Editor’s note

Professor Georgette Yakman and her team put forward STEAM education (science, technology, engineering, art and mathematics) on the basis of STEM education, constructed the STEAM education framework, designed the STEAM teaching process card, and STEAM education training certification. STEAM education based on mathematics, engineering and art from the perspective of science and technology, interdisciplinary concept of different subjects will be integrated for the development of modern society to provide excellent human resources support. As a researcher and practitioner in the field of STEAM education, she has helped STEAM education in the United States, Korea and other countries, and has been widely recognized by international peers. She also developed the STEAM Education website to meet the needs of different audiences for STEAM educational resources.

Because of his success in STEAM education, Professor Georgette Yakman was invited to chair the STEM Education Conference in Virginia in 2009 (correction: she served a 3 year term as president (elect and past) for the Virginia Technology and Engineering Educators Association, and served as the conference chair for the 2009 term year) and Senator Mark Warner was nominated for the National Cable TV Association Education Specialist of the Year (correction: Educator of the Year for the New VA Corridor Technology Council). In 2010, she was elected president of the Virginia Tech & Education Association. The interview focused on Prof. Georgette Yakman’s vision of STEAM’s education, its practical framework, its vision for future development, and recommendations for implementing STEAM in China.

Keywords: STEAM education; STEM education; interdisciplinary; teaching reform

INTERVIEW:

Reporter: Professor Yakman, thank you very much for joining us. Your STEAM education research is very fruitful, in the international influence, can tell the Chinese readers about your STEAM education motivation?

Yakman: Depending on the nature of the comprehensive study, I solve the problem of how schools teaching a single discipline arising out of multi-level thinking. I envision turning traditional schools into integrated learning centers, giving students full access to all disciplines. Based on these assumptions and practical needs, I put forward STEAM education theory.

STEAM educates students in the fields of science, technology, engineering, art and mathematics with an interdisciplinary approach, leading students to adapt to constantly changing professional knowledge and rapidly changing social life. STEAM education philosophy can be summarized as: based on mathematics, engineering and art interpret science and technology. STEAM Education supports students to understand the world in a multi-disciplined way, transforming the world in the form of comprehensive innovation, and cultivating their ability to solve problems. STEAM education is mainly based on project-based learning, problem-based learning
as the main teaching (learning) approach to guide students through cooperation and practice, to complete the theme of the project and solve problems encountered in life. As a kind of transcending traditional education mode, STEAM education can narrow the gap between the existing knowledge and skills of the students and the vocational knowledge and skills, and enhance the students' employment competitiveness.

STEAM education on the basis of the original STEM education by adding art, help students from different perspectives to understand the link between different disciplines to improve their comprehensive use of knowledge to solve practical problems. In 2015, Georgette more deeply researched the humanities and arts universities, professional organizations and art groups to form a more extensive level of analysis of "art" category. Art "A" covers a wide range of humanities and arts subjects, covering social studies, language, physical, musical, fine and performing.

From STEM education to STEAM education to STREAM education (with reading / writing ability 'Reading / wRiting'), STEAM education has been enriched and become a hot topic in education. STREAM (science, technology, reading / writing, engineering, art, and math) education has come into being in the wake of STEM and STEAM education. In fact, the emphasis on literacy is an important component of science, engineering, and technical education, with the aim of enabling high-quality professionals to write reports, experiment materials, and communicate with others.

*The languages are a social construct and mix of music and physiology blended with geography and culture based on algorithms. The subject of languages, therefore categorically falls under the "Arts category as well. – GY 10/18/16)

STEAM education has been recognized by the public, and gradually become a more complete model of human resources education. We can be based on practical needs, with lifelong learning efficiency of STEAM education known as the "universal effectiveness of learning." As of January 2016, we have trained more than 2,000 teachers from 34 countries in one country and the United States. After STEAM education, students' participation in curriculum activities and mastery of knowledge have improved significantly, and many families, communities and enterprises have a strong interest in it. With the international application of STEAM in practical teaching, I have been invited as a consultant to assist in the development of STEAM education in the United States, Korea and Qatar. In 2014, I was invited to Shanghai to give a keynote speech STEAM education. I would like to take this opportunity to introduce STEAM's educational philosophy to China. “ In 2015 and 2016 I was invited to Nanjing and Nanning to be part of the World Maker Education Association and also invited to give a talk and presentation on these visits. – 10/18/16 - GY

**Reporter:** STEAM education research concentrates on S, T, E, A and M unfold, what is the link between them? What role does art play in it?

**Yakman:** STEAM education shows the researched order in the relationship between the structure of science, technology, engineering, mathematics, arts, people in the analysis and transformation of the world played their role. In STEAM education, science supports people to understand the laws of the world; engineering and technology support people to transform the world according to social needs; art helps people enrich the world in good form; and mathematics provides structural analysis for people to develop and apply science, engineering, art and technology Methods and analysis tools.

It is with the tools of the technology can we more deeply understand the science and to understand the arts and mathematics is to engage more deeply in engineering research and development. We focus on how to analyze the interdisciplinary knowledge of the link to explore their application in the real world, rather than concerned
about whether some knowledge belongs to which research areas. STEAM education is not to focus on a subject, but on guiding students to adopt a disciplinary fusion of learning, the use of interdisciplinary thinking to solve practical problems.

Art to join the science, technology, engineering, mathematics education, is a good supplement to the four STEM courses. STEAM can help students to optimize the understanding of different disciplines of knowledge and application. For example, "sound" has the effect of imparting and influencing students' knowledge of communication and language. Through art, students have a better understanding of past and present cultures and aesthetics; students understand human nature and morality, freedom and art knowledge, which all help to understand social development.

STEAM Education puts the "Who and Why" in the humanities and arts into the "What and How" in the field of STEM education, making people and ethics in the innovation process play an important role. Therefore, STEAM education can enhance students' deductive and inductive logic thinking ability and also cultivate students to develop practical problems to solve the necessary flexibility and adaptability, so that they have cross-cultural communication skills. STEAM education allows students to stay away from the fragmentation of knowledge and memorization process, and guide students to contact the knowledge between different disciplines, and continuously enhance the students' logical thinking ability, problem-solving ability to innovate, peer cooperation ability, and self-realization of the incentive capacity. Therefore, STEAM education is conducive to the development of a creative and innovative spirit of the comprehensive development of people, to support them as future inventors and creators.

Reporter: STEAM education framework you build integrated STEAM research results and help promote the relevant research results. How do you think about building a STEAM education framework? What is the specific meaning of the framework?

Yakman: STEAM in research and practice in education, and I have been in many countries (regions) with educational representatives (and agencies) looking to cooperate. I have done research to find the overlapping or identical patterns in the implementation of good interdisciplinary practices globally to contribute to STEAM education. There are quite a few good examples of these types educational practices. Referring to the STEAM pyramid representing the STEAM education framework that we have constructed, it shows the organic links in many disciplines and can be regarded as a biological tree in STEAM education field connecting the subject areas to the business world divisions.

STEAM education framework (see Figure 1), the top is the ultimate goal for educators and what every individual goes through their life doing (Life-long Holistic Learning), that STEAM lifelong education, integrity; the second layer is STEAM, can be as a comprehensive level (Multidisciplinary Level) The third layer is STEM plus art (STEM + A), emphasizing the penetration of art on various disciplines; the fourth layer is the subject level, mainly to explore the science, technology, engineering, engineering and other disciplines, Art and mathematics. The bottom level is the Content Specific Level, which is mainly related to science, technology, engineering, art and mathematics. For example, scientific disciplines include physics, biology, chemistry, space and geography.
STEAM education framework can be used to help educators design teaching patterns, improve teaching activities. STEAM education framework not only supports educators to interdisciplinary way to link different disciplines, and guide the educators will be different disciplines and life skills, career development link. STEAM education has been successful in P (preschool) K (kindergarten) -12, university courses, museums, extracurricular programs, rehabilitation of dementia patients and other areas. We can improve the STEAM education framework in many ways or form, but there is no need to fundamentally change it, after all, it has depth, clarity and completeness.

**Reporter:** STEAM change the traditional form of teaching, reform the current teaching activities. How can we reform our teaching so as to better reflect the new changes in this field?

**Yakman:** I'm happy to help people conduct research and application STEAM education on the basis of the existing education system on. For STEAM education, I have carried out nine years of theoretical exploration and practical research. According to my research, if STEAM education professional development support is provided to school personnel on a regular basis, it will normally take three years for the school to fully implement a STEAM program.

In order to promote the teaching reform and improve the teaching level, STEAM education needs to teachers, teaching assistants and projects to provide face-to-face and online training, so that more educators understand STEAM education philosophy, characteristics and methods. For example, for STEAM instructors, I offer eight hours of online training. Teachers usually take a week to digest and absorb the contents of each chapter.

Teachers should develop the ability to collaborate between students, students and others. When the students have the ability to work together to complete the task, the results is more like life and conducive to their own cooperation skills. At this point, we need to group students according to their various skills and levels, so that the there is a balance of student talents to address the real issues of project activities to improve the skills of each student's cooperation. Students can also experience the benefits of cooperation from the practice, thus contributing to their work and life in an effective co-operation.

**Reporter:** You designed the teaching process STEAM card (project cover sheet) to guide teachers and students to carry out teaching, teaching us the process how to use STEAM card (project cover sheet), conduct relevant research and practice?
Yakman: This card goes with each projects and asks the students to find the links to the subject areas throughout the things they are working on and to keep an overall scope fo the project in mind while working on the details. This helps them to understand, follow and then learn to create plans for operational needs, through problem-oriented project practice, to achieve integration of multiple disciplines to provide students with experience of innovation, opportunities for independent thinking and teamwork. Although STEAM education provides many ways to support learning, students still need to be responsible for individual learning and they need to continue to play their initiative and creativity. STEAM education teaching is not to impart content knowledge as the main task, but to develop students’ problem-solving ability and innovation ability as the goal. It is to help them learn to be able to be more adept life-long learners. Compared to the traditional design of teaching activities, STEAM methodologies adhere to the student-centered. Teachers not only tell students how to do, but also guide students to experience the process of solving practical problems in the exploration to open the student’s creativity.

In order to cultivate innovative talents, teachers should encourage students to question and reflect, rather than rely on rote memorization; to guide students to innovation-oriented issues, rather than emphasizing the simple application. To this end, STEAM teachers need to scientifically arrange the teaching process, that is, what to do (the purpose of the activity), what to do (equipment, elements and materials, etc.) and achieve what effect (what the students found, harvested what). In order to improve the effectiveness of teaching STEAM, STEAM teaching process according to our design STEAM education and teaching process card. The course card covers the main content of the project activities, can help students understand the elements of project activities and how to carry out project activities. Students play a leading role in the guidance of teachers, select the materials and tools needed to participate in planning, organization, practice, reflection and improvement.

Reporter: What is student feedback on STEAM education projects? What aspects of them have been improved?

Yakman: If now published a special report in this regard may be premature. The number of schools implementing STEAM education is still rapidly growing. STEAM programs in many schools are still awaiting approval and funding. In order to meet the needs of the community and parents, many STEAM programs have been expanded, --with a 25% increase in the number of program courses. – (not sure what this number specifically refers to, possibly the network’s growth rate.)

The STEAM School Project in the United States has been in operation for about four years. The survey shows that, with the optimization and organization of interdisciplinary learning in STEAM, students have a better
understanding of the original isolated subject knowledge content, and students' classroom attention, attendance and recall have been improved.

STEAM education can help students enrich their learning experience at a lower cost, which is essential for students to succeed in a rapidly changing world. STEAM educates students to assess their personal interests and life opportunities and career development in history, current and potential contexts, and to guide students to understand the future of their careers, to help them understand their professional interests, and to do well in knowledge, skills and psychology of the preparation.

For STEAM education, information technology is not only a means of people to optimize education, but also to promote people to carry out research, investigate and demonstrate the effectiveness of tools. The media that reflect STEAM's educational effectiveness can be social media sites, press releases, interviews, documentaries, etc. Each year, the school should hold 4-6 times STEM education theme exhibitions in public places such as the news media or the main population, restaurants and corridors.

Schools have realized that high-quality STEAM education can prepare students for the 21st century with the skills they need to prepare for their future careers and jobs. Schools should optimize the STEAM education environment, improve students' awareness and participation in STEAM education, and support students to improve their innovation and work skills through STEAM education.

Reporter: You worked with many institutions and integrated knowledge visualization, crossover study, tell us about the different schools, how people from different disciplines to carry out collaborative STEAM education?

Yakman: In STEAM education, the integration of different disciplines is fundamental. Topics should be integrated between disciplines? This requires greater communication among different disciplines, and interdisciplinary thinking. STEAM teachers should be based on the characteristics of students to carry out different roles across the subjects, integration between different courses, and focus on project activities through the integration of curriculum, students STEAM culture (science, technology, engineering, art, mathematics literacy) and solve problems of innovation based on students unique abilities. Schools can provide teachers with the time and resources to collaborate, create their shared professional knowledge and enhance the teaching skills of the conditions, and continuously promote the professional development of teachers.

Different disciplines should make full use of various social institutions, social professionals and other resources, pay attention to the development of school-based curriculum reform of classroom teaching model, designed to meet the needs of students learning resources and teaching mode. For example, a teacher can turn a taught course into an integral part of the STEAM curriculum and invite relevant experts to integrate their perspective into the STEAM education and to co-teach around common themes.

STEAM education to be successful, cannot do without the multi-sectoral cooperation, but also between schools and schools need synergies. Different STEAM education schools should strengthen cooperation and exchange, share teaching resources, education modes and methods. STEAM teachers and support staff should have a certain time each week to carry out inter-school cooperation, in order to facilitate the sharing of STEAM education experience among different school teachers, and jointly enhance the effectiveness of STEAM education.

Reporter: For educators, STEAM education is an important part of implementation. Can you offer some advice?
**Yakman:** STEAM education, educators need to learn new knowledge to achieve the desired teaching experience, and continuously improve the instructional design capabilities. Educators should guide students to "understand themselves" and "how to be part of teamwork" and other basis, to help students master how to overcome challenges.

Learn their own and network interactions, to become a member of the team, how to carry out teamwork and gather knowledge. These activities involve the basic writing, the scientific processes, use of vocabulary and behavior investigation, etc. These skills are need to be part of the processes of education for students to address problems with effective organization and implementation skills.

STEAM education has strict requirements for program certification. For the educators, at least 90% of the backbone teachers, instructors, management personnel in the relevant fields need professional STEAM certification and approval. In addition, all new teachers (including art, technology and engineering, sports, etc.) should be STEAM education certification.

Among them, as the core staff of educators, teachers should design interdisciplinary project activities according to the characteristics of students' interest and different subject knowledge, adopt different teaching methods and individualized teaching, and constantly enhance the practical problems, curriculum content, Activity design, ability development and future work, and guide students to improve their ability to solve problems.

**Reporter:** What does certification of STEAM education programs do?

**Yakman:** We provide "certification program" for the implementation of education programs STEAM school, so the school can fully adopt and implement STEAM education. For STEAM educators who do not have the ability to bring our staff on-site for live access, we ask schools to provide relevant photos, instructional videos, and Internet phone contact times so that they can be guided through the Internet, if necessary. We support the professional development of STEAM educators by setting up a training and certification program based on the original / current foundation of the school.

STEAM education and training helps to enrich the professional knowledge of educators so that they can better understand how to work with other educators (local and international) to help them understand how to organize students' learning activities, to take advantage of the individual innovations of students, and help them to design teams, so that all members of STEAM education programs can contribute.

Each STEAM education transition school should include at least one administrator, one mentor and 90% of the professional staff. If necessary, the school can be face to face or the way the network of relevant personnel training. Training for STEAM educators (school administrators, educators, library assistants and extracurricular program instructors) focuses on helping them learn how to integrate science, technology, engineering, art and math education with a focus on guiding teachers How to carry out the design of teaching activities in curriculum integration, and support students to solve practical problems in an interdisciplinary way.

STEAM training is a combination of virtual and on-site training. The training resources are 24 videos and 7.5 hours of training support. The course includes STEAM Theory, STEAM Programs and Integrative Themes, STEAM Teams, and how to write a custom STEAM course/lesson; The training objective is to train educators who are able to write and submit a brief introduction to the STEAM course/lesson (see Table 1).
STEAM training and STEAM certified educators have some differences. Educators who have participated in a full STEAM training can say that they have received STEAM training and have learned how to teach and teach through STEAM curriculum planning and practice. Educators who have completed the course plan and are certified will be able to claim that they have been successfully certified by STEAM and that they already know how to write a STEAM course plan. STEAM training and certification personnel have access to training and teaching documents, including access to resources that are continually updated in the STEAM course plan during the one-year training period. Educators with STEAM certification and experience are popular in the global market.

In the implementation process, we require all courses based on grade level and subject standard basis, in close contact with STEAM education, to achieve and STEAM education theme match. Students can take courses outside the core curriculum (art, music, sports, etc.). Standardized assessment can help students to understand their "what should be aware of" and "can do." Studies have shown that the standardized evaluation of STEAM education can promote students' continuous progress.

**Reporter:** STEAM educators are using websites and other forms of promotion. Can you explain your site (http://steamedu.com/) and how it is designed, so that we can get the information?

**Yakman:** Internet changing how human produce, live, play and learn. The STEAM website is a combination of educational research and the internet where I can share important research projects and professional development. There we have an on-line course of STEAM education. We have developed a website platform (http://steamedu.com) so that more countries and regions of the education experts or institutions through the
website to understand the development of STEAM education. We design the site in different modules, clearly demonstrated to different audiences, to facilitate interested individuals or groups to obtain the desired resources.

This site provides a wealth of resources, introduces the development of STEAM education concept, my personal and the development of the project, STEAM in the United States and other countries and regions, as well as different levels of networks for members that have the privilege level. The "Downloads and Resources" section provides free information about STEAM's educational background, philosophy, trademarks, research areas, and course offerings. The "FAQ" section provides answers to common STEAM questions, such as the definition of the STEAM education framework, the information of the members of the STEAM education team, the contents of the training courses and so on. The "Contact Us" section has published the contact information for different categories of candidates so that interested organizations or individuals can contact us. We provide different positions (office manager, global manager, marketing manager, support manager, business manager, etc.) for different clients (general consultation, international consultation, media request, customer support, financial institution, etc.); News and the "Store" section provide information related to STEAM education programs, policies and materials and products for STEAM learning. The role of the education program, such as the objectives to be achieved through participation in the project, and other similar information and resources are available through the website (see Table II).

![Table Image](image)

We also use the social platform to promote the STEAM education. We also have links to eight social networking sites such as Twitter, Facebook, Pinterest, Reddit, Academia, Imgur, YouTube, LinkedIn, etc., and provide a better channel for the public to understand the project. The social networking site has a wide audience and spreads the immediate advantages to expand the impact of STEAM education and promote STEAM education. We are adding WeChat group soon.

**Reporter:** You have registered trademarks published on the site, which is to promote training. What are the benefits?
Professor Yakman: In the knowledge economy, STEAM education’s thrust is to promote student innovation, but to carry out such training and promotion, we also have to have some commercials. Our STEAM education company has been personally funded since 2007, making it easier to realize the vision of an independent contributor to develop STEAM education. The company is not a social organization, but for the purpose of profit. As a STEAM education and promotion of enterprises, the registered trademark has its necessity.

In the promotion of STEAM education and training, we have been focused on the cause of education to create a global service enterprise, so the business reputation of the important, trademark design is particularly critical. The registration of the trade mark will help our schools to gain the exclusive rights of the STEAM education network, so that the research results and the practical products are protected by law. In addition, the trademark to improve STEAM recognition of education, is conducive to distinguish it from other educational products.

According to the marketing theory, we have carried out the visualization design of the STEAM educational trademark, and gave the logo the connotation of the concept. For example, "STE @ M = Science & Technology interpreted through Engineering & the Arts, all based in Mathematical elements" means to explain science and technology through engineering and art on a mathematical basis. The word "STEAM" is included in the trademark. Instead of "E", there is a sigma, and the symbol "@" replaces "A", and "=" joins to show the relationship. This concisely expresses the subject of STEAM education, and to a certain extent attracts the general public (students, parents (guardians), community members, managers, business leaders, politicians, etc.) to promote the promotion and dissemination of STEAM education.

Reporter: Can you carry STEAM education to China and offer some advice?

Yakman: STEAM education is based on practical problems, students are encouraged to complete the project through collaboration and practical, problem-solving. These processes help students develop a comprehensive literacy and problem solving skills, the formation of human resources, and have excellent innovation ability. Training for the promotion of scientific and technological level has played a catalytic role, so STEAM education is becoming an important driving force of technological innovation. Although not all students can enter the STEAM industry, but other industries are becoming more dependent on STEAM skills. Nearly all professions require students to be proficient in STEAM education.

In order to develop STEAM in China, it is recommended that STEAM be taught as a way to enhance creativity in teaching the course. For example, for one of the arts education, STEAM education is not the purpose of teaching art, but to enable students to understand how to use art in real life, and constantly improve the current way of life and where the real world.
Second, the education support staff should be integrated into the STEAM team, including: 1) mentors who want to help students understand their interests and preferences, guide them in choosing career goals, and guide them to match their skills and interests with future careers; 2) librarians / media specialists who want to help students find information, find educational experts, and provide space for students to showcase their work in the STEAM educational program, to let students see what they are doing, how to do it, and to guide students; 3) Information / education technicians who want to improve the process and methods of STEAM application, optimize teaching and learning, and make suggestions on how to purchase and use emerging educational technology. 3) Information and education technology personnel should learn how to improve their products or solutions.

To help STEAM achieve better results, I recommend: 1) Each school should have a STEAM Certified Coordinator. As a course specialist, application writer and community liaison, these coordinators should be familiar with the interrelationships of education, science, technology, engineering, art, mathematics, and other disciplines, such as career planning, problem-based learning and curriculum integration. (3) Purchasing equipment and design courses should have the vision of sustainable development, both based on the actual situation of STEAM education, but also to meet the future needs of STEAM education; (4) In order to meet the needs of STEAM education, To achieve the deep integration of information technology and STEAM education, teaching methods such as the use of flip-class activities.
Implementing STEAM Education and Improving the Students’ Innovation Ability: An Interview with the STEAM Education Scholars Georgette Yakman in USA

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Abstract: Virginia Tech University scholar Georgette Yakman proposed STEAM education (Science, Technology, Engineering, Arts, and Mathematics) on the basis of STEM Education. Georgette Yakman and her team constructed the framework of STEAM education, designed the teaching process card of STEAM education, conducted training certification of STEAM education. STEAM = Science & Technology interpreted through Engineering & the Arts, all based in Mathematics elements. STEAM education integrated different types of subjects, and constantly improved STEAM theory through thematic studies and practical applications, to provide human resources support for the development of modern society.

As a researchers and practitioners of STEAM education, she helped the United States, South Korea and other regional and international countries STEAM education, and has been widely recognized by the social organizations. In order to meet the STEAM education needs for different audiences, she designed and developed STEAM education website (http://steamedu.com/). Due to the outstanding achievements in the field of STEAM education, Georgette Yakman was invited to host STEM meetings in 2009 held by Virginia governor; was nominated for the education expert of National Cable Television Cooperative announced by the Senate Mark Warner; was invited the spring graduation speaker in Virginia Tech University; was elected President of the Virginia Association for Science and Technology Education in 2010.

Through this interview, we attempt to know the background, conceptual framework the future trends of the STEAM education from Georgette Yakman, and her recommendations about how to carry out the STEAM education programs in China.

Key words: STEAM education; STEM education; interdisciplinary; teaching reform

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