enough or the right kind of information in order to raise the level of orientation increase relevance to the higher education community. Also, the omission of such information may have the opposite effect, in that the omission of such information may be decreasing the need for orientation to the professional sector by validating a lack of relevance. Following a thorough understanding of the theory's application in this research, a clearer depiction of the mechanism by which an agenda would be advanced was warranted. Thus, Figure 11 illustrates ASCT in action.

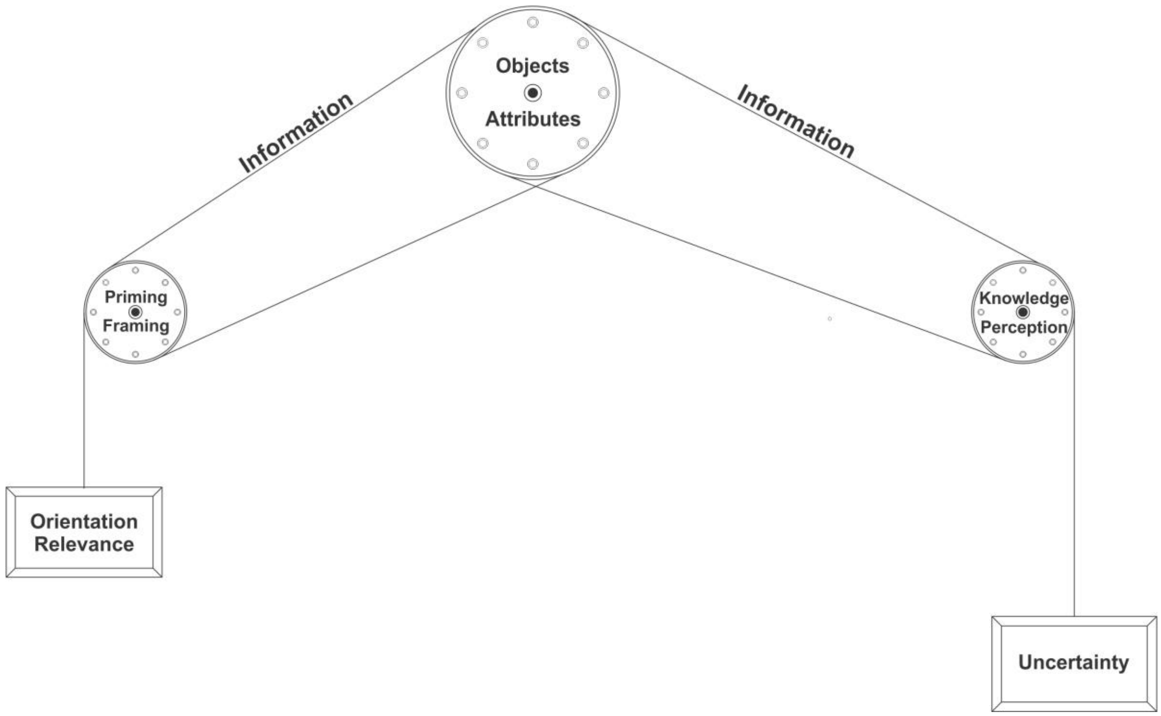

Figure 11. Agenda Setting Communication Theory Theme in action. Copyright 2016 by M. Abdallah

This mechanism illustrates the interdependency of all of the theory's components. With information as the belt unifying the gears' motion, as orientation and relevance increase, uncertainty decreases. This occurs through the effects of priming and framing regarding objects and attributes for the progression of knowledge and perception. As any one component of the system moves, so will all other components. In this study, the *Chronicle* was examined for its reporting on one object, STEM education. Under the ASCT model, STEM education is the first level of agenda setting. As addressed by the first research question, the *Chronicle* was found to be participating in reflecting the national STEM education agenda at this first level. However, it was not found to be participating in advancing the agenda of creating a STEM literate citizenry.

Thus, the central gear depicted above exists with STEM education as the object but not with a STEM literate citizenry as the object.

As for the second level of agenda setting, the attributes that the *Chronicle* exhibited include the seven themes, Government & Politics, Diversity, Employment, State of STEM, International & Study Abroad, Institutional Initiatives, and Curriculum & Instruction. As addressed by the second research question, the *Chronicle* was found to be reflecting the national agenda with diversity having the highest salience. However, the *Chronicle* was not found to be participating in advancing the national agenda for a STEM literate citizenry due to the lack of emphasis on collaboration and the evolution of integrated STEM education. As also addressed by the third research question, the *Chronicle* was not found to be participating in advancing the national agenda to create a STEM literate citizenry due to its lack of purposeful priming and framing to establish relevance to the higher education community. That is, the *Chronicle* was not found to be sufficiently or directly communicating the need for collaboration in order to leave its readership with a sense of relevance and efficacy that could mobilize them toward similar action.

Overall Implications

As the leading news medium for the higher education community, the *Chronicle of Higher Education* can play a central role in mobilizing the higher education community toward the creation of a STEM literate citizenry. However, in order to be effectively serving that purpose, the *Chronicle* would have to be aware of both the subtle and direct ways in which priming and framing regarding objects and attributes serves to increase relevance and orientation and decrease uncertainty regarding the higher education community's role in creating a STEM literate citizenry. Such effects could be pronounced if the *Chronicle* were to focus on reporting more current trends in the national STEM education agenda. Such trends primarily include the movement toward integrated STEM education and the increased need for STEM skills in all disciplines, as well as, the increased awareness of the need for collaboration for success in most STEM initiatives. Without such a focus, the higher education community may remain segmented in their efforts with only those who are highly STEM engaged serving the national demand. The results of this research suggest that the higher education community is not yet oriented or may not yet be experiencing a need for orientation regarding their role in the STEM education agenda. As the higher education community will be chiefly responsible for meeting the national call for an all hands on deck approach to developing a STEM literate citizenry, the *Chronicle of Higher Education* would do well to inform its readership of their ability to do so. By not providing such information, the *Chronicle* has not set the gears in motion for a STEM-literate citizenry.

Recommendations for Future Research

Future research should continue to explore the ways in which all members of the higher education community can serve to advance the national interest in the area of STEM literacy. The following is list of potential areas for further research.

1. An analysis of non-STEM higher education professionals' beliefs regarding their ability to contribute to STEM education.

2. An analysis of the CHE's reporting on STEM education in comparison with other topics and/or other news mediums.
3. An exploration of reader perceptions regarding STEM education themes. Which are more popular, which elicit the most responses and an analysis of the type of responding.
4. A qualitative analysis of academic leaders' perceptions of their roles and demands in meeting the national STEM education agenda.
5. Determination of the leading provider of information regarding the most current trends in STEM education initiatives and analysis of the extent of its reach.

APPENDIX A
IMMIGRATION AND CUSTOMS ENFORCEMENT STEM FIELDS LIST

STEM-Designated Degree Program List
2012 Revised List: Additions are in Bold

CIP Code Family	2010 CIP Code	Numeric Order CIP Code Title
1	**1.0308**	**Agroecology and Sustainable Agriculture.**
1	1.0901	Animal Sciences, General
1	1.0902	Agricultural Animal Breeding
1	1.0903	Animal Health
1	1.0904	Animal Nutrition
1	1.0905	Dairy Science
1	1.0906	Livestock Management
1	1.0907	Poultry Science
1	**1.0999**	**Animal Sciences, Other.**
1	1.1001	Food Science
1	1.1002	Food Technology and Processing
1	**1.1099**	**Food Science and Technology, Other.**
1	1.1101	Plant Sciences, General
1	1.1102	Agronomy and Crop Science
1	1.1103	Horticultural Science
1	1.1104	Agricultural and Horticultural Plant Breeding
1	1.1105	Plant Protection and Integrated Pest Management
1	1.1106	Range Science and Management
1	**1.1199**	**Plant Sciences, Other.**
1	1.1201	Soil Science and Agronomy, General
1	1.1202	Soil Chemistry and Physics
1	1.1203	Soil Microbiology
1	**1.1299**	**Soil Sciences, Other.**
3	**3.0101**	**Natural Resources/Conservation, General.**
3	**3.0103**	**Environmental Studies.**
3	3.0104	Environmental Science
3	**3.0199**	**Natural Resources Conservation and Research, Other.**
3	**3.0205**	**Water, Wetlands, and Marine Resources Management.**

3	3.0502	Forest Sciences and Biology
3	**3.0508**	**Urban Forestry.**
3	3.0509	Wood Science and Wood Products/Pulp and Paper Technology
3	**3.0601**	**Wildlife, Fish and Wildlands Science and Management.**
4	**4.0902**	**Architectural and Building Sciences/Technology.**
9	9.0702	Digital Communication and Media/Multimedia
10	10.0304	Animation, Interactive Technology, Video Graphics and Special Effects
11	11.0101	Computer and Information Sciences, General
11	11.0102	Artificial Intelligence
11	11.0103	Information Technology
11	11.0104	Informatics
11	**11.0199**	**Computer and Information Sciences, Other.**
11	11.0201	Computer Programming/Programmer, General
11	11.0202	Computer Programming, Specific Applications
11	11.0203	Computer Programming, Vendor/Product Certification
11	**11.0299**	**Computer Programming, Other.**
11	11.0301	Data Processing and Data Processing Technology/Technician
11	11.0401	Information Science/Studies
11	11.0501	Computer Systems Analysis/Analyst
11	11.0701	Computer Science
11	11.0801	Web Page, Digital/Multimedia and Information Resources Design
11	11.0802	Data Modeling/Warehousing and Database Administration
11	11.0803	Computer Graphics
11	11.0804	Modeling, Virtual Environments and Simulation
11	**11.0899**	**Computer Software and Media Applications, Other.**
11	11.0901	Computer Systems Networking and Telecommunications
11	11.1001	Network and System Administration/Administrator
11	11.1002	System, Networking, and LAN/WAN Management/Manager
11	11.1003	Computer and Information Systems Security/Information Assurance
11	11.1004	Web/Multimedia Management and Webmaster
11	11.1005	Information Technology Project Management

11	11.1006	Computer Support Specialist
11	**11.1099**	**Computer/Information Technology Services Administration and Management, Other.**
13	**13.0501**	**Educational/Instructional Technology.**
13	**13.0601**	**Educational Evaluation and Research.**
13	13.0603	Educational Statistics and Research Methods
14	14.0101	Engineering, General
14	14.0102	Pre-Engineering
14	14.0201	Aerospace, Aeronautical and Astronautical/Space Engineering
14	14.0301	Agricultural Engineering
14	14.0401	Architectural Engineering
14	14.0501	Bioengineering and Biomedical Engineering
14	14.0601	Ceramic Sciences and Engineering
14	14.0701	Chemical Engineering
14	14.0702	Chemical and Biomolecular Engineering
14	**14.0799**	**Chemical Engineering, Other.**
14	14.0801	Civil Engineering, General
14	14.0802	Geotechnical and Geoenvironmental Engineering
14	14.0803	Structural Engineering
14	14.0804	Transportation and Highway Engineering
14	14.0805	Water Resources Engineering
14	**14.0899**	**Civil Engineering, Other.**
14	14.0901	Computer Engineering, General
14	14.0902	Computer Hardware Engineering
14	14.0903	Computer Software Engineering
14	**14.0999**	**Computer Engineering, Other.**
14	14.1001	Electrical and Electronics Engineering
14	14.1003	Laser and Optical Engineering
14	14.1004	Telecommunications Engineering
14	**14.1099**	**Electrical, Electronics and Communications Engineering, Other.**
14	14.1101	Engineering Mechanics
14	14.1201	Engineering Physics/Applied Physics
14	14.1301	Engineering Science

14	14.1401	Environmental/Environmental Health Engineering
14	14.1801	Materials Engineering
14	14.1901	Mechanical Engineering
14	14.2001	Metallurgical Engineering
14	14.2101	Mining and Mineral Engineering
14	14.2201	Naval Architecture and Marine Engineering
14	14.2301	Nuclear Engineering
14	14.2401	Ocean Engineering
14	14.2501	Petroleum Engineering
14	14.2701	Systems Engineering
14	14.2801	Textile Sciences and Engineering
14	14.3201	Polymer/Plastics Engineering
14	14.3301	Construction Engineering
14	14.3401	Forest Engineering
14	14.3501	Industrial Engineering
14	14.3601	Manufacturing Engineering
14	14.3701	Operations Research
14	14.3801	Surveying Engineering
14	14.3901	Geological/Geophysical Engineering
14	14.4001	Paper Science and Engineering
14	14.4101	Electromechanical Engineering
14	14.4201	Mechatronics, Robotics, and Automation Engineering
14	14.4301	Biochemical Engineering
14	14.4401	Engineering Chemistry
14	14.4501	Biological/Biosystems Engineering
14	**14.9999**	**Engineering, Other.**
15	15.0000	Engineering Technology, General
15	15.0101	Architectural Engineering Technology/Technician
15	15.0201	Civil Engineering Technology/Technician
15	15.0303	Electrical, Electronic and Communications Engineering Technology/Technician
15	15.0304	Laser and Optical Technology/Technician

15	15.0305	Telecommunications Technology/Technician
15	15.0306	Integrated Circuit Design
15	**15.0399**	**Electrical and Electronic Engineering Technologies/Technicians, Other.**
15	15.0401	Biomedical Technology/Technician
15	15.0403	Electromechanical Technology/Electromechanical Engineering Technology
15	15.0404	Instrumentation Technology/Technician
15	15.0405	Robotics Technology/Technician
15	15.0406	Automation Engineer Technology/Technician
15	**15.0499**	**Electromechanical and Instrumentation and Maintenance Technologies/Technicians, Other.**
15	15.0501	Heating, Ventilation, Air Conditioning and Refrigeration Engineering Technology/Technician
15	15.0503	Energy Management and Systems Technology/Technician
15	15.0505	Solar Energy Technology/Technician.
15	15.0506	Water Quality and Wastewater Treatment Management and Recycling Technology/Technician
15	15.0507	Environmental Engineering Technology/Environmental Technology
15	15.0508	Hazardous Materials Management and Waste Technology/Technician
15	**15.0599**	**Environmental Control Technologies/Technicians, Other.**
15	15.0607	Plastics and Polymer Engineering Technology/Technician
15	15.0611	Metallurgical Technology/Technician
15	15.0612	Industrial Technology/Technician
15	15.0613	Manufacturing Engineering Technology/Technician
15	15.0614	Welding Engineering Technology/Technician
15	15.0615	Chemical Engineering Technology/Technician
15	15.0616	Semiconductor Manufacturing Technology
15	**15.0699**	**Industrial Production Technologies/Technicians, Other.**
15	15.0701	Occupational Safety and Health Technology/Technician
15	15.0702	Quality Control Technology/Technician
15	15.0703	Industrial Safety Technology/Technician
15	15.0704	Hazardous Materials Information Systems Technology/Technician
15	**15.0799**	**Quality Control and Safety Technologies/Technicians, Other.**

26	26.0202	Biochemistry
26	26.0203	Biophysics
26	26.0204	Molecular Biology
26	26.0205	Molecular Biochemistry
26	26.0206	Molecular Biophysics
26	26.0207	Structural Biology
26	26.0208	Photobiology
26	26.0209	Radiation Biology/Radiobiology
26	26.0210	Biochemistry and Molecular Biology
26	**26.0299**	**Biochemistry, Biophysics and Molecular Biology, Other.**
26	26.0301	Botany/Plant Biology
26	26.0305	Plant Pathology/Phytopathology
26	26.0307	Plant Physiology
26	26.0308	Plant Molecular Biology
26	**26.0399**	**Botany/Plant Biology, Other.**
26	26.0401	Cell/Cellular Biology and Histology
26	26.0403	Anatomy
26	26.0404	Developmental Biology and Embryology
26	26.0406	Cell/Cellular and Molecular Biology
26	26.0407	Cell Biology and Anatomy
26	**26.0499**	**Cell/Cellular Biology and Anatomical Sciences, Other.**
26	26.0502	Microbiology, General
26	26.0503	Medical Microbiology and Bacteriology
26	26.0504	Virology
26	26.0505	Parasitology
26	26.0506	Mycology
26	26.0507	Immunology
26	26.0508	Microbiology and Immunology
26	**26.0599**	**Microbiological Sciences and Immunology, Other.**
26	26.0701	Zoology/Animal Biology
26	26.0702	Entomology
26	26.0707	Animal Physiology

26	26.1102	Biostatistics
26	26.1103	Bioinformatics
26	26.1104	Computational Biology
26	**26.1199**	**Biomathematics, Bioinformatics, and Computational Biology, Other.**
26	26.1201	Biotechnology
26	26.1301	Ecology
26	26.1302	Marine Biology and Biological Oceanography
26	26.1303	Evolutionary Biology
26	26.1304	Aquatic Biology/Limnology
26	26.1305	Environmental Biology
26	26.1306	Population Biology
26	26.1307	Conservation Biology
26	26.1308	Systematic Biology/Biological Systematics
26	26.1309	Epidemiology
26	26.1310	Ecology and Evolutionary Biology
26	**26.1399**	**Ecology, Evolution, Systematics and Population Biology, Other.**
26	26.1401	Molecular Medicine
26	26.1501	Neuroscience
26	26.1502	Neuroanatomy
26	26.1503	Neurobiology and Anatomy
26	26.1504	Neurobiology and Behavior
26	**26.1599**	**Neurobiology and Neurosciences, Other.**
26	**26.9999**	**Biological and Biomedical Sciences, Other.**
27	27.0101	Mathematics, General
27	27.0102	Algebra and Number Theory
27	27.0103	Analysis and Functional Analysis
27	27.0104	Geometry/Geometric Analysis
27	27.0105	Topology and Foundations
27	**27.0199**	**Mathematics, Other.**
27	27.0301	Applied Mathematics, General
27	27.0303	Computational Mathematics
27	27.0304	Computational and Applied Mathematics

15	15.0801	Aeronautical/Aerospace Engineering Technology/Technician
15	15.0803	Automotive Engineering Technology/Technician
15	15.0805	Mechanical Engineering/Mechanical Technology/Technician
15	**15.0899**	**Mechanical Engineering Related Technologies/Technicians, Other.**
15	15.0901	Mining Technology/Technician
15	15.0903	Petroleum Technology/Technician
15	**15.0999**	**Mining and Petroleum Technologies/Technicians, Other.**
15	15.1001	Construction Engineering Technology/Technician
15	15.1102	Surveying Technology/Surveying
15	15.1103	Hydraulics and Fluid Power Technology/Technician
15	**15.1199**	**Engineering-Related Technologies, Other.**
15	15.1201	Computer Engineering Technology/Technician
15	15.1202	Computer Technology/Computer Systems Technology
15	15.1203	Computer Hardware Technology/Technician
15	15.1204	Computer Software Technology/Technician
15	**15.1299**	**Computer Engineering Technologies/Technicians, Other.**
15	15.1301	Drafting and Design Technology/Technician, General
15	15.1302	CAD/CADD Drafting and/or Design Technology/Technician
15	15.1303	Architectural Drafting and Architectural CAD/CADD
15	15.1304	Civil Drafting and Civil Engineering CAD/CADD
15	15.1305	Electrical/Electronics Drafting and Electrical/Electronics CAD/CADD
15	15.1306	Mechanical Drafting and Mechanical Drafting CAD/CADD
15	**15.1399**	**Drafting/Design Engineering Technologies/Technicians, Other.**
15	15.1401	Nuclear Engineering Technology/Technician
15	15.1501	Engineering/Industrial Management
15	15.1502	Engineering Design
15	15.1503	Packaging Science
15	**15.1599**	**Engineering-Related Fields, Other.**
15	15.1601	Nanotechnology
15	**15.9999**	**Engineering Technologies and Engineering-Related Fields, Other.**
26	26.0101	Biology/Biological Sciences, General
26	26.0102	Biomedical Sciences, General

27	27.0305	Financial Mathematics
27	27.0306	Mathematical Biology
27	**27.0399**	**Applied Mathematics, Other.**
27	27.0501	Statistics, General
27	27.0502	Mathematical Statistics and Probability
27	27.0503	Mathematics and Statistics
27	**27.0599**	**Statistics, Other.**
27	**27.9999**	**Mathematics and Statistics, Other.**
28	**28.0501**	**Air Science/Airpower Studies.**
28	**28.0502**	**Air and Space Operational Art and Science.**
28	**28.0505**	**Naval Science and Operational Studies.**
29	29.0201	Intelligence, General
29	29.0202	Strategic Intelligence
29	29.0203	Signal/Geospatial Intelligence
29	29.0204	Command & Control (C3, C4I) Systems and Operations
29	29.0205	Information Operations/Joint Information Operations
29	29.0206	Information/Psychological Warfare and Military Media Relations
29	29.0207	Cyber/Electronic Operations and Warfare
29	**29.0299**	**Intelligence, Command Control and Information Operations, Other.**
29	29.0301	Combat Systems Engineering
29	29.0302	Directed Energy Systems
29	29.0303	Engineering Acoustics
29	29.0304	Low-Observables and Stealth Technology
29	29.0305	Space Systems Operations
29	29.0306	Operational Oceanography
29	29.0307	Undersea Warfare
29	**29.0399**	**Military Applied Sciences, Other.**
29	29.0401	Aerospace Ground Equipment Technology
29	29.0402	Air and Space Operations Technology
29	29.0403	Aircraft Armament Systems Technology
29	29.0404	Explosive Ordinance/Bomb Disposal
29	29.0405	Joint Command/Task Force (C3, C4I) Systems

29	29.0406	Military Information Systems Technology
29	29.0407	Missile and Space Systems Technology
29	29.0408	Munitions Systems/Ordinance Technology
29	29.0409	Radar Communications and Systems Technology
29	**29.0499**	**Military Systems and Maintenance Technology, Other.**
29	**29.9999**	**Military Technologies and Applied Sciences, Other.**
30	30.0101	Biological and Physical Sciences
30	30.0601	Systems Science and Theory
30	30.0801	Mathematics and Computer Science
30	30.1001	Biopsychology
30	**30.1701**	**Behavioral Sciences.**
30	30.1801	Natural Sciences
30	30.1901	Nutrition Sciences
30	30.2501	Cognitive Science
30	**30.2701**	**Human Biology.**
30	**30.3001**	**Computational Science.**
30	**30.3101**	**Human Computer Interaction.**
30	30.3201	Marine Sciences
30	**30.3301**	**Sustainability Studies.**
40	40.0101	Physical Sciences
40	40.0201	Astronomy
40	40.0202	Astrophysics
40	40.0203	Planetary Astronomy and Science
40	**40.0299**	**Astronomy and Astrophysics, Other.**
40	40.0401	Atmospheric Sciences and Meteorology, General
40	40.0402	Atmospheric Chemistry and Climatology
40	40.0403	Atmospheric Physics and Dynamics
40	40.0404	Meteorology
40	**40.0499**	**Atmospheric Sciences and Meteorology, Other.**
40	40.0501	Chemistry, General
40	40.0502	Analytical Chemistry
40	40.0503	Inorganic Chemistry

40	40.0504	Organic Chemistry
40	40.0506	Physical Chemistry
40	40.0507	Polymer Chemistry
40	40.0508	Chemical Physics
40	40.0509	Environmental Chemistry
40	40.0510	Forensic Chemistry
40	40.0511	Theoretical Chemistry
40	**40.0599**	**Chemistry, Other.**
40	40.0601	Geology/Earth Science, General
40	40.0602	Geochemistry
40	40.0603	Geophysics and Seismology
40	40.0604	Paleontology
40	40.0605	Hydrology and Water Resources Science
40	40.0606	Geochemistry and Petrology
40	40.0607	Oceanography, Chemical and Physical
40	**40.0699**	**Geological and Earth Sciences/Geosciences, Other.**
40	40.0801	Physics, General
40	40.0802	Atomic/Molecular Physics
40	40.0804	Elementary Particle Physics
40	40.0805	Plasma and High-Temperature Physics
40	40.0806	Nuclear Physics
40	40.0807	Optics/Optical Sciences
40	40.0808	Condensed Matter and Materials Physics
40	40.0809	Acoustics
40	40.0810	Theoretical and Mathematical Physics
40	**40.0899**	**Physics, Other.**
40	40.1001	Materials Science
40	40.1002	Materials Chemistry
40	**40.1099**	**Materials Sciences, Other.**
40	**40.9999**	**Physical Sciences, Other.**
41	41.0000	Science Technologies/Technicians, General
41	41.0101	Biology Technician/Biotechnology Laboratory Technician

41	41.0204	Industrial Radiologic Technology/Technician
41	41.0205	Nuclear/Nuclear Power Technology/Technician
41	**41.0299**	**Nuclear and Industrial Radiologic Technologies/Technicians, Other.**
41	41.0301	Chemical Technology/Technician
41	41.0303	Chemical Process Technology
41	**41.0399**	**Physical Science Technologies/Technicians, Other.**
41	**41.9999**	**Science Technologies/Technicians, Other.**
42	42.2701	Cognitive Psychology and Psycholinguistics
42	42.2702	Comparative Psychology
42	42.2703	Developmental and Child Psychology
42	42.2704	Experimental Psychology
42	42.2705	Personality Psychology
42	42.2706	Physiological Psychology/Psychobiology
42	42.2707	Social Psychology
42	42.2708	Psychometrics and Quantitative Psychology
42	42.2709	Psychopharmacology
42	**42.2799**	**Research and Experimental Psychology, Other.**
43	43.0106	Forensic Science and Technology
43	**43.0116**	**Cyber/Computer Forensics and Counterterrorism.**
45	**45.0301**	**Archeology.**
45	**45.0603**	**Econometrics and Quantitative Economics.**
45	45.0702	Geographic Information Science and Cartography
49	**49.0101**	**Aeronautics/Aviation/Aerospace Science and Technology, General.**
51	**51.1002**	**Cytotechnology/Cytotechnologist.**
51	**51.1005**	**Clinical Laboratory Science/Medical Technology/Technologist.**
51	51.1401	Medical Scientist
51	51.2003	Pharmaceutics and Drug Design
51	51.2004	Medicinal and Pharmaceutical Chemistry
51	51.2005	Natural Products Chemistry and Pharmacognosy
51	**51.2006**	**Clinical and Industrial Drug Development.**
51	**51.2007**	**Pharmacoeconomics/Pharmaceutical Economics.**
51	**51.2009**	**Industrial and Physical Pharmacy and Cosmetic Sciences.**

51	**51.2010**	**Pharmaceutical Sciences.**
51	**51.2202**	**Environmental Health.**
51	**51.2205**	**Health/Medical Physics.**
51	**51.2502**	**Veterinary Anatomy**
51	**51.2503**	**Veterinary Physiology**
51	**51.2504**	**Veterinary Microbiology and Immunobiology**
51	**51.2505**	**Veterinary Pathology and Pathobiology**
51	**51.2506**	**Veterinary Toxicology and Pharmacology**
51	**51.2510**	**Veterinary Preventive Medicine Epidemiology and Public Health**
51	**51.2511**	**Veterinary Infectious Diseases**
51	51.2706	Medical Informatics
52	52.1301	Management Science
52	52.1302	Business Statistics
52	52.1304	Actuarial Science
52	**52.1399**	**Management Science and Quantitative Methods, Other**

APPENDIX B

IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901, 407-882-2012 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

From : **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To : **Maya Abdallah**

Date : **October 26, 2015**

Dear Researcher:

On 10/26/2015 the IRB determined that the following proposed activity is not human research as defined by DHHS regulations at 45 CFR 46 or FDA regulations at 21 CFR 50/56:

Type of Review:	Not Human Research Determination
Project Title:	Setting The Agenda For STEM Literacy In Higher Education: A Content Analysis Of The Chronicle Of Higher Education.
Investigator:	Maya Abdallah
IRB ID:	SBE-15-11674
Funding Agency:	
Grant Title:	
Research ID:	N/A

University of Central Florida IRB review and approval is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are to be made and there are questions about whether these activities are research involving human subjects, please contact the IRB office to discuss the proposed changes.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 10/26/2015 02:40:53 PM EDT
IRB Manager

APPENDIX C
SAMPLE DETAILS

Article #	Title	Year	Author	Author Affiliations
1	Educators to create technology institute in Africa	2005	Kigotho, Wachira	Wachira Kigotho is an Independent Researcher and correspondent with expertise in Educational Assessment, Educational Leadership, Educational Policy
2	A Plea for Spatial Literacy	2006	Newcombe, Nora	Nora S. Newcombe is a professor of psychology at Temple University.
3	Black and Hispanic students are about as likely as their white and Asian-American peers to enter college interested in majoring in the "STEM" fields--science, technology, engineering, and mathematics	2006	Schmidt, Peter	Peter Schmidt is a senior writer for The Chronicle of Higher Education, where he covers affirmative action, academic labor, and issues related to academic freedom. He also is the author of the critically acclaimed Color and Money: How Rich White Kids Are Winning the War Over College Affirmative Action
4	Science and Math Make Money	2006	Martin, Michael	Michael V. Martin is president of New Mexico State University
5	Federal Programs to increase science are not well reviewed, panel finds	2006	Bollag,Burton	Burton Bollag is a reporter covering teaching, religion, accreditation, international issues at U.S. colleges and universities

6	House panel Quizzes Universities on value of Overseas Vetures	2007	Blumenstyk, Goldie	Goldie Blumenstyk has been a reporter and an editor at The Chronicle of Higher Education since 1988. She has covered a wide range of topics, including distance education, the Internet boom and bust, state politics, university governance, and fund raising. She is nationally known for her expertise on for-profit higher education, college finances, and university patents and the commercialization of academic research. She has reported for The Chronicle from several countries in Europe and from China, and her stories have received numerous awards, including first place from the Education Writers Association for 2011 for beat reporting on the Business of Higher Education.
7	The Real Science crisis: bleak prospects for young researchers	2007	Monastersky, Richard	Richard Monastersky, a senior writer at The Chronicle of Higher Education, was awarded the David Perlman Award for Excellence in Science Journalism – News at the AGU Spring Meeting Honors Ceremony, which was held on 29 May 2002, in Washington, D.C. The award recognizes excellence in science news reporting, prepared with a deadline of one week or less.
8	America can teach asia a lot about science. Technology,and math	2008	Bharucha, Jamshed	Jamshed Bharucha is Provost and senior vice president and a professor of psychology, neuroscience, and music, Tufts University
9	Africa steps up efforts to train top Scientists	2008	Lindow, Megan	Megan Lindow has lived and worked in Africa for six years. She is the Africa correspondent for The Chronicle of Higher Educationand has written for Time, Newsweekand The Christian Science Monitor.

10	Obama offers bill to align science-education programs	2008	Field, Kelly	Kelly E. Field, chief Washington reporter, joined The Chronicle of Higher Education in 2004 and covers federal higher-education policy. Field received a bachelor's degree in Spanish and psychology from Colby College in 1999 and a master's in journalism from Boston University in 2002.
11	Silos of Academe thwart diversity on campus	2008	Gilbert, Juan	Juan Gilbert is Professor and associate chair of research, Department of Computer and Information Science and Engineering, University of Florida
12	South Korea Powers Ahead with globalization Plans	2009	McNeill, David	David McNeill is the Japan correspondent for The Independent and other publications, including The Irish Times, The Economist and The Chronicle of Higher Education. He covered the nuclear disaster for all three publications, has been to Fukushima ten times since 11 March 2011, and has written the book Strong in the Rain (with Lucy Birmingham) about the disasters. He is an Asia-Pacific Journal editor and Lecturer (part-time) Faculty of Liberal Arts, Sophia University Tokyo.

13	Scientist and Enginners are plentiful: the problem is with their jobs	2009	Baskin, Paul	Paul Basken, staff writer, joined The Chronicle of Higher Education in 2007 and covers science and government policy. Basken worked previously at Bloomberg News, where he started the State Department bureau and covered beats including health care and education. He also worked for United Press International, spending five years covering the White House, with regular participation in televised presidential news conferences. He also covered Congress, led a team of foreign desk editors in London, and handled international assignments that included war coverage in the Middle East and Bosnia-Herzegovina. Basken holds a bachelor’s degree in journalism and electrical engineering from the University of Massachusetts at Amherst.
14	2-year colleges help learning disabled students break into math and science	2010	Marchand, Ashley	Ashley Marchand Orme is the research manager for NACD, helping to shape, write, and edit flagship research for the organization. Prior to assuming this role in June 2015, she served as the associate editor of NACD Directorship magazine, interviewing and writing about top leaders in corporate governance.A trained journalist, Ashley served as a senior staff writer for the News Division of the Advisory Board Co., a health care industry consulting firm in Washington, D.C. Her bylines have appeared in Houston community newspapers, the New York Times, and the Chronicle of Higher Education.

15	NSF seeks new approach to help students in science	2010	Baskin, Paul	Paul Basken, staff writer, joined The Chronicle of Higher Education in 2007 and covers science and government policy. Basken worked previously at Bloomberg News, where he started the State Department bureau and covered beats including health care and education. He also worked for United Press International, spending five years covering the White House, with regular participation in televised presidential news conferences. He also covered Congress, led a team of foreign desk editors in London, and handled international assignments that included war coverage in the Middle East and Bosnia-Herzegovina. Basken holds a bachelor’s degree in journalism and electrical engineering from the University of Massachusetts at Amherst.
16	Move or Die: If you don't want our department we'll go to another college	2010	Miller, Mary Helen	Mary Helen began in journalism as a print reporter, interning at the Christian Science Monitor, The Chronicle of Higher Education, and the Maine Center for Public Interest Reporting. She graduated from Bowdoin College in Maine, where she was a visual art and art history major, and editor-in-chief of the Bowdoin Orient.

17	Meet Societal Challenges by changing the culture on campus	2011	Hirschman, Elliot L. & Hrabowski, Freeman A.	Elliot L. Hirschman is the Provost, University of Maryland-Baltimore County. Freeman A. Hrabowski is Senior vice president for academic affairs, University of Maryland-Baltimore Count. He has been president of the University of Maryland-Baltimore County since 1992. His newest book, Holding Fast to Dreams: Empowering Youth From the Civil Rights Crusade to STEM Achievement, will be published next year by Beacon Press.
18	Online-Mentor Program raises retention of at risk science students	2011	Redden, Molly	Molly Redden is a reporter in Mother Jones' Washington bureau. Previously, she worked for The New Republic, covering energy and the environment and politics, and The Chronicle of Higher Education. Her work has also appeared in Salon, Washington City Paper, and Slate
19	New NSF Policies Provide Flexibility for Researchers who Juggle Family and Career	2011	Hebel, Sara	Sara Hebel is assistant managing editor at the Chronicle and oversees a team of editors and reporters who cover broad trends in higher education, including the changes, problems, and questions that confront colleges and the people who grapple with them. Hebel has worked as a reporter and editor at The Chronicle since 1999.

20	New York Taps into Israeli Institute's Expertise	2012	Kalman, Mathew	Matthew Kalman is The Chronicle's Israel correspondent.
21	States Push Even Further to cut Spending on Colleges	2012	Kelderman, Eric	Eric Kelderman, a staff reporter at The Chronicle of Higher Education, covers state policy, the future of public higher education and accreditation, and occasionally legal issues and music. Kelderman joined The Chronicle in 2008 from Stateline.org, a project of the Pew Center on the States. He has also covered education and state politics for The Gazette newspapers in Montgomery County, Md. In 2010, Eric was part of a team of Chronicle reporters that won first prize from the Education Writers Association for their articles.

22	How "Flipping" the classroom Can Improve the Traditonal Lecture	2012	Berrett, Dan	Dan Berrett, senior reporter, covers teaching, curriculum, and research on higher education. Previously, he worked as a reporter for Inside Higher Ed, where he covered faculty issues and disciplinary associations, and for the Pocono Record in Stroudsburg, Pa., where his beats spanned elementary, secondary, and higher education. While at the Record, Berrett earned several awards from the state press association for investigative reporting, feature writing, and breaking news. His work has also appeared in Newsweek and The New York Times, among other outlets.
23	Tuning In to Dropping Out	2012	Tabarrok, Alex	Alex Tabarrok is a professor of economics and a research fellow with the Mercatus Center at GeorgeMason University, as well as research director of the Independent Institute.
24	STEM Fields: Yes, We Can!	2012	Leary, Warren E.	Warren E. Leary, a journalist who has reported on science, technology and medicine for more than 40 years, is a retired science correspondent for The New York Times.

25	21 Colleges Win Grants to Study What Helps Minority Ph.D. Students in Sciences.	2012	Patton, Stacey	Stacey Patton, who joined The Chronicle of Higher Education in 2011, writes about graduate students. Her coverage areas include adjuncts, career outcomes for Ph.D.'s, diversity among doctoral students in science, technology, engineering, and math fields, and students navigating the graduate-school experience.
26	Work-Life Balance Is Out of Reach for Many Scientists, and Not Just Women.	2012	June, Audrey Williams,	Audrey Williams June is a senior reporter who writes about the academic workplace, faculty pay, and work-life balance in academe.
27	Is Anyone Teaching Teachers of Science	2012	Putz, Francis E. & Jones, Linda L. Cronin	Francis E. Putz is Professor of Biology, University of Florida, Gainesville, Fla. Linda L Cronin Jones is Associate Professor of Science Education, University of Florida, Gainesville, Fla.
28	Subsidizing the Liberal Arts	2012	Gerson, Lydia	Lydia Gerson, Director, Gateway Academic Center City College of the City University of New York, New York
29	Subsidizing the Liberal Arts	2012	The Chronicle (Bonalibro)	

30	For Women to Think Mathematically, Colleges Should Think Creatively.	2012	Hill, Theodore P., Rogers, Erika,	Theodore P. Hill is a professor emeritus of mathematics at the Georgia Institute of Technology and a research scholar in residence at the California Polytechnic State University at San Luis Obispo. Erika Rogers is retired from the California Polytechnic State University, where she was a professor of computer science and director of the university honors program.
31	Economy Has Had Far-Reaching Effects on Higher Education	2012	Berrett, Dan	Dan Berrett, senior reporter, covers teaching, curriculum, and research on higher education. Previously, he worked as a reporter for Inside Higher Ed, where he covered faculty issues and disciplinary associations, and for the Pocono Record in Stroudsburg, Pa., where his beats spanned elementary, secondary, and higher education. While at the Record, Berrett earned several awards from the state press association for investigative reporting, feature writing,and breaking news. His work has also appeared in Newsweek and The New York Times, among other outlets
32	Why STEM Fields Still Don't Draw More Women	2012	The Chronicle	

33	Trends in Numbers of Science and Math Degrees Earned in Virginia, 1992-2011	2012	The Chronicle	
34	Despite Efforts to close gender gaps, some disciplines remain lopsided	2012	Mangan, Katherine	Katherine Mangan, a senior reporter based in Austin, Tex., joined The Chronicle in 1986. She covers community colleges, professional schools, college-completion and work-force issues, and higher-education news in the Southwest
35	More gender diversity will mean better science	2012	Rosser, Sue V.	Sue V. Rosser is provost at San Francisco State University. She is the author of Breaking Into the Lab: Engineering Progress for Women in Science (New York University Press, 2012) and many other books and articles on women and gender in science.

36	Why STEM Fields Still Don't Draw More Women	2012	Coger, Robin N.; Cuny, Jan; Klawe, Maria; McGann, Matt; Purcell, Karen D	Robin N. Coger: Dean, College of Engineering, and professor of mechanical engineering, North Carolina A&T State University. Jan Cuny: Program director, National Science Foundation's Computing Education for the 21st Century. Maria Klawe: President, Harvey Mudd College, and former dean of engineering and professor of computer science at Princeton University. Matt McGann: Director of admissions,Massachusetts Institute of Technology. Karen D. Purcell: Founder and president of PK Electrical Inc., a Nevada-based electrical-engineering firm, and author of Unlocking Your Brilliance: Smart Strategies for Women to Thrive in Science, Technology, Engineering, and Math (Greenleaf Book Group Press, 2012)

37	Fulbright Tries Out Short-Term Fellowships	2012	WILHELM, IAN	Ian Wilhelm is editor of the Chronicle’s international section. He reports on the international activities of American colleges, manages the newspaper's foreign correspondents, and edits WorldWise, a Chronicle blog on global higher education.Wilhelm previously worked for 10 years at The Chronicle of Philanthropy, covering international philanthropy and large private grant-makers. He has reported from Africa, China, Germany, and Sri Lanka, among other places, for The Chronicle of Philanthropy and The Chronicle of Higher Education. He holds a bachelor’s in writing from the Johns Hopkins University and a master’s from Columbia University’s Graduate School of Journalism.

38	Changes take root in the desert	2012	Blumenstyk, Goldie	As a reporter and an editor at The Chronicle of Higher Education since 1988, Goldie Blumenstyk has covered a wide range of topics, including distance education, the Internet boom and bust, state politics, university governance, and fund raising. She is nationally known for her expertise on for-profit higher education, college finances, and university patents and the commercialization of academic research. She has reported for The Chronicle from several countries in Europe and from China, and her stories have received numerous awards, including first place from the Education Writers Association for 2011 for beat reporting on the Business of Higher Education.
39	In Defense of equal tuition for all majors	2013	Villasenor, John	John Villasenor is a nonresident senior fellow at the Brookings Institution and a professor of electrical engineering at the University of California at Los Angeles.
40	Community Colleges respond to demand for STEM graduates	2013	Mangan, Katherine	Katherine Mangan, a senior reporter based in Austin, Tex., joined The Chronicle in 1986. She covers community colleges, professional schools, college-completion and work-force issues, and higher-education news in the Southwest

41	Black and Hispanic Science Ph.D.'s Are More Likely to Graduate With Substantial Debt.	2013	Patton, Stacey	Stacey Patton, who joined The Chronicle of Higher Education in 2011, writes about graduate students. Her coverage areas include adjuncts, career outcomes for Ph.D.'s, diversity among doctoral students in science, technology, engineering, and math fields, and students navigating the graduate-school experience.
42	The Rift	2013	Hollinger, David A.	David A. Hollinger is a professor of history emeritus at the University of California at Berkeley. His latest book is After Cloven Tongues of Fire: Protestant Liberalism in Modern American History (Princeton University Press, 2013).
43	Sharing Math's Appeal With First-Generation Students	2013	D'AGOSTINO, SUSAN	Susan D'Agostino is an assistant professor of mathematics and coordinator of the Math Major program at Southern New Hampshire University
44	Research by Undergraduates Helps Underfinanced Colleges as Well as Students	2013	CARPI, ANTHONY, LENTS, NATHAN H	Anthony Carpi is interim associate provost for the advancement of research and a professor of environmental toxicology at John Jay College of Criminal Justice at the City University of New York. Nathan H. Lents is director of undergraduate research and an associate professor of molecular biology at the college.

45	The STEM-Crisis Myth.	2013	ANFT, MICHAEL	Senior writer MICHAEL ANFT covers science and medicine for the Johns Hopkins magazine. During his 25 years as a journalist, he has covered nonprofit organizations nationwide for The Chronicle of Philanthropy, delved into media and political matters and the arts for Baltimore's City Paper, written about pop music for The Baltimore Evening Sun, and penned stories on business for Warfield's. He has also reviewed books for The Washington Post, music for OPTION, and the arts for a host of magazines.

46	Many Students Don't Practice Vital Quantitative Skills in Their Coursework, Survey Finds	2013	BERRETT, DAN, SANDER, LIBBY	Dan Berrett, senior reporter, covers teaching, curriculum, and research on higher education. Previously, he worked as a reporter for Inside Higher Ed, where he covered faculty issues and disciplinary associations, and for the Pocono Record in Stroudsburg, Pa., where his beats spanned elementary, secondary, and higher education. While at the Record, Berrett earned several awards from the state press association for investigative reporting, feature writing, and breaking news. His work has also appeared in Newsweek and The New York Times, among other outlets. Libby Sander, a senior reporter, writes about student affairs, exploring the experiences of collegians from all walks of life. The Education Writers Association has twice recognized her feature writing with first-prize awards, most recently for “Out of Uniform,” a 2012 series of articles about student veterans and the new GI Bill. She joined The Chronicle in 2007 to cover college sports, focusing on the people and finances of major NCAA programs, and in 2010-11 was the lead author of the Players blog.
47	Data Point	2013	The Chronicle	
48	To understand science, study history	2014	Dubcovsky, Alejandra	Alejandra Dubcovsky is an assistant professor of history at Yale University.
49	Graduate students	2014	The Chronicle	

50	Group Seeks to Align Curricula With Job Skills in High Demand	2014	Mangan, Katherine	Katherine Mangan, a senior reporter based in Austin, Tex., joined The Chronicle in 1986. She covers community colleges, professional schools, college-completion and work-force issues, and higher-education news in the Southwest
51	What the Head of Hiring at Google Doesn't Understand About Skills	2014	Raffa, Guy P.	Guy P. Raffa is an associate professor of Italian studies at the University of Texas at Austin.
52	You Pay It Forward'	2014	The Chronicle	
53	Black Man in the Lab	2014	Patton, Stacey	Stacey Patton, who joined The Chronicle of Higher Education in 2011, writes about graduate students. Her coverage areas include adjuncts, career outcomes for Ph.D.'s, diversity among doctoral students in science, technology, engineering, and math fields, and students navigating the graduate-school experience.

54	How to Get More Black Men Into Science	2014	HRABOWSKI III, FREEMAN A	Freeman A. Hrabowski is Senior vice president for academic affairs, University of Maryland-Baltimore Count. He has been president of the University of Maryland-Baltimore County since 1992. His newest book, Holding Fast to Dreams: Empowering Youth From the Civil Rights Crusade to STEM Achievement, will be published next year by Beacon Press.
55	How U. of San Diego Added 8 Female STEM Professors	2014	The Chronicle	
56	Data Point	2015	The Chronicle	
57	Why Just Filling the Pipeline Won't Diversify STEM Fields	2015	June, Audrey Williams,	Audrey Williams June is a senior reporter who writes about the academic workplace, faculty pay, and work-life balance in academe.
58	STRAIGHT TALK ABOUT STEM	2015	Jones, Jackie	Jackie Jones is an associate professor and chair of the Department of Multimedia Journalism at Morgan State University's School of Global Journalism and Communications.
59	Helping Minority Ph.D.'s in STEM: Something's Working	2015	GARDNER, LEE,	Lee Gardner, a senior reporter, covers the management of the university and how leaders navigate change. He also writes about higher-education marketing and branding, and about the forces that challenge traditional college models.

60	Minority Ph.D.'s Find Career Success in STEM	2015	Leslie, Francis M.	Francis M. Leslieis is the Dean of the Graduate Division and a professor of pharmacology, and of anatomy and neurobiology, in the School of Medicine at the University of California at Irvine
61	Student Mentors Keep High-Schoolers Engaged Through College	2015	Mangan, Katherine	Katherine Mangan, a senior reporter based in Austin, Tex., joined The Chronicle in 1986. She covers community colleges, professional schools, college-completion and work-force issues, and higher-education news in the Southwest
62	Learning the Ways of the Force	2015	LAMBERT, W. MARCUS	Marcus W. Lambert is director of diversity and student services at Cornell University's Weill Cornell Graduate School of Medical Sciences, in New York City.
63	The Importance of Writing in Tech Fields.	2015	MACPHAIL, THERESA,	Theresa Macphail is an Assistant professor, science, technology, and society program, Stevens Institute of Technology

APPENDIX D
LIST OF EXCLUDED ARTICLES

Article #	Title	Year	Author
1	Egypt Puts a Scholar, and Academic Freedom, on Trial	2001	Del Castillo, Daniel
2	Revising the Book of Life	2002	Monastersky, Richard
3	AmeriCorps Cuts Back on Volunteers, Prompting Concern for Programs	2003	Selingo, Jeffrey
4	Toward a Single Definition of College	2003	Moore, David G.
5	Chronicle of Higher Education. Volume 50, Number 18, January 9, 2004	2004	Chronicle of Higher Education
6	Textbook Pirates Find a Huge Market in China	2004	Lin-liu, Jen
7	Crying Foul Over Fans’ Boorish Behavior	2004	Hoover, Eric
8	Thailand to Open a University in a Muslim Region, to Defuse Tension	2004	Overland, Martha Ann
9	Back to School	2004	Toor, Rachel
10	Genetically Altered Papayas Pit Scientists Against Protesters in Hawaii and Thailand	2004	Monaghan, Peter
11	Inadmissible Evidence: Terror, Torture, and the World Today.	2004	Harpham, Geoffrey Galt.
12	Hawaii’s Fading Star	2004	Monastersky, Richard
13	A New Model for Textbook Pricing	2004	Granof, Michael H.
14	Lack of Diversity Among Football Coaches Reflects Broader Problem, Study Finds	2004	Engber, Daniel
15	Do-It-All Campus ID Cards: Too Corporate?	2005	Blum, Debra E.
16	A Philosopher’s Humanity	2005	Romano, Carlin
17	A “Nonacademic” Career	2005	Henderson, Natalie
18	OUT AGAIN	2005	Selingo, Jeffrey
19	Facing Death in a Culture of War	2005	Torgovnick, Marianna
20	Red in Tooth, Claw, and Trigger Finger	2005	Barash, David P.
21	Rights for Some People, Not Others	2005	Noriega, Chon A.
22	Abandoning Cassette Tapes, Purdue U. Will Podcast Lectures in Almost 50 Courses	2005	Read, Brock.
23	Outlook for Higher Education in the State Legislatures: VIRGINIA	2006	Hebel, Sara
24	Researchers Battle Against ‘Badware’	2006	Kiernan, Vincent
25	15 Board Member Resign at Canadian Medical Journal	2006	Birchard, Karen
26	Reform and Resistance at Oxford	2006	Labi, Aisha
27	Disasters and Deregulation	2006	Steinberg, Ted
28	Applications Rise at Business Schools	2006	Der Werf, Martin Van

29	India, Europe, America: a Geocultural Triangle	2006	Pells, Richard
30	Not for Women Only	2007	Bollag, Burton
31	Time for Reading	2007	Waters, Lindsay
32	Shooting From the Hip in Neveda	2007	Fischer, Karin
33	Legal Barriers Hamper Scholars' Access to Papers of Recent Presidents	2007	Glenn, David
34	Athletics Programs Consider Taking Out Life-Insurance Policies on Boosters	2007	Wolverton, Brad
35	Is There an Autism Epidemic?	2007	Monastersky, Richard
36	Swedish University, Alleging Culture Clash, Forces out 2 Tenured Foreign Professors	2007	Labi, Aisha
37	Deconstruct THIS Immigration	2007	Goldstein, Evan R.
38	British Faculty Union Opposes Plan for Monitoring Extremists	2007	Labi, Aisha
39	Big Ten Network Faces Tough Questions as It nears Start Date	2007	Wolverton, Brad
40	A Year Later, Spellings Report Still Makes Ripples	2007	Basken, Paul
41	In India, Economic Success Leaves Universities Desperate for Professors	2007	Neelakantan, Shailaja
42	Alumni Credit Cards Offer Rewards to Stem Decline in Use	2008	Strout, Erin
43	Some Schools of Architecture Could Use a Good Architect	2008	Fisher, Thomas
44	A Ceramony to Help Heal 'the Tragic Legacy of 1942"	2008	Monaghan, Peter
45	House of Representatives OKs Student-lending Bill	2008	Field, Kelly
46	Racial Paranoia and Jeremiah Wright	2008	Jackson, John L.
47	States Push Colleges to Fight Online Piracy	2008	Foster, Andrea L.
48	Go Ahead, Steal My Car	2008	Blake, Bill
49	Disputes and Resignations Roil the Middle East Center at the U of Utah	2008	Wasley, Paula
50	A Dialogue Among Scholars About a Dialogue With Islam	2008	Goldstein, Evan R.
51	Psychology and Torture	2008	Glenn, David
52	On Stupidity	2008	Benton, Thomas H.
53	ROTC Seeks to Expand on Campuses, and Colleges Cope with a Conflict	2008	Wiedeman, Reeves
54	A Wealth of Data, and Nobody to Charge	2008	Guernsey, Lisa
55	Despite Alcohol Crackdown, the Party Goes On	2008	Wilson, Robin

56	In Search of New Frontiers: How Scholars Generate Ideas	2008	Hampel, Robert L
57	Students Deserve a Bailout, Too	2009	Sims, Jeffrey
58	Notoriety Yields Tragedy in Iowa Sexual-Harassment Cases	2009	Wilson, Robin
59	We Must Teach Students to Fail Well	2009	Glasser, Leah Blatt.
60	New Rules Require More Sunshine on Terms of Private Student Loans	2009	Nelson, Libby
61	What's Ahead	2009	Chronicle of Higher Education
62	At Harvard, Tenure Isn't Just for Old People Anymore	2010	Wilson, Robin
63	The Elements of Clunk	2011	Yagoda, Ben
64	It's Your Fault	2011	Perlmutter, David D.
65	Online Programs Face New Demands From Accreditors	2011	Kelderman, Eric
66	Anger Darkens Mood on Campuses	2011	Blumenstyk, Goldie, Stripling, Jack
67	In India, Caste Discrimination Still Plagues University Campuses	2011	Neelakantan, Shailaja
68	Science and Security clash on Bird-flu	2012	Fischman, Josh
69	Bucking Cultural Norms, Asia Tries Liberal Arts	2012	Fischer, Karin
70			
71	The Week in Brief	2012	Chronicle of Higher Education
72	The Benefits of Making It Harder to Learn	2012	Lang, James M.
73	The Trouble with the Other N-Word	2012	Miller, D. Quentin
74	We Asked You to Invent Your Own College: Here Are Our 5 Top Picks	2012	Chronicle of Higher Education
75	In a Secret Classroom in Georgia, Immigrants Learn to Hope	2012	Sander, Libby
76	Microaggression and Changing Moral Cultures	2015	Campbell, Bradley; Manning, Jason
77	On the Academic Job Market, Does Patience Pay Off?	2015	Wood, Maren

APPENDIX E
CODEBOOK

I. Select articles to be coded.

All articles accept those without any reference to STEM or Science, Technology, Engineering, or Mathematics education must be coded.

II. Identify article characteristics

1. Title of article
2. Author and author credentials and/or affiliations
3. Date of publication

III. Determine article theme/category

Although articles may briefly discuss or convey elements of other themes, placement is determined based on the article's primary focus being the elements of one of the below themes. Articles may only placed into a single theme.

1. Government/Politics: Articles that deal primarily with government initiatives and policies regarding STEM education.

2. Diversity: Articles that deal primarily with underrepresentation of specific populations and the recruitment or retention of underrepresented populations in STEM education. Specific populations include primarily African-American's, Hispanics, Women, and students with disabilities.

3. Employment: Articles that deal primarily with the job outlook for STEM students/graduates and conditions affecting retention in the field.

4. State of STEM: Articles that deal primarily with highlighting the concerns and conversations in higher education as they relate to STEM education including issues of STEM and the liberal arts, the economy and economic competition, the STEM shortage, and data regarding enrollment and graduation trends.

5. International/Study Abroad: Articles that deal primarily with international developments in STEM education U.S./International collaborations, and U.S. study-abroad and research programs.

6. Institutional Initiatives: Articles that deal primarily with reporting specific institutional initiatives regarding STEM education.

7. Curriculum/Instruction: Articles that deal primarily with highlighting matters relating to STEM curriculum and instructional methods or pedagogy.

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