Introducing Teaching STEAM as a Practical Educational Framework for Korea
By Georgette Yakman

As an educator, one is honored by seeing students excel and go on to do impressive things in their lives and careers for themselves and for the world. Among my greatest accomplishments is using the STEAM framework that I created with a group of secondary school children in an underprivileged school who were previously accustomed to doing as little as possible to get by in their education. All of the students, whom were taught with the STEAM framework during the school day, were offered the opportunity to join an after-school club to extend their education. These children enjoyed this way of teaching so much, that instead of leaving school in the mid-afternoon, as is common in western cultures, they would ask for dinners to be provided for them so that they could study until the late evenings. In American culture, there is no true equivalent of ‘hagwon’ (Byun) and most families cannot afford what few programs are available for after-school enrichment. Based on the reality, that in many countries there seems is an overall increasing stronger global emphasis on providing practical learning, the STEAM framework has been developed as a result of a three-year application to try and improve upon my previous three years of theoretical research and planning (Yakman, 2006). This program was run with money raised with students and all on volunteer time, so that this new framework could have the flexibility to adapt the curriculum for what worked best for the students, the instructor and the community. The goal was to see if providing this way of teaching made students more interested in learning, as well as if it had significant effects on their standardized testing results in their core subjects. Although there was no formal qualitative or quantitative testing on this group of students, it can be said without a doubt that the student’s enthusiasm to learn, retain and utilize more information in both broad bands of knowledge and specifically deep areas of mathematics, science, technology, language arts, social sciences, ethics and engineering was significantly higher than any other students with whom I had previously taught. This group of students created many projects, one of which went on to win a national student engineering competition during the first year that this program was offered. The benefits were substantial for the students. They learned more about many things including; what they each excelled in, how they could work with and respect others for having different focuses of specialties on a team, and how they could learn a common specific language of content (Huber, 2005) in the S-T-E-A-M fields to be able to communicate more effectively with each other and the global community.

It was hoped that the design the STEAM educational framework would be very adaptable to all levels, types and styles of teaching. There was no desire to design a framework that would replace any institution’s established way of educating, but instead to compliment and expand on what was already working for a certain educational community. Before its use could be extended beyond the United States to international students, there needed to be a study of other country’s educational systems. The Korean educational cultural history and current directions with education at school and in out-of-school contexts has been fascinating to learn about (Byun, Choi). Korea already has a majority of educational and cultural frameworks in place that are very conducive to moving towards a more formal system of whole community STEAM education . The size of the country, cultural integrity, moral values, and long respect for creating excellence in education, developed educational formats and a desire by the citizens to be well-learned has resulted in being on the global forefront of developing the abilities of an extraordinarily high rate of quantitative and qualitative growth in education for Korean citizens for over half a century. (KBS World – History) The literacy rate in Korea nearly 99% and secondary education standards have risen to be some of the best in the world. (KBS World – About) A large aspect behind the academic successes in Korea is the 5000 years history of moral upbringing as the central feature of human life established to develop moral virtues, reasoning for developing autonomous self-discipline and character traits that to lead desirable lives with social manners and an ability to solve conflicts with justifiable methods of moral autonomy. This has been established to help create and maintain a national identity ‘for and after the unification of Korea’ by using a synthesis between traditional values and democratic values (Chu, Hoge & Park, 1996) All of this has resulted in an instilled national desire for each individual to achieve as much as they can and therefore the Koreans have a cooperative push to excel at academics by encouraging autonomous development in education (KBS World – History). This desire is backed by the devotion of the central government both financially (Choi) and with policy (Chu & Park, 1996) to create one of the best educational systems in the world with an astonishing
97%+ literacy rate (KBS World – History). In large part, due to such a well-educated and devoted citizenry, Korea has now made incredible developments in modern sciences and general technology (KBS World – History). With these aspects in place, Korea is well-suited to continue to flourish to find more ways to contribute to the development of human civilization and culture on the basis of such advancements. (KBS World - History). It is promoted by the Minister of Education that the inclusion of a STEAM educational framework in public education will help boost those efforts and results.

Korea’s Minister of Education’s announced in 2011 to commit to formally include the STEM/STEAM movement across the country as an innovative way to teach K-12 science education. By including these methods, some work will be needed up front to accommodate these educational philosophies and practices. But using this concept will pay off grandly for students to acquire a deeper and broader essential knowledge to progress themselves as well as better develop concept of where they as individuals fit into the greater community of their country and the world. They will learn to work in balanced communities of learners as they emerge into the university and professional worlds. For educators, it will help develop a stronger sense of community for themselves and with other professionals. This will allow for a deeper ability to develop and guide students towards their particular interests and goals while still enforcing the concept that one must understand the interconnections of subjects in life to be a good citizen, consumer and professional. The country of Korea should be able to see benefits not only in their individual children's accomplishments, but in an advancement in their global status.

STEAM is a relatively new framework of educating across the disciplines. It has been evolving to support a new educational theory. STEAM is based on STEM education, which grew out of the vast need to have more students achieve success in understanding the systems and connections (Dugger, 2003) that bind together the hard sciences, technology, engineering and mathematics, in order to help solve the problems of a rapidly changing world (Dakers, 2006). This concept has received so much recent emphasis, that it has created a new educational branch, STEM, which can be defined in two ways:

1. the more traditional way, I like to write as S-T-E-M education, as it is the individual ‘silo’ fields of science, technology, engineering and mathematics education. Each has evolved to formally include elements of the others within their own standards and practices (AACTE).

2. the newer trend is the concept of integrated STEM education. It includes the teaching and learning practices when the subjects are purposefully integrated. When taught, one field may be the dominant base field, or all may be blended unilaterally (Sanders, 2006).

While studying the common factors of teaching and learning across the disciplines of S-T-E-M, it was hard to not include the influences of the arts disciplines. The arts contain all of the divisions that interact with the pure possibilities of combining the other fields to shape the direction of development. Based on that fact it is necessary to include the key elements of the arts such as: aesthetics, ergonomics, sociology, psychology, philosophy and education into the study of the S-T-E-M concepts that we supposed to go on and shape our developing world and cultures? This concept began the development of an educational framework that could formally link the study of the hard sciences to that of the divisions of the arts. This investigation led to a deeper study of each of the main subject areas with the hope that the finer educational divisions could be classified as having value and influence within each of the other silo disciplines including all the areas of social, fine and physical arts. The following base definitions and classifications are the result of that investigation:

- **Science** - what exists naturally & how it is affected (Rutherford & Ahlgren) including: Biology, Biochemistry, Chemistry, Geosciences, Inquiry, Physics and Space
- **Technology** - what is human-made or “innovation, change, or modification of the natural environment to satisfy perceived human needs and wants” (ITEA, 2000) including: Agricultural, Construction, Communication, Information, Manufacturing, Medical, Power & Energy, Production and Transportation
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- **Mathematics** - the study of numbers, symbolic relationships, patterns, shapes, uncertainty & reasoning. (AAAS, Chap 9 & NSTM, 1989) including: Algebra, Calculus, Data Analysis & Probability, Geometry, Numbers & Operations, Problem Solving, Reason & Proof, Theory and Trigonometry

- **Arts** - Fine, Language & Liberal, Motor and Physical
  - **Language Arts**: The way that all kinds of communication is used & interpreted, which includes: written, spoken, sung, signed, shown with one’s body, etc. (Patterson).
  - **Physical**: manual and athletics arts including ergonomic movements (NASPE).
  - **Liberal and Social**: Including: Education, History, Philosophy, Politics, Psychology, Sociology, Theology, Science Technology Society (STS) and more…(Featherstone)
  - **Fine Arts**: Aesthetics and where the oldest sustainable cultural pieces come from that teach of the earliest records in civilizations (Mishook, J. J., & Kornhaber).

Unraveling the fields of the social, fine, manual, physical and liberal arts led to an understanding of how they expand outwards to influence and be influenced by the studies and practices of the S-T-E-M fields. All of this investigation led to the development of the STEAM framework to help educators teach subjects more like they are related to one another in reality. From all of these connections, following diagram was created as a way to establish a framework to give structure to and analyze the interactive nature of both the practice and study of the formal fields of science, technology, engineering, mathematics and the arts.

STEAM-style education can be enjoyably and meaningfully delivered in more engaging and deeply embedding ways within the already well-established realm of education. The philosophy of STEAM revolves around the concept that: **STEAM = Science & Technology interpreted through Engineering & the Arts, all based in Mathematical elements** (Yakman, 2006). A significant common thread is that each
primary division promotes a need for students to develop a proficiency in the subject that would make them literate enough in the discipline to be able to continue to adapt to and learn about the basic developments that the field takes. When looking across the breadth of the categories, I can point to a significant amount of research done on how to instill scientific literacy, technological literacy, the design process, mathematical literacy and language literacy in students. (Driver, Rutherford & Ahlgren) I would argue that this leads to a conclusion that students need a literacy of a breadth of the primary disciplines which would include an ability to transfer knowledge with higher order thinking between disciplines so that students may obtain a functional literacy (DeBoer, Yakman, 2006). Discipline specific thinking is transferable to other bases of content. Functionally literate people are more effective because how to think across the spectrum of topics and understand the connections between the disciplines. Students engaged with STEAM, not only learn to be literate in a singular (silo) field, but they become life-long learners who are much more capable of advancing the global society. This also assists them to better understand people and things rooted in other disciplines, perspectives and cultures so they can communicate and work with one another while still maintain their own identities.

It is important that each subject still maintain its own educational base in the disciplines, so that ‘scholars of teaching and learning (can) address field-specific issues if they are going to be heard in their own disciplines, and they must speak in a language that their colleagues understand’ (Huber & Morale, p. 2). It is also important that each division be taught with formal acknowledgment of the commons between all the disciplines, because “the easier it is to engage other subjects, due to factors like common language, the easier it is for students to realize how to apply knowledge from one curriculum to another.” (Huber & Morale, p. 2). Despite the fact that science (the natural world) precedes technology (human-made items), science and technology are independent disciplines with different goals, methods and outcomes, yet technology ontology (study and development) predates science ontology (study and investigation) in a dialectical relationship with neither a dominant partner. (Gardner) With this knowledge, the use of the word ‘study’ is correct for both fields, in science it relates more to the definition of something being analyzed on how it naturally occurred, versus in technology it relates to defining the way in which something can be artificially constructed. The vocabulary is the same, but the relationship to the individual discipline is the key to understanding what the vocabulary refers to in differing contexts. When students are aware of these contexts, their depth of knowledge is broadened and deepened by the transference of knowledge from one discipline topic to another. Cooperation among disciplines provides realistic dynamics and influences that allow students to learn how to accommodate to the real world. Cooperation..., can also have the effect of encouraging the use of common language, common analogies and an appropriate level of detail across the two subjects thus avoiding misconceptions and regression” (Barlex & Pitt, p. 41). If you add in an understanding of the nuances and variations in meanings between languages such as Korean and English, one’s understanding of the known world in the global context becomes exponentially better. If more people understood that Korean, or ‘hangeul’ was originally called “Humninjeongeum,” which means “the right sounds to enlighten the people” and that it is the most recognized worldwide as the most scientific and logical writing system, marked by ingenuity and efficiency and an ease to learn (KBS world), it would add to a better global understanding of the culture of Korea and logically have an influence to promote more respect for Korean equity, especially in the business and engineering fields. But to be more thoroughly understood, one must master the arts of communication that go well beyond spoken and written languages.

The relatively recent Kuhnian revolution in the field of mathematics education has some fascinating implications for all fields (Ernest). “It’s time to let the secret out: mathematics is not primarily a matter of plugging numbers into formulas and performing rote computations. It is a way of thinking and questioning that may be unfamiliar to many of us, but is available to almost all of us” (Paulos, p. 3). This led to an exploration of the intrinsic elements that show that mathematics is the base element of social constructivism for the other silos, although it is not infallible as such. Mathematics, and mathematics alone, is essential for the study of the other silos, it is even the base of the study of language (Hersh, p. 14). Mathematics is the primal language that cuts across all other field’s boundaries, which is the closest the world has to a common language that can be currently used to provide structure for the other silos. In 1978, Schawab introduced the four ‘commonplaces of teaching mathematics;’ These are; the subject (mathematics), the learner of
mathematics, the mathematics teacher, and the milieu of teaching, including the relationship of mathematics
teaching and learning, and its aims, to society in general (Ernest, p. 3). It is this last statement about
mathematics’ relationship to society, which brings in a wealth of applicable constructivist elements. ‘The
study of technology and engineering is not possible without the study of the natural sciences. This in turn
cannot be understood in depth without a fundamental understanding of mathematics’ (Dugger).

Mathematics is not just a primal language but a network of practical and theoretical divisions of varying
methods includes projects, constructions, analysis and process work, as well as (instead of solely) the results
that interact with other subjects as well as stands alone as a branch of natural science. (NCTM) It is a field
necessary for; all kinds of learners, overall concepts of theory, history & applications. It is truly reality-
based in that way that it is the primary analyzing tool for all practices, applications, values, testing and
assessment of any element of society and nature, including education. (Dewey & NCTM) It not only relates
to all aspects of society, but as a finite language, mathematics can also transform culture (Paulos), so it
needs to be expressed carefully and accurately.

When one realizes that the commons of language arts used to teach across the disciplines, directly
supports transference of knowledge between subjects, then it becomes another extension of that same
concept to believe that a commons of epistemology, pedagogy and methodology would also be beneficial to
deeper and broader understandings, despite the context of a specific discipline. This is not to say that a
singular unified language or method is best, but more accurately to say that a variety of well-explored and
planned uses of languages and methodologies would help to establish more connections to knowledge,
resulting in a more substantial level of understanding across the disciplines. There needs to be an
“exploration of existing views to create new theoretical ideas, experimental work and cross-discipline,
consensus-approved language styles (Barlex & Pitt). John Dewey, and educational researcher and
practitioner who’s writings have yet to be broadly implemented after a century, has a great deal to say on the
topic. One of his most succinct quotes is this: ‘experience that is integrated – that which attains the fullest
possible meaning – is a primary goal of human activity… growth under the circumstances of life as an
ongoing experiment involves risk and the willingness to relinquish the authority of tradition, but it should
enable the person, as well an entire society, to look critically at previously accepted beliefs in the light of
new experience’ (Dewey). It is within that quote that Dewey both reveals the reasons for the need of
integrated, reality-based, inquiry learning as well as the primary reasons why it has yet to be adopted.

Although it is essential to teach people to work within a society to advance the global culture, it is very
difficult to create real-world experiences in a classroom atmosphere and equally as demanding to do so
within any particular culture and the established beliefs affiliated with it, this latter concept can be termed
the ‘Galileo effect.’ By using the term ‘Galileo effect,’ it is in reference to the societal resistance when
European culture transferred from the practice of alchemy into the study of science. The resistance to
Galileo’s ideas is a prime example of societal established norms are so powerful, that even when scientific
and technological evidence proves such beliefs to be false, there is a great pressure to dismiss logical
advancements and continue to function in long-accepted traditions. Every culture is guilty of this, because it
is by established cultural ‘rules’ that societies have advanced enough to get where we are today. All cultures
that have survived, have seen others destroyed by holding fast to their out-dated beliefs as well as have seen
some cultures destroyed by adopting too quickly new positions that were believed and adhered to before
proven. Therefore, it is at the heart of the essence of educating, to provide students the means by which to
advance knowledge and also the common sense by which to test and prove the theories affiliated with
intellectual advancements.

STEAM tries to help solve the above-described educational dilemma, by not specifically teaching any
one group of topics, but instead by teaching students how to interpret the vast changes they will encounter in
their lifetimes. STEAM tries to do this by teaching students to adopt the attitudes, habits and intellectual
skills to be adaptable life-long learners. ‘The idea that it is impossible to teach people to think,… did not
proceed from scholarly research, but from an unscholarly assumption that if thinking was not being taught,
and had not been taught, it therefore could not be taught.’ (Ruggiero) STEAM is a substantiated, economical
and sociologically adaptable as a framework by which to transition, maintain, create and evolve educational
elements, programs and institutions to include multidisciplinary-oriented practices catering to developing
more functional citizens. The goal of STEAM is to be strong, benchmarked, measurable and easily reinforcing of standards in unique and engaging ways. It is also planned in order for it to be accepted into many different types and levels of learning environments. It has been created to be adaptable so that it can accurately be representative of the surrounding culture and built to be tolerant of all types of diversity both, within those represented who are studying with it and for all of the cultures known to them. STEAM is a plan for public, common education where ALL subjects and types of learners can validly contribute and all effort is encouraged and measurable for group and individual achievements. STEAM can be implemented to be engaging, hands-on and reality-based, yet inexpensively, with many extensions to draw education, industry, government and the community together for the common good of bettering public education for all while meeting standard’s guidelines and STEM related goals.

When students deeply believe that one person can make a major difference in a global economy, they feel empowered to succeed personally, culturally and for the betterment of all. They become invested in a competitiveness that still fosters community spirit. It doesn’t contradict, but actually assists the efforts of "harsh competition-oriented and success-oriented parenting goals (Hwang), as stated by, Dr. Lee Mi-na, while encouraging students to genuinely feel that encouraging their peers and learning from one another is to everyone’s benefit. The key to unleashing that power in whole classes of students is to, from the beginning, embed meaningful challenges and individual assessments into teams with a wide array of strengths so that everyone has a place to be recognized for their advanced skills while also having personal interactions and respect for those with other strengths that balance theirs.

Learning and believing in how to be an effective and valued team player is an important skill in its own right since it is how industry works. This skill is essential in the professional world as there are a resounding number of heads of businesses based in cultures where students are taught as individuals who are openly saying that one of the most difficult thing for young people to learn is how to work as part of a team. In the professional world one cannot succeed on one’s own, yet our educational systems are structured so that we train people from very young ages to work by themselves. There is a belief that it is simpler to assess a single person with a single instrument, when in fact it is more natural to have people learn and work with each other to achieve common goals. The primary difficulty lies in how to accurately assess people’s progress with education in a less structured system. This is a universal problem for modern education, but not and insurmountable one. First there needs to be recognition and acceptance of the fact that it is more useful to teach people how to learn in modern society than to learn any one particular set of factoids. The reasons to teach people how to learn are numerous. ‘First everyone wants to be surrounded by professionals in all fields that are knowledgeable people with which to interact and cooperate in a large network or team. People need to be informed users so that they can evaluate needs, wants and opportunities and respond with innovations that help everyone and set the in motion plans that make things perpetually better for the next generation through education, example and practice.’ (Barlex, p. 180) There have been many attempts, both small and large scale at moving towards such a goal. Most of these ideas have evolved around the concept of teaching holistically. But with the way most school systems have been established to teach the individual, the systems themselves lag in coordinating positive efforts to collect the ideas that are working and eliminate those that do not hold up to the test of practicum. In an age where the world is in perpetual communication, those ideas are starting to blend in structural ways and collaborative efforts to improve education globally are on the rise.

Holistic education in the STEAM context is denoted as life-long learning; therefore all purposefully planned programs of teaching that have been called holistic education, are considered an attempt at it. It can be argued that holistic learning cannot be controlled or planned; it is the interpretation of each person’s sphere, or universe, of influence. The results of these influences, both internal and external, greatly shape what people do with what they are exposed to and what they understand. Since each person’s perspective is different, holistic education cannot be delivered equally to students. This is why the very top of the STEAM pyramid is the universal level, as it is where individuals learn from their environments that are not possible to be controlled for true planned ‘holistic learning.’ The next level is denoted as ‘STEAM’ in the pyramid to establish a place for planned integration. It is at this level where students can obtain a broad scope of all the fields and a basic overview of how they inter-relate in reality by teaching them with a purposefully planned
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and reality-based interdependence. It is at this stage that students begin to understand what and how to explore all areas of opportunities in the educational realm. Instructors have the choice of focusing in depth on specific areas or covering a broad scope of the topic. Teams of teachers can work together to provide in depth coverage of their areas of expertise while reinforcing what students are learning in other specific areas. The next level denoted on the diagram is the multidisciplinary level. It is at this level where students can obtain a scope of specifically chosen fields and a concentrated overview of how they inter-relate in reality. An excellent way to teach about natural inter-relations in practice of both STEM and STEAM is to teach reality-based/authentic units. When purposefully planned to cover certain fields and concepts, instructors can still easily use themed education, but with integration the fields should be represented in a more balanced way. Whereas with multidisciplinary levels, the fields not in primary focus should not be all together excluded from the curriculum, but instead, at least explained as being an element of the scope that would occur in reality. The next level of the diagram is the discipline specific level. It is at this level where individual silo divisions of fields, or disciplines, are taught at focus levels. It is where individual subjects are the primary topic of focus. This is not to say that other subjects are excluded, subjects should still be covered contextually. The primary subject is explored significantly more in depth then the related fields. This is the level at which to explore what areas of expertise a person wishes to acquire as career and hobby. The most specific level of the pyramid is the content specific level. It is at this level that content areas are studied in detail. It is here where professional development happens and students delve into the tighter realm of the specific content areas of their interest. Areas can be studied alone or in specifically grouped clusters from within their own silos or from across the fields. Again, this should still be relevant and contextual to the world at large, but this is the point where educational and professional practice most fully interrelate with each other’s developments.

Current trends in education have already established STEM as a relevant block of core fields. Trends have also shown many of the branches of the arts being more and more marginalized. In most public education, only the language arts and social studies are still formally given substantive attention as having importance outside of the STEM areas. This can be seen a tragedy, as it eliminates many primary ways for students to obtain contextual understanding of all fields. Therefore, as students are exposed to prominent and marginalized fields, they begin to understand the hierarchy and politics of both education and practice. It is here that students might begin to have a concept of specific areas of interest to explore as potential career paths and subsequently be turned away from investigating fields that are not dominantly represented by people in their realm. With the ‘flattening of the world’ through the advancements of technology, we are approaching a time where people from anywhere in the world, from any socio-economic backgrounds have more and more access to any type of career they wish to pursue and every country is doing its best to educationally evolve as rapidly as possible to keep up with such changes. STEAM has been purposely developed to be adaptable to changes so that it does not become a dated method.

STEAM is ‘built on the educational giants’ before it and tries to promote the overlapping trends that are geared at educating the whole learner. The most closely aligned trends already being used and tested pedagogies and curricula fall under the titles of integrated, themed, inquiry, discovery or reality-based and constructivist education (Dewey, Barlex & Pitt, Petrina). The six primary features of constructivism are: engagement, understanding, performance, reflection, generativity & commitment (Furth). STEAM aligns well with many educational theories and instructional strategies already widely accepted such as: Constructivism, which includes a tenants that directly relates it to liberal education and openly adheres to no sole or best method or simple rules for pedagogy, but instead is universally adaptable and open to interpretation and implementations and it ideal for integrative learning (Lauda, deVries, ITEA, Dakers, Salinger, Zuga, Wicklein) with their being no fix borders between the disciplines but instead insists on necessary cross-links for relatively and reality (Rutherford & Ahlgren) with its only restriction being that it is used to teach how to learn, not what to learn (Furth). Many specific terms are used as aspects of these trends that promote educating the whole learner in an interdisciplinary reality-based team manner. “Learners as discoverers,” “team sharing participants,” multiple perspectives and roles, teacher as guide, observer and cooperator or co-learner, situational and potentially contradicting to beliefs being explored for whys and why nots, realistic and relevant environments and lessons, contextual subjects, methods and skill
development, application and problem-solving decision based learning (Dewey, Rousseau & Furth)
scaffolding and proximal development by Vygotsky (Driscoll) ‘Multiple Intelligences’ (Berger & Pollman),
‘(Marzano)’s Strategies,’ inter-related discipline recognitions with interdependent advances and integrated
SMT and STEM (LaPorte & Sanders, Wells), learning how to learn and/or guided discovery (Ruggiero, DeBoer, Driver, Froebel), teacher and student collaborative learning, (Freire, Barlex & Pitt) ‘Actor Network Theory,’ (Latour & Woolgar) critical and higher order thinking ‘(Bloom)’s Taxonomy’, socio-cultural ethical perspectives (Driscoll ), commons of disciplines used by all, (Huber & Hutchings) deductive reasoning and discourse, small group interactions, modeling, whole learner applications (indigenous tribes, Reggio Emilia (Firlik, 1996) (Montessori) Waldorf (AWSNA, 2008) and home schooling movements (Eisler, 2005; Minnis & John-Steiner, 2005). Bruner explains the concept of ‘sociocognitive conflict’ where experiences trigger people remember related events which they did not or do not currently understand in order to create an assimilation through connections that will decrease their confusion in a effort to make sense of their interactions and environment (Rogers). This concept is also in line with the concept of Science and Technology in Society (STS) and how societies revolve in influence with technology being reliant on each other and victims of each other as development happens. (Pinch & Bijker)There are many more epistemologists educational psychologists whose work also support and are encompassed by the STEAM framework. Although they have not been formally included in mass, there are also numerous cognitive scientist’s work that also support this framework for people of all ages. (Bragdon & Gamon). With the ongoing research, development, implementation and refinement of STEAM, I continue to find more substantive backing for its use and have been avidly seeking faults in it to address.

When one looks at the subjects traditionally taught in modern education, most cultures put the most emphasis on science, language arts, mathematics and the social sciences as they relate to their specific culture. Although they are not regularly included in subjects taught at most K-12 schools, the fields’ technology and education are the ones that, in reality most easily transcend the boundaries of all the disciplines, in order for their progression to have been established and continue to flourish. “Technology education became one of the few areas of study to adopt a structure (from its beginning) that allows for, and encourages, changes in its core structure to accommodate changes in the technological world that inter-relate with society in a very reciprocal way. (This concept is assisted by) a lack of structured textbooks” outlining specific topics (Zuga). Engineering has been mostly being taught under the divisions of technology education as it does not have a history of ever being taught as a silo discipline in K-12 until very recently. This has resulted from the fact that by its nature, engineering is inter-connected to the advances in all of the other fields and has primarily been developed above the K-12 realm due to its complexities and has not bonded to a core curriculum to provide a base from which to be formally taught. Since it is based in a language of mathematics, it has been the field with which to transcend language boundaries most easily to support global extraction, production distribution and consumption of its products. The company IKEA is a prime example of this concept as the directions for the products are all sketches and numbered sequences so that they do not have to be translated to other languages. This concept also helps prove that developments in the fields of engineering and technology does not require much in the way of language arts, it requires ingenuity, but in order to share any concepts that have been developed, there needs to be a common language that goes beyond the literal translations of mathematics to engage the humanity behind the acceptance of new things. Technology education is the niche in the K-12 arena where the resulting products of engineering’s processes are learned about and studied. Without this field opening the door for younger people to explore the physical concepts behind design, individuals who are more creative gravitate towards the fine and musical arts. As illustrated well by Leonardo DaVinci’s life, the fine and musical arts can develop by means of a precise concentration of creativity and mathematics, but it is with the addition of more substantive mathematics, science, and sometimes ergonomics that defines the difference between the emotions conjured by art and the usefulness of technological devices. Specifically, the field of engineering being a team-based enterprise representing the research and design of creating new solutions to problems is a subset of the field of technology. Thus, the technology laboratory, previously conceptualized as a place to make things, has graduated into more of a place to learn the interconnections of things (Zuga). This fact has made it possible for engineering to start making an appearance in K-12 education, especially at the middle
and high school levels where students are capable of developing more advanced solutions to problems. The structure of most elementary school having a single teacher to deliver most of the curriculum allows for ease of thematic integration and introductory technology and engineering lessons to be implemented. Both technologists and engineers need to have the following abilities, the technologists to use and maintain the products that engineers continue to develop and reinvent. Those abilities include: evaluating needs, wants & opportunities, applying mathematics, science and technology, designing & conducting experiments, analyzing and interpreting data, designing systems, components or processes, working in multi-disciplinary teams, formulating and solving problems effectively and responsibly, communicating effectively, engaging in life-long learning of contemporary issues, techniques and skills.

In order to develop students who have enough of an understanding of the S-T-E-M topics to make educated decisions about which careers they care to devote their lives to, students must be given ample opportunity to engage with those topics. Korea is very advanced in the structure by which it offers compulsory education in a very broad spectrum of subjects through the majority of its K-12 grades. A substantial difference between Korean middle school structure, and that which is used in America, is that the students stay in the classroom, while the teachers rotate to teach them different topics. This is much more conducive for learning in that students do not have to put away all everything from one topic to formally transition to another. This set up also makes it much easier for teachers to work with a common theme that can be established in a classroom and used as a thread to tie discipline concepts together. In American middle schools, all of the prompts and aids used to illustrate points in each subject are not available for other teachers to use in order to provide more connections to learning for the students. This also makes it more difficult for assessment to change in America, there is a lot of time wasted getting students ready to leave a class and getting settled into the new one and there is no central location for ongoing projects to be kept where multiple students and teachers can build on them throughout the semester. Korean “teachers are encouraged to “branch out from traditional teacher-oriented instruction methods to use a combination of pedagogical methods (including the inquiry mode, dilemma discussion, and student-centered instruction) so as to make a class meaningful, effective, and enjoyable and to stimulate and develop the thinking abilities of students” (Chu & Park, 1996). The Korean elementary and middle school structure is very accommodating for the trend to keep developing. Having the Standards Olympiad provides students with a practical competition where students find out how to solve inconvenient cases stemming from lack of standardization (Choi), this too sounds like an opportunity to further develop with STEAM framework integrations. Beyond that, it is commendable that community service projects were implemented as required extracurricular activities in both middle and high schools almost a decade ago (Onishi). Korea has an excellent existing framework by which to be an exemplary place to work towards a system of subject integration.

What follows in this paper is a series of implemented and refined STEAM-based projects used primarily with young adults, but easily adaptable to be used with young children, adolescents, adults and even the elderly for a deeper and broader connection to comprehending the full spectrum of discipline fields with the goal of engaging life-long learners to stay functionally literate.

‘What’s Your Point?’ is the first stand alone STEAM course to be developed, which could be introduced to any upper elementary, middle school, first year high school or even early college course of study. It would be used as a seed for developing integrated curriculum throughout a student’s academic career and/or an entire school system. It has been implemented as a way to expose students to a large range of skill sets and career choices through reality-based integrated learning. Students perpetually evaluate their points of interest, experience and talents in relation to a diverse spectrum of topics from various careers and the related discipline skills. They are involved in evaluating local, regional, national and international career path opportunities and developments and results of historical, current and potential contexts. This gives the student a better understanding of what other courses and activities they need to plan for in order to achieve their personal career goals. This course also helps develop a basic understanding of many modern and common technological competencies that are needed in order to be functionally literate and adaptable to modern life regardless of what career path is chosen. The topics covered align with regional and national standards. A portfolio process of collection, reflection and evaluation helps organize students, teachers and school systems to more universally evaluate the individual in relation to others in the same grade level, no
matter what their skill sets are. In this system, students are placed on teams based on their personality make-up, academic and social strengths and weaknesses to learn from one another through a process such as professionals do in the workplace. With each person having a different role in a similar project, but everyone having individual duties, it creates and atmosphere of unity in working towards a common goal, a willingness to help each other excel, find a way to have balanced teams, respecting and promoting each other’s natural skills and developing knowledge as well as a desire to do ones own best. Since each person works on developing their own portfolio as well a group project and portfolio, this process of instruction and data collection allows for students of all learning styles and interests to excel at creating award-winning projects. It is also easier to evaluate their growth over the year in addition to only ranking them against a set of standards All project designs are developed with the basic 10 Step Design Process: 1. DEFINE - identify the need or the problem, 2. RESEARCH the need or problem, 3. Develop possible solutions (BRAINSTORM), 4. SELECT the best solutions, 5. EVALUATE with focus group market analysis or expert, 6. DELEGATE the team into specialties, 7. Construct a PROTOTYPE, 8. TEST and evaluate the solutions, 9. REDESIGN, 10. PRESENT, communicate the solutions (Goldberg, 2011). For each project that includes engineering (research, design and development) they are asked to; Describe their project: Then: Briefly explain how they did it, Explain what was the most interesting thing about it, Explain what could be better about the project (this helps me decide how to improve on the course), What they would do differently if they did it again. Students perpetually evaluate their own points of interest, experiences, knowledge acquired, and talents developed as they complete their project while adding to their portfolios. While students are progressing through the assignments, they take notes and make plans on a ‘Daily Notes Sheet,’ (Appendix A) this is used by them to create their individual and team portfolios. At the end of the course they have built themselves a portfolio that can be edited, added to or stream-lined to follow them through their school years and build as a resume of their accomplishments to use as a venue for applications. The beginning of the student portfolios provides a frame of personalizing the course for them. They are allowed a couple of weeks to learn the classroom structure, rules, procedures and investigation of some careers they wish to achieve. As Korea was the first country in the world to provide high-speed internet access for every primary, junior, and high school (Onishi), this and other global research should be easier to accomplish than in most countries. During this time, they are also educated on common living costs and the personal, community and global ethics of their career choices. They fill out their portfolio based on their primary career choice, including: why they chose it, what educational path they need to follow to achieve it and a range of details about the career such as; needed training, equipment, practices, salaries, related industries, lifestyle, status and impacts.

The remainder of the course explores a wide range of integrated STEAM thematic lessons including:
TECHNOLOGY & SOCIETY – WORLD ABILITIES - Academic History – Personal Interests - Career

Intro – Baduk (*underlined items are explained more fully in this paper)

TRANSPORTATION – ‘Around the World in Many Ways’

MEDICAL & BIOMEDICAL - Dialysis Project – Nanotechnology

AGRICULTURE & BIOTECHNOLOGY - Biorestoraton – Recycling

CONSTRUCTION - Geometrics – Architectural CAD – Building – Bridge Supports – West Point Bridge

Designer – Cartoonista – Yurts - Pallets


Rubber & Foam & Metal Forming – Fabric – Product Prototype – Story of Stuff

DESIGN -(Lip Balm): Product & Packaging Research & Development; Logos & Advertising

COMMUNICATION & INFORMATION - Drafting – Digital Photography & Editing – Digital Video —

Animation –Business Card - Intaglio Printing – Notebook Making

The first adaptable STEAM curricula developed to be introduced as a single lesson in one classroom or as a whole semester thematic unit to be delivered by a team of teachers at the level of elementary, middle school, secondary school or college was “Around the World in Many Ways.” This curriculum is based on something that everyone uses and is familiar with, no matter who they are or where they live, transportation
systems. These systems are defined as a combination of at least two means of moving anything from one location to another. The introductory lesson has been delivered to all age groups and for varying lengths of time. All attempts have been successful in expanding knowledge and being so engaging that most people are reluctant to leave the topic and move on to other things. It is easy to help other teachers understand the topic and adapt it to their subjects.

Ideally a thematic unit is taught by multiple teachers working with the same grade level that can offer discipline-based instruction. When done this way, each teacher revolves some of their weekly lessons around the common theme agreed upon with other teachers and makes connections to their discipline’s standards when doing so. To introduce the theme, all instructors should be careful to deliver the same lesson at similar times. There is a developed introductory lesson for this topic that covers the basics of the theme and how it relates to the S-T-E-A-M fields. This curriculum starts with the definition and the base categories of transportation systems: what, how and where, with examples of how they are all inter-related. It goes on to discuss historical timelines of technological development defined within the constructs of how different things were invented and used in various locations and how those things affected culture, industry and governments/militaries. This is where the social arts, historical studies and technology teachers can focus their related lessons from history, the present or the projected future. The overview lesson then teaches about transportation systems being much more than planes, trains and automobiles and that it includes information like smoke signals to wireless technology, body and sign language and even weather patterns. This is the point that science’s lessons are most closely linked to inputs, outputs, impacts and byproducts, with very strong links to chemistry. Geography is especially linked to what is suited for use where and the global impacts, which are also strongly linked to ecology and biology. Engineering, physics, mathematics, language and fine arts are related to all of these topics, but particular projects can be done with aesthetics, ergonomics, invention, testing, use, reports and industry.

At the end of the introduction lesson a game (Appendix B) is planned to test each student’s grasp of the content covered. The game is first played as a class with the instructor as the guide, then if time allows, students may be chosen to lead the game with variations and conditions added. The basic goal of the game is to get a ball around the world. A ball is used instead of a human, because there are fewer things to worry about regarding safety, temperature, size and condition. The base rules are that a physical map of the world is shown without political boundary lines and students must choose a different mode of transportation for each geographical region they encounter. You may not stay in Antarctica for more than 1/10 of your journey. You can use any transportation method from the past, present or immediate future, for example: chariots, trains and solar cars are okay, space cars are not. There need to be a minimum of ten connections for the first round of games. As teachers develop the curriculum to better fit the topics they need to cover, the rules can be manipulated to accommodate those lessons. For instance; algebra can be taught by having students study how much it would cost to have the ball travel a certain distance by different motorized methods. Trigonometry can be applied for the analysis of short and long term trends, benefits and drawbacks for individuals, companies, the local economy, world culture and universal impacts. Geometry and physics can figure out how to design a trebuchet with the proper trajectory needed to get the ball over a river or how the ball will transfer between devices. Geography can be taught by limiting the travel to certain specific regions, ecology, economics (if political boundaries are added) and sociology can be studied by learning about the long-term impacts of promoting different methods of travel. Language arts can be embedded in any of these studies or for related research or creative writing topics. Social history is very deeply related to the development of transportation technologies, both in the personal and the governmental and/or military environments in which they are surrounded. Engineering and technology will utilize all the other fields if components of systems are designed, tested and redesigned. Even someone studying things such as; advanced physiology for understanding movements of the body or satellite correspondence and energy can study any aspect of transference movements and relate it to transportation systems. Since this topic touches all aspects of living and commerce and therefore the practices and ethics behind; extraction, limits, production, distribution, consumption, disposal, byproducts and consequences across time and cultures, it has common themes that can be easily adapted to any scholastic situation and structure.
Baduk is the main component of another curriculum that I have adapted to the STEAM framework. It has been part of my curriculum since 1996 when I was tutoring students in mathematics and opened an evening club in my town for beginners and advanced players. The first public baduk school was opened in Japan around 1600 (Smith), currently there are over 50 baduk clubs at public K-12 schools across the United States (AGA). There is one college, Middlebury, in Vermont, that offers a bachelor’s level courses in baduk, but there are no advanced degrees offered in the United States as there is like the one a Myongji University in Korea. As I understood learning and the game better, I realized that it could be used to enhance learning in all subjects, especially because one needs to use creative and logical abilities of both sides of the brain (Ruggiero). Also with the black and white stones representing ying and yang and there needing to be constant balance of interplays on the board, baduk is also conducive to teaching ethics and morals including kibun. When I first began teaching full-time I introduced the game to all of my technology classes early on in the semester and devoted one or two class periods to making sure that students understood the basic rules. I explained that “no one can say really what go (baduk) is, how you should play it, what it ought to mean to you. That can only be a personal discovery, perhaps with the aid of a native guide pointing out the features of the terrain… It is simple, but it is not easy.” (Kim & Soo-hun p. vii ) I kept multiple sets and teaching books in the classroom, put a digital version on all of the computers in the classroom, and established it as something that the students could use when they were ahead on their work. Some of my students played regularly and got quite good at it, others did not play very much at all, but at least were familiar with the game and knew that it could be used to strengthen general intellectual ability. Because of the built-in handicapped system, it was easy for students to accommodate playing with one another. (Lasker, p. xviii) I also explained the game’s connection to the STEAM fields. After the first time I introduced it in public school classes, I wrote a presentation on how I did this, with the help of Professor Jin Soo Kim, where I presented it at the International Society of Exploring Teaching & Learning conference (ISETL) and published it with the American Go Association (AGA) as a presentation titled “Using the Game of Baduk to Teach Across the Disciplines” (Kim & Yakman, 2007). In this presentation the connections made for my students between baduk and the STEAM fields are as follows. In science, not only can the nature of the materials, especially katsura wood used to make the game, be studied, but within the game, the connection to science is that the 360 plus 1 intersections compare to the days of the lunar year and the center represents the pole star, the four quarters of the board is comparable to the four seasons, the 72 circumference points represent the [five-day] weeks of the [Chinese lunar] calendar and the stones are compared to night and day (Smith). In technology, not only can the materials and processes of the game’s construction be studied, but the processes of creativity, strategy and pattern design within the game is very important. In engineering, the primary connections include the development of deeper concentration powers needed for in-depth tasks like creating new products and computer programming. Interestingly enough, there can be no computer program that plays the game of baduk well until true artificial intelligence can be used. Currently the level of computer Baduk games remains about that of a human who has studied Baduk for a month (Bozulich). Baduk’s connections to the arts is quite extensive. Not only are there patterns and an aesthetic nature of the game that need to be recognized, but there are very artistic creations of boards, stones, bowls and carrying devices. The history of baduk starts in China over 4,000 years ago (Lasker, p.xiii) It is most played in China, Japan and Korea. Originally in China the game was banned for commoners and kept only for nobility as it was known to increase intelligence and improve memory (Smith). It was not until 735 A.D. that the game went to Japan nobility until 1080’s when it was introduced to vassals and commoners (Lasker, p.xv-xvi) It was in the 1600’s that the game became known in western culture at all. It was played by Samuri warriors (Smith) and used in WWII with the Japanese on both sides of the Pacific, the Japanese war planners used the game to establish the best places to make bases, it made no sense to the Allied troops and it took them quite a while to make the pattern connection to baduk. (Life, p.96) For the Japanese in America during WWII, many were removed from their homes, belongings and places in society to be put in relocation camps where playing baduk became an important part of daily life to keep a connection to cognitive maintenance and development as well as amusement, status and honor. (Eaton) In language arts, there have been many famous writings on it including; the Bayu, a poet from
around 240 B.C., (Smith) a 1979 novel called Shibumi (Trevanian) and Hikaru No Go (Hotta) a current graphic novel set written for the pre-teenage market. In mathematics it is an excellent tool for teaching geometrical pattern recognition and binary mathematics, which I use to introduce calculus to very young children. It also helps me teach chemistry and physics when I relate the number of possible games playable to be more than the number of molecules in the universe (AGA). There are more connections for integrated STEAM education from the game of baduk, but when I teach the students these connections and let them play the game, it is exciting to have them come back and tell me of the other connections that they make in their own encounters in life to the lessons they get from their own journey with learning to be a better baduk player.

A more arts and business-based developing curriculum is structured around producing **lip balm**. Student teams are created with the concept that each team is a different company all pitching their ideas to an investor (the instructor) who will only invest in one company’s business plan. It is structured that if more than one team does an outstanding job, they can decide to merge and split the investment, which realizes as bonus points. It is also structured that if no team excels, that the investor decides to withdraw the offer, and no team receives exemplary grades. At that point, individuals who desire to do the extra work can reinvent and resubmit their teams plan or construct their own business plan to receive their own grade.

The business plans include the development of the following areas: product materials and processes research, target market analysis, brainstorming, prototyping a recipe, developing a flow-chart for industrial processing, developing a marketing plan with; a unique company name, a unique product and name for it, a logo, accurate and legal labels, a shipping and display box, a print ad and a television commercial at the end the plan must also have a cost analysis for producing the products in bulk. The team must adhere to the ordered plan, each person taking the lead in one or more areas of development and produce a sellable batch of tubes of lip balm, usually 20. Since all that is needed is a clean working surface and a microwave, this project can be done in any setting with electricity. Some of the constructs of the project include the fact that students get full credit if they can reasonably support the local economy in an ecological way by primarily buying local and organic ingredients, producing in ecological minded ways, filling a need in a specialty market with a significant demand, appealing to a unisex audience, including a medicinal element, and proving that they have developed their specific product and marketing campaign based on research and the design loop. In this process, students learn what it takes to create and maintain a small start up company with real-life competition and consumers. When the products are made, they are ‘released’ to a test market of people at school and their appeal to the general public with their marketing, product and end-user survey results are analyzed. They are given the opportunity to react to this collected data and asked to analyze it for possible improvements to the product. During this process, the students also receive the benefit of paying for their own supplies. Each student earns one of the products for completing their work up to production, but if the team is successful and wishes to create and additional batch to sell, they are allowed to split the profit from the second round of sales. This project involves the sciences of studying ingredients and possibly their effects on healing, the technology process needed to plan and complete the steps, the engineering of a new concept and its ability to be mass produced in a cottage-industry environment, the aesthetic arts of its presentation and marketing, the language arts of creating appealing names and the business plan and the communication technology and arts of the technical aspects of the commercial, label and logo. Behind all of this is a considerable amount of mathematics used as the drafting and geometry of creating the box and marketing items and the accounting and algebra needed to analyze the costs for the business plan and sales. Overall students react very favorably to this lesson. It allows for a multitude of talents that are creative, detail oriented and cover a broad range of topics at the same time. It is also quite fun for them as they identify with their previous knowledge of the product and already feel like consumer experts going into the project. This provides them with the confidence to make well rounded teams no matter how specific their individual skills are.

Although classroom management and assessment need to be planned from before the lessons start, they are being addressed at the end of this paper. This is done because what is most often heard from people is that they think the concept of interdisciplinary teaching is great, but more difficult than single discipline teaching. In my experience, once a teacher or school system and the students understand and accept what is
being asked of them and different ways to achieve those goals that work with their particular needs and style, it is actually easier to teach across the disciplines for more enrichment and understanding than to purposely try to avoid overlapping other disciplines and to keep the students focused on only one element of the topic they are studying. Very often students who have a hard time understanding mathematics will come to my classroom and learn when and how the mathematics skills and understanding will help them achieve a result they want. It is then that they are excited to learn the deeper elements of mathematics to solve the problem before them. It means more to a student then analyzing if they understand a certain concept taught out of context. I have found this true for students learning language and writing, science, history, technology and engineering design. Few students get excited about writing a paper or speaking properly in their base language or a foreign language, but when they are given the opportunity to report, share or converse with other students and educators on topics which they have learned about through solving real-life problems, they feel very powerful to be a part of the growth of world knowledge and strive in all areas to have their work represented to the public as valid, important, correct and comprehensive.

Here are offered some of the things used in the American public education system to help teaching and learning in an integrative STEAM-based way go more smoothly. Not all of them will work for all of you, but hopefully all of them allow you the opportunity to adapt the concepts to work in your own settings. My classroom rules break down to the word ‘WELCOME.’ There are signs around the classroom and on the classroom door that has this word written from top to bottom with the concept it represents after it. W= within – meaning that all students are expected to be in the classroom with their materials ready every day that school is in session and if they are absent, they are responsible for knowing what happened within the classroom when they were not there. E = everyone – meaning that everyone has value and plays a different role in making a difference in the classroom and the world and that everyone should respect one another physically, emotionally and intellectually, this relates to the Korean concept of kibun. L = learning – meaning that everyone should learn from one another and value what they can contribute and what they can better understand from others and understand the base concept that the more they learn, the more they should realize how important it is to have a variety of experts since there is so much knowledge in the world to manage. C = cooperates – meaning that full cooperation is essential from everyone in the classroom from listening, to accomplishing, to suggesting ideas that may improve on the topic at hand. O = observing – meaning that at times there is a need for teacher-centered instruction, usually done for a small amount of time at the beginning of each instruction period, where students need to be quiet, aware, take notes, watch processes being done, and ask questions that are of general importance to the group. M = makes – meaning that everyone is part of the team in the classroom and in the world that they are contributing to and that their best efforts at performing their role makes life better for everyone, and that sometimes they get to bring home something that they made and that even if the topic is difficult for them, they should be proud of the abilities learned and results of their project. E = enjoy – that the best way to learn is to be interested, engaged and positive about what concepts are at hand and that even when a topic being covered is not of particular interest to a student, that they should want to understand the topic enough to be able to be an educated world citizen and be able to have an intelligent conversation on the topic with someone who might be an expert in the field.

Another key to integrative classroom management is to create teams of students with varying skills. However many students I have, I break them into four groups To do this fairly, I spend the first week of the school year learning about them as individuals through assignments and watching them interact with one another and myself. The collection of introductory assignments that I use include reviewing; the syllabus, general workplace readiness skills, general lab safety and basic specific equipment usage and safety. I give out a background a course questionnaire on the first day asking them about what out of school experiences they’ve had with making things, what their hobbies are, what they might have been exposed to through their families lines of work or in their neighborhoods, what their favorite subjects are and why and what they see as their biggest academic challenges and why they feel these things are difficult. This questionnaire gives me a lot of information about their personal insight into their interests, strengths and weaknesses. Next they are given a basic overview of Integrative STEAM (Appendix C), including an introduction to the methods used by which to use it (Yakman, 2006). A brief STEAM definition is covered with a review of all...
the fields within each content specific silo. Students get a general scope of the fields and the multitudes of jobs within them and across them and how people with various skills to fill differing niches to create successful teams (Yakman, 2006). At the end of this lesson, a review is given of the eight ways in which people receive and interpret information, also called the Multiple Intelligences of learning (Berger & Pollman). After reviewing the different ways in which students can be taught, students are asked to list the top three ways that they feel they learn best. The next piece of identifying how to create balanced teams of students is to have them take the Myers-Briggs personality test (Similar Minds) and review the suggested jobs that are recommended to be affiliated with the specific personality that each student identifies with (BSM). When they have had a chance to do this and reflect on the suggestions, then three is an instructor lead conversation about likely careers for them as a particular group of students that align with each of the personality divisions. During this discussion the basic skills, budgets and lifestyles affiliated with the careers talked about are covered for understanding by the students. The last piece of gathering information for establishing the teams in the classroom is for the students to be encouraged to investigate specific career options for themselves in the future and how they are going to achieve those goals through academic and training avenues. I encourage them to think about where they want to see themselves in the future not just for the status and the financial gains they may see for their own families, but in relation to how they want to change the world and be remembered globally as individuals and as a nation.

The area most recently being refined is assessment. The primary assessment tactic used with STEAM is a backwards design (Wiggins & McTighe) team-based portfolio project of creating generic titles for each type of strength distributed for the skills needed for each type of team project. Within this structure, one or two students can be assigned to be the lead or co-captain one or multiple job titles. The grading is broken down to the same general portfolio building, rubric structure. All the elements of the project and how they are evaluated are explained in advance with the instructions for fulfilling the requirements for the portfolio due at the end of the project. Students can see the checkpoints and get feedback, credit and encouragement for their work throughout the process. Various assessment techniques can be embedded in the portfolios, such as personal observations, interviews, check-lists, attitude scales, questionnaires written tests and more. Each title area of the project is given an equivalent point value, for instance, to use STEAM, each of the divisions receives 20/100 points, with partial points being also awarded. Grading is done continually through the process, but when it the project is completed and the grades are finalized, all students on the team receive a grade consisting of the total of team points acquired for each division averaged with the grades from the topic(s) they were the leader on. To illustrate this, lets say that at the end of the project grades are assigned as the ‘S’ component getting 18 points, the ‘T’ getting 17, the ‘E’ getting 15, the ‘A’ getting 16 and the ‘M’ getting 12. All of the students will have 78 for their group grade, which will get averaged with the equivalent of the grade that each student was in charge of directing, recording and reporting for the project, if a student was assigned to lead or co-captain two or more areas, those grades are averaged before the individual grade is averaged with the team average for a final grade. So, a student leading ‘S’ would get 18/20 = 90% averaged with 78% equals 84% for a final grade, where as a student leading ‘T’ and ‘E’ would get 32/40 = 80% averaged with 78% equals 79% for a final grade. Hopefully, all of our students do better than these examples. This way each student is held accountable for the whole team’s efforts and results as well as their own specific grade for how they did with the area of the project that they possessed specific skills for and the averaged final project grade reflects both equally. Students adapt very quickly to helping each other succeed and doing all they can as individuals to take charge of encouraging, helping and guiding their team as leaders and participants. Since no one student is in charge, no one maintains the power in the group. Students who get particularly interested in a specific part of the project are encouraged to build up that area of the team’s portfolio and explore related topics. It is also very helpful since students tend to befriend others with similar skills, it affords students an opportunity to not only see the value of others with different types of skills, but to obtain in-depth knowledge as to how other types of people think, react and process information. This leads to a type of working and societal community knowledge that cannot be taught without experience. Students who are excellent at rote memorization and regularly receive excellent grades on memory based tests are often given more affirmation of their accomplishments than those who do not excel at memorization. With this structure,
those students who are excellent at understanding processes and creating new things can be recognized as skilled designers, technicians and engineers. Even students with significant limitations are offered ways to not only participate, but to teach others on the team. Often teams who have students who would not be great friends outside of the classroom come to appreciate the skills and perspectives of the rest of their teammates who are usually different from them. It has been very exciting to see students who have not understood each other’s perspectives previously, suddenly encourage and thank each other for contributing their skills to the project. STEAM teams evolve into communities and connections are made that extend far beyond the classroom.

Both the reasoning of why there is a global movement towards developing more people in the S-T-E-M fields, and the knowledge that there is something about these ‘hard’ fields that make many choose paths of liberal arts studies, especially women and minorities, makes the concept of STEAM not only more than a possibility. It is critical for global culture that students be interested in these fields as well as be able to succeed in learning and developing themselves with professional and realistic attitudes and skills. As (Dewey) said, the disharmony between textbooks and students’ life-experiences creates problems with motivation and transfer of learning. With STEAM students create their own portfolio texts so that their knowledge is as current as possible and they solve real-life problems that empower them as well as deeply seed their knowledge in multiple ways for transference.

Many of the arguments laid out here for the adoption of this framework can be promoted in additional ways for more reasons including: this way of teaching helping prove that your students can learn more and deeper for less money and be ecologically responsible. This and the results of students being easier for businesses to train will help with a deeper interest in business donations and involvement in education. If students are given projects that fill community needs the community itself will immediately benefit and be behind promoting the growth of similar programs. Breaking down the walls of the silos will help teachers to work more closely with each other to support each other’s goals while still giving each other the space to teach in the ways that work best for their topic and themselves. The bottom line is no matter what country students are in, public education needs to progress with a rapidly changing technological society while supporting more students with less resources and money and STEAM is a way to continue that effort with an flexible structure.

It is impressive that the Korean flag with its white background, taegeuk pattern, and four trigrams signify peace, unity, benevolence, justice, wisdom, courtesy (kibun) a ying (id) and yang (ego) balance, creation, hope, integrity and eternity all in a constant revolving pursuit of perfection. (KBS World Symbol). All of these things are promoted in the STEAM framework as it is the hope that more countries than Korea will base their community efforts on these humanistic values so that no matter how distinct people and countries can be from each other, there is acceptance of differences while understanding that there is a unifying force of humanity that all people embody and are responsible for cultivating as we all interact with the universe. Because this responsibility relies on the efforts of all people, STEAM has been developed with the hopes that it is useful to learn about for all people, but that it is originally focused for those in formal education including; administrators, legislators, educators, students and that from there it will spread to the general community. STEAM could help make good education better. The STEAM framework, like steam itself, can fit anywhere and take innumerable shapes, and if used purposely can be a very powerful tool.

Appendix A: STEAM Daily Worksheet
Appendix B: Around the World Worksheet
Appendix C: STEAM Overview Worksheet Front and Back

References


33. Hotta, Y. (June 16, 2004). *Hikaru No Go.* VIZ Media LLC


55. Myongji University in Korea.
58. Onishi, N. (April 2, 2006). In a Wired South Korea, Robots Will Feel Right at Home
Appendix A: STEAM Daily Worksheet
Introducing Teaching STEAM as an Educational Framework in Korea

G. Yakman

Elements & Materials
what I had
(SCIENCE)

Equipment
what I used
(TECHNOLOGY)

Process - what I did: (TECHNOLOGY & ENGINEERING)

Outcome - what was the result: (T&E)

Eureka! - what I learned

Opinion - What I thought about it (ARTS)

Interest - most interesting point

Improve
activity suggestions

Name:

Date:

Topic:

*Put drawings, calculations & notes on back. (MATH)
Appendix B: Around the World Worksheet
Plan a Transportation System

**The Goal:**
Get a ball around the world.

**The Rules:**
Use a different mode of transportation for each geographical region.
You may not stay in Antarctica for more than 1/10 of your journey.

You can use any transportation method from the past, present or immediate future.
Ex: chariots, trains and solar cars are okay, space cars are not.

Variations: fastest, eco-friendliest

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**AROUND THE WORLD IN MANY WAYS**

An Overview of Transportation Systems

This belongs to:

created by: G. Yakman 2006
<table>
<thead>
<tr>
<th>Mathematics is...</th>
<th>Math Divisions:</th>
<th>Engineering is...</th>
<th>Social Studies is...</th>
</tr>
</thead>
</table>

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**Legend:**
- **Class Code:**
- **Name:**
- **Functional Literacy:**
  - What is human-made?
  - Technology is...

**Arts Divisions:**

---

**Diagram:**
- STE@M logo with circular flowchart indicating various STEAM-related concepts.
Introducing Teaching STEAM as an Educational Framework in Korea

Tech. Divisions:
Nature of Technology,
Technology & Society,
Design,
Technological World Abilities,
The Designed World
– Includes –
Medical & Bio-Medical,
Agriculture & Biotechnology,
Construction,
Manufacturing,
Information & Communication,
Transportation,
Power & Energy

Language Arts is...
The way that all kinds of communication is used and interpreted.

Engin. Divisions:
Aerospace,
Architectural,
Agricultural,
Bio-Chemical,
Bio-Medical,
Bio-Technology
Civil,
Computing,
Electrical,
Environmental,
Fluid,
Industrial/Systems,
Mechanical,
Materials,
Mining,
Naval Architectural,
Nuclear & Ocean

Multiple Intelligences:

Process & Inquiry

Concepts,
Nature of,
History of,
– Includes –
Biotechnology,
Biomedical,
Biopharmacy,
Space Science,
Geo-Science,
Chemistry,
Biology,
Physics

Integrative/Interpersonal/People Smart
Music Smart
Kinaesthetic/Body Smart
Special/Picture Smart
Nature Smart
Mathematical/Logical Smart
Linguistic/Word Smart

What's best for you?
Understanding of K-12 education in Korea:

From kindergarten to high school, matriculating through the grade levels is not determined on knowledge, grades or passing of any tests, but is based purely upon the student's age. Elementary school consists of grades one to six. Students learn subjects including, but not limited to, Korean, mathematics, science, social studies, fine arts, English, P.E., moral education, practical arts, and music. Usually, the class teacher covers most of the subjects; however, there are some specialized teachers in professions such as
physical education and foreign languages, including English. Middle school students spend most of the day in the same homeroom classroom with the same classmates; however, students have different teachers for each subject that mostly move around from classroom to classroom. Only a few, who teach special subjects, have their own rooms to which students come. Almost all middle schools offer the same courses, Math, English, Korean, social studies, and science form the core subjects, but students also learn music, art, PE, history, ethics, home economics, technology, and "Hanja.” It is during the last two years of high school, that Korean students are offered courses relevant to their specialization. (BBC) In 1987: 60% of students attended general or academic high schools, as compared with 30% in vocational secondary schools. (OECD) Vocational schools specialized in a number of fields: primarily agriculture, fishery, commerce, trades, merchant marine, engineering, and the arts. Since, 2007 professional high school students have better access to colleges and universities. (BBC) 2005 study of Organization for Economic Co-operation and Development (OECD) member countries, some 97% of South Korea's young adults do complete high school. This was the highest percentage recorded in any country. (BBC) Korean high-school students produce outstanding results in the area of mathematics and demonstrate high literacy, ranking among the very best in the world. [1].

Koreans do excel in both math and science over Americans, as Prof. Choi stated, but educational studies have shown this advantage is only visible in K-12, and quickly disappears at the university level and higher. This short-term Korean advantage is simply due to the fact that both disciplines involve a lot of rote memorization, which Korean are famous for, and sadly epitomizes the entire Korean teaching method both new and old. Koreans are wonderful at copying another's idea, but as for being creative and independent thinkers, Koreans lag far behind Americans. (Foard)

The Republic of Korea, through the Korean Standards Association (KSA), has prepared life-long education programs on standardization to promote and benefit the global society through international trade and national economies, while helping to increase social efficiency and individual pursuit of a comfortable and safe life. These are developed for every learning level and workshops for consumers. Standards Olympiad provides students with a practical competition where students find out how to solve inconvenient cases stemming from lack of standardization. (Choi)

Moral educators emphasize that moral education as a subject matter focuses on the affective domain when it deals with those issues while other subject matters emphasize the cognitive domain. However, many educators still have doubts about the identity of moral education as a separate subject matter. (Chu & Park)

1. 한국인 문맹률 1.7%... 선진국 수준
5. Foard, R. Obama’s Educational Ignorance
6. OECD review of vocational education and training in Korea