

THE IMPOTANCE OF ART IN STEAM EDUCATION

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Abstract: The art in STEAM education provides an opportunity to make the educational environment function more like the real-world by developing authentic connections between academic content and practice. With the art in the Steam, students can learn to solve real-world problems using cross-content skills and knowledge, enabling and strengthening their creative and innovative thinking. This practice clearly recognizes a real-world role of the arts in STEAM. The art helps students and educators explore, dialogue, problem solve, and experiential learning, STEAM becomes an effective educational method that helps students improve creativity, critical thinking and problem-solving, higher decision-making skills, better visual learning, increased interaction among students and aesthetic orientation. Thereby showing us the important role of art in the STEAM.

Keywords: STEAM, STEM, arts, the role, education method, development.

1. INTRODUCTION

STEAM is a term derived from STEM, the concept of STEM was introduced in 2001 by science managers at the US National Science Foundation (NSF), STEM stands for Science, Technology, Engineering and Mathematics. STEM education is defined by Tsupros as: *“An interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy”* [15]. It focuses on training students to gain proficiency in collaboration, questioning, problem solving, and critical thinking. These are essential skills needed for a society that is expected to see the growth of science and technology-related positions in the workforce. But then educators realized that there was an incompleteness in the STEM education model, and STEAM was born with the Art element to complement this model. STEAM is the original idea of the Rhode Island School of Design (USA), then used by many educators and spread throughout the United States, short for Science, Technology, Engineering, Art and Mathematics.

The letter A - “Art” in STEAM represents the visual arts, social studies, history, physicality, fine arts, and music. In common sense, the arts and sciences are seen as two different fields and seem to have nothing in common, but what STEAM education does

is bring the two together to create a unique approach to learning. Multidisciplinary approach to technology development, robotics, industrial design, engineering...

The key difference between STEM and STEAM is that STEM represents a modern approach to science and related subjects that focuses on problem solving with critical thinking and analytical skills. STEAM education explores the same subjects, but incorporates creative thinking and applied arts into teaching and real-world situations. The arts are used to increase creativity and imagination to enhance the development of essential STEM skills and enhance flexibility, adaptability, productivity, responsibility, and acumen. Situational management and innovation - essential skills for success in any field. Art is about discovering and creating multimodal problem solving, integrating principles, and presenting vivid visual information... Adding elements of art to STEM-based thinking, researchers educators believe that students can use both sides of their brains - analytical and creative - to develop tomorrow's innovators.

2. THE ROLE OF ART IN STEAM EDUCATION

STEAM can be understood as a blend of many subjects to improve learning ability. The goal of the inclusion of the arts in STEM is to promote learning through the arts, integrating the arts with other subjects. The John F. Kennedy Center for the Performing Arts defines arts integration as: *"A method of instruction in which students construct and express their understanding through an art form. Students engage in a creative process that connects one art form and another subject area and meets evolving goals in both"* [9]. The 1967 Cambridge Conference of Correlation of Science said that recent years have witnessed a drastic change in STEM education across the US and around the world. STEM is a solution, but the learning results that it brings are not really high because an important part is missing, which is arts.

2.1. STEAM is an effective pedagogy when art is involved

On May 6, 2011, President Obama's Committee on the Arts and Humanities issued a report at the Arts Education Partnership (AEP) Conference called "Reinvesting in Arts Education." " states that students are involved in the arts, their academic achievement can be quadrupled, their GPA/SAT scores are also higher, they can also improve their IQ to zero. time - his time up to 56%. The Math level of grade 12 students is significantly improved, students interact with their teachers and friends more, become more confident and present their views better. The report shows the importance of connecting art, culture, creativity and innovation. Incorporating the arts into STEM education has proven benefits such as increased creativity, improved learning outcomes, motor skills, enhanced decision-making skills, better visual learning, and enhanced experience. study. STEAM education helps students explore subjects, combine creative thinking and design through the arts. Therefore, the arts play an important role in reducing the constraints of learning, creating a more engaging, comprehensive educational method that empowers learners and how to solve problems. in practical life.

In the STEAM education model, teaching is based on clear learning goals and there is an integration of subjects: science, technology, engineering, art and math based on

intersections and common points. of subjects in terms of content, knowledge... but still preserving the specificity of each subject. This approach allows teachers to guide students to explore, learn, and create, while ensuring that learning goals are met. For STEAM learning to be practical, students need to explore the real world, then experience the learning process and the product of the learning process. STEAM education not only has one teacher to guide all content areas but requires teachers to have a basic understanding of other areas and be able to create lesson plans that are integrated by intersections between disciplines. Therefore, the design and planning of lessons requires the cooperation of the teachers involved.

By fostering the imagination and encouraging new ways of understanding, the arts extend the structure of a formal education [14]. In all grades, art serves as both a healthy medium of expression as well as a means of improving cognitive development such as high-level thinking skills. Educators from Makeblock (a global provider of Steam education solutions) argue that STEM may be essential for technological advancement, but without art students cannot reach their full potential. The arts allow students to freely exploit the capabilities of STEM subjects, help them expand their thinking to see problems from different perspectives, have more freedom in experimentation, increase interactivity, makes STEM topics more interesting, thought-provoking, and increases student interest.

When the arts are appropriately incorporated into the STEAM method, it will bring cultural and technical relevance, in line with the social progress of each country in order to train a high-quality workforce for each country. future and improve learning outcomes.

2.2. Art ncrease creativity, critical thinking and problem solving

Art teaches students to think flexibly and allows them to freely explore different designs and ideas. Art is one of the factors affecting people that makes people want to work, explore, and research, which is the act of creativity. When an artist hears a piece of music, when he sees a work of art, there will be a vibration in his soul and this has the opposite effect on their thoughts, making them able to generate new ideas, different initiatives. That is creativity through art.

We seem to forget that real innovation doesn't come from a mathematical equation, technology, or new chemicals, but from disciplines like art, design, or simply it. from who we are. Innovation in life in general and in the sciences in particular is always associated with human experiences, in a certain way, whether directly or indirectly. The human experience gained through art-related interactions helps you see things in a more natural, receptive and open way. Our world is built by analytical thinkers. However, artists or designers - intuitive thinkers are the ones who open up many possibilities for us. Great innovations happen when we combine analytical thinking and intuitive thinking. Different innovations from art plus the development of science and technology have turned many ideas considered absurd into reality in people's lives. Everyone from software engineers and aerospace technicians to biotechnologists, professional mathematicians and laboratory scientists knows that building great things and solving Solving real problems requires a measure of creativity.

The intersection between arts and STEM is this: *“Without art and science, our world would be a dull place and creativity would see the light of day less often”* [4]. Unlike conventional teaching, which separates science from technology, with STEAM science education, technology and math are no longer independent, challenging subjects that all have to come together, and then students will have an integrated view in life, in profession, in creativity, going from the logic of science to the technique and technology of a product, a specific result.

The benefit of STEAM (over STEM) to learner empowerment is the inclusion of a discrete set of creative processes for problem-solving. STEAM encourages learners *“to be curious, experiment, and take risks-key dispositions artist habits of mind engender”* [2] They are also focused and creative, using a variety of methods, as they work to find solutions to the problem.

There have been many studies on the relationship between art and cognitive development. Specifically, research demonstrates that art education has an impact in developing critical thinking skills [5]. Or Sir Ken Robinson, Richard Florida and Daniel Pink shed light on the importance of creativity. Their books *Out of Our Minds: Learning to Creative* (2011), *The Rise of Creative Class* (2004) and *A Whole New Mind* (2005), respectively, have brought academia to the importance of art and creativity create formal studies. STEAM pedagogy promotes intellectual development through several important cognitive processes: planning, interpretation of figural relations, interpretation of visual-spatial patterns and relationships, verbal reasoning, nonverbal reasoning, memory and memory retrieval, and quantitative and qualitative relationships. The arts give learners agency through creativity, challenge, and diverse instructional strategies. As a result, they become more engaged, self-confident, and motivated about their learning experience. In addition, learners have greater self-regulation when comparing arts classes to non-arts classes.

In the book *“Giáo dục Stem/Steam từ trải nghiệm đến thực hành sáng tạo”*, author Nguyen Thanh Hai (2019) (University of Missouri) presents his views on teaching students from critical thinking to creativity and ability. Ability to solve problems in a scientific and logical manner with integrated knowledge [13]. According to the author, STEAM science education should be included in early learning, but not focusing on remembering a lot of knowledge, but the purpose is to prepare the capacity for future generations of citizens. Since then, the teaching method is based on an age-appropriate foundation but is led to go from the curiosity of children to the formation of human higher-order thinking, the creative thinking of an adult.

STEAM education places great emphasis on the formation and development of problem-solving abilities for learners. In each thematic lesson, students are presented with a situation with a practical problem to be solved related to scientific knowledge. To solve that problem, students must explore and research knowledge of subjects related to the problem (through textbooks, study materials, experimental equipment, technological equipment) and use them to solve the problem posed. These knowledge and skills must

be integrated, integrated and complementary to help students not only understand the principles but also be able to practice and create products in daily life.

For example: In the book "Khám phá giáo dục STEAM" [17], the author outlines 10 teaching topics designed with Steam education orientation. Each topic is designed according to the following process: 1. Identify the problem (requirements design, manufacture); 2. Research background knowledge; 3. Propose design solutions and discuss; 4. Manufacturing models/equipment according to the design plan; testing and evaluation; 5. Present and discuss the manufactured product, modifying the original design.

After experiencing the above process, students understand that each subject/discipline: Science, Technology, Engineering, Art, and Mathematics has knowledge that students need to understand, combine this knowledge to create products. In which, art plays the role of liberating and opening up multi-dimensional thoughts, many answers to a problem, there are many ways to connect knowledge to create products, so it helps students expand their horizons, thinking and creativity. Critical ability is demonstrated when students defend their own ideas, come up with ways to solve new problems that need to be recognized by peers/groups and by teachers.

Problem-solving skills are the results shown through students' design products that match the requirements of the given topic, with this learning method, each student/group can create many products. with various shapes and colors based on the established principles of science with the flexibility of art.

Most creators don't let their work be limited to one field, they draw inspiration from the connection between fields. This kind of cross-disciplinary thinking resonates with the STEAM model, drawing fundamentals from science and math, and encouraging creativity from the arts [12].

Art in STEAM education means liberating and opening up multi-dimensional thoughts, many answers to a problem, so it helps students expand their thinking and critical ability to solve their own problems.

2.3. Better decision making skills

In STEAM education, students focus primarily on the task-solving process. Allowing creativity and imagination to be free is a "*learning by play*" way of art that can lead to improved problem-solving skills in children as they learn to interpret information and articulate ideas. and ideas in a creative, confident way. Dr. Kagan said at a talk on acquisition, art and the human brain at John Hopkins University in 2009: "*Art and music require the use of both schematic and procedural knowledge and, therefore, amplify a child's understanding of self and the world*".

With regard to the integration of the arts in science education, the arts are often seen as the catalyst that causes scientists to see things differently or consider alternative solutions to the problems they study. Challenges of skill and creativity in the arts can provide students with many solutions and choices, or rather, making their own decisions about a

problem to be solved. Barlow in his book says: *“The art of exposure to other disciplines also has positive effects. Students can take advantage of the question-based nature of art subjects and apply this to their respective subjects, thus analyzing problems in a different way and arriving at multiple solutions. Without this perspective from the arts disciplines there can be only one solution or no solution at all”* [3]. And when there are solutions, it is the student who makes the decision to solve the problem.

The arts have the ability to enrich individuals of different ages and of varying achievement levels because *“the creative arts do not discriminate”* [14]. Across all educational levels, the arts act as healthy outlets for expression as well as a means of improving cognitive development such as higher level thinking skills. With a student-centered mindset, students are encouraged and encouraged to be creative and explore, so they are always given the opportunity to be challenged and learn science through an artistic path that allows them to be allowed. fail in the process of searching to become more mature and importantly, students are proactive in overcoming themselves, actively making decisions for themselves.

2.4. Better visual learning

Art in interaction with Stem is not simply teaching drawing but taking art activities to improve students' understanding in many aspects: morality, intelligence, thinking, aesthetics... Therefore, art has important position, equal to other subjects in this teaching method. This is a direct visual subject with observation and visualization methods playing a fundamental role, so it becomes a means of supporting knowledge transmission with learners quickly, vividly and effectively. A variety of learning materials and means can free teachers or students from many purely technical jobs, create excitement about learning for students, and form the right learning motivation.

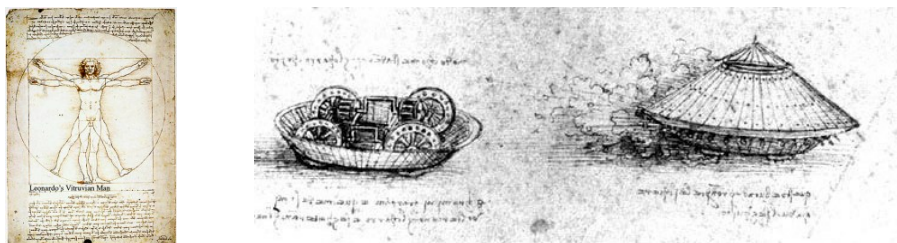
Visual arts combined with scientific projects can help students reflect on their scientific studies through creating drawings or paintings. Not only does it make the project more fun and enjoyable for the student, but it can also encourage more focus, improve observation skills and can support problem solving skills. Manipulative visual arts such as sketching, photography, and origami have been reported to be effective for spatial intelligence, which is a crucial attribute of successful STEM professionals. Drawing activities help students learn quicker and more effectively.

Students have different learning styles, and neuroscience shows that humans are capable of learning through visual, auditory, and kinesthetic cues. Integrating art allows content to be taught in multiple ways, thus creating more neural pathways and a higher probability of knowledge retention [10].

The cognitive benefits of artistic endeavors were brought to the forefront with John Dewey's (1934) seminal work, *Art as Experience*. His pragmatic theory of aesthetics contributed towards the acceptance of the arts as a viable and complex academic branch of learning that is essential to a well-rounded education. Traditionally, arts coursework is inquiry-based, which means it revolves around questioning and understanding concepts

versus finding the answer to a given problem. The arts are highly interdisciplinary and regularly require an individual to engage in multiple skills [7]. Other findings from this book include that visual arts and visual experiences are correlated with math skills (especially geometry), music has a relationship with reading skills, dance has a relationship with reading skills. correlated with observational learning, the performing arts are associated with language and memory development.

Principles for the Development of a Complete Mind: *"Study the science of art. Study the art of science. Develop your senses – especially learn how to see. Realize that everything connects to everything else."* - Leonardo da Vinci's Notebook (1452-1519) [1]. Da Vinci brought science and art together. He felt that artists should be adept at mathematics and geometry so as to accurately demonstrate perspective in their art (depth, relationships between objects). A pen and ink sketch from when he was 21 years old demonstrates his understanding of the degradation of light with distance (physics), his awareness of rock formations (geology) and his eye for detail. He used art for the purpose of studying the anatomy of the human body in medicine or coming up with the idea of an *"armored combat vehicle"* - 1487.



"Vitruvian Man" - 1490 and "Armored combat vehicle" - 1487.

Source: Stanford University

Dr. Jerome Kagan, Professor Emeritus at Harvard University and one of the 22 most famous psychologists of the 20th century, he argues that the arts contribute to motivating people to learn surprisingly well, because The arts often combine three main tools that the human mind uses to receive, store, and impart knowledge: motor skills, sensory visualization, and language. language. Thereby we see that, art is included in STEM education method in addition to improving learning, integrating art can be engaging and bring joy to learning. In essence, STEAM education provides an opportunity for students to experiment with a variety of ideas, listen to different opinions, and create a knowledge base that is relevant to real life.

With the participation of art, visual drawings, music, diverse learning methods will be a directional thinking path that benefits students' creativity and learning.

2.5. Promote communication and cooperation among students

Art is more than just an activity enjoyed by many students or more than just entertainment or enjoyment, the power of art can be just what we need. Knowledge of science, technology, engineering, and math is certainly important, but imagination, creativity, and

how we interact with others are just as important. Like any flower, the stem is valuable for nourishment, but the blooming of the flower sparks a lot of our emotions and imaginations - and that's what people connect with through art. *"Art drives cultural change, ignites community imagination and action, and serves as a bridge toward scientific understanding and adoption of sustainability efforts"* [6]. Integrating the arts with STEM has the potential to be a promising and win-win initiative to enhance learning in technical fields while highlighting the contributions of the arts. Sarah Pease - A graduate of the Rhode School of Design, she led the club from STEM to STEAM at RISD (Rhode Island School of Design) said: *"Our contemporary world craves empathy and understanding in the face of an intensified onset of technological advances and a decline in direct interpersonal communication. Art and design can offer just that."*

The visual and performing arts give students a perspective on how others perceive, interpret, and evaluate the intention of their work. This teaches students to follow-through on ideas, defend their thoughts, and take pride in the finished product. Through the arts, students are able to make connections with their peers, other subject areas, and the world around them. In a student reflection example provided on the National Coalition for Core Arts Standards (NCCAS), the student stated that engaging in the collaborative process taught them to be cooperative with our partners. Developing the capacity for communication, cooperation and social relations is an advantage of the arts. In the process of learning by STEAM method, students have the opportunity to exchange and discuss with friends about methods, color coordination, solution selection, use of supporting tools, etc., thereby promoting their capacity. communication is formed. In addition, they need to cooperate with each other to make collective products, which helps each individual express his or her own opinion and point of view, and at the same time listen and select options. to come up with a common way for the group to do it. In the process of cooperation promotes the ability to work in groups, the ability to listen and present ideas. Teamwork is an essential skill in the learning and working process of children in the future.

The United Nations Educational Scientific and Cultural Organization has stated: The benefits of introducing the arts and cultural practices into learning environments showcase a balanced intellectual, emotional, and psychological development of individuals and societies. Such education not only strengthens cognitive development and the acquisition of life skills-innovative and creative thinking, critical reflection, communication, and interpersonal skills but also enhances social adaptability and cultural awareness for individuals, enabling them to build personal and collective identities as well as tolerance and acceptance, appreciation of others. [16]

In addition, art in STEAM also helps students develop mentally, socially and emotionally. Children learn to collaborate with peers and teachers, allowing them to experience the emotional, academic, and physical experiences of the activities they participate in. Through learning and working together, sharing responsibilities, and compromising with others to achieve a common goal, children learn self-confidence and realize that their

contribution is valuable even when they are not the biggest role. The arts have the potential to enrich individuals of different ages and levels of achievement because “*creative art does not discriminate*”. It not only teaches us empathy or what it means to interact with others, but also leads to multidimensional thinking.

2.6. Aesthetic orientation

The educational function of art is first of all aesthetic education. It is the process of improving the aesthetic capacity of each person, including fostering aesthetic feelings, aesthetic tastes and aesthetic ideals. Building healthy, pure and strong emotions so that people can clearly distinguish between the old - the new, between the bad - the beautiful is the central work of aesthetic education. For Steam education, art plays a role in the following aspects:

- Educate the correct, scientific and progressive aesthetic views.
- Educate the ability to perceive, evaluate and create based on art.
- Educating pure and good aesthetic emotions based on basic criteria: truth, goodness, beauty.

Aesthetics is a long-term, enduring capacity formed through art. By creating products, students have been exposed to works of art, providing them with basic knowledge and skills (such as how to draw lines, shapes, layout, colors; how to use materials such as watercolor, paper, glue...; knowledge of art history, design...). These knowledge and skills will be applied to design and shaping activities in STEAM. The lessons in STEAM are all based on the principles of the basic sciences and the expansion of multidimensional thinking of art will create many products that meet both criteria: function and aesthetics. Illustrated example on the topic: “*Chiếc dù bay* - Sách Khám phá giáo dục Steam, 10 chủ đề dạy học ở tiểu học” [17]. From scientific principles, how to choose materials, students learned and creat a design plan for the parachute, then solved the requested problems with the actual product. The fact that they want to "beautify" individual/group's products into colorful shapes, patterns, etc. is a practical need and that is the way that STEAM leads the aesthetic orientation of the students, the future inventors: products in addition to functionality must have aesthetic elements.

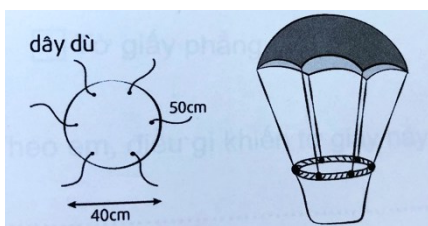
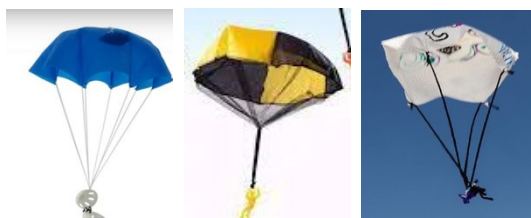


Illustration of the design



Student's products

“*New technologies draw on both artistic and scientific knowledge, each contributing to the other's design*” [8]. For example, majors such as graphic design, computer art, have become relatively popular at universities. Similarly, technical programming tools are

foundational skills for digital, new media, and video artists. There is a strong push to highlight art-based technology education because the artistic applications of technology are an important aspect of learning.

In the field of science and technology, the more modern technological products are, the more attention is paid to aesthetics. The manufactured products must meet the functional, functional and aesthetic requirements to be easily accepted in the market and bring in revenue for companies. For the field of education, scientific and technological products from robots, experimental machines to reports... the aesthetic element is always present. The products created must have the participation of art to achieve the requirements of the product's perfection.

Sarah Pease said in *"STEM is incredibly valuable, but if we want the best innovators we must teach the arts"* (Washington Post, 2014): *"Industry leaders such as Boeing, Nike, Apple, Intel, 3M, and many more cite design and/or creativity to be a priority for their companies when seeking innovative solutions"*. There were digital music players before the iPod, but it took Apple time to design and develop the interface of the iPod to change the way the world listens to music. Therefore, when it comes to portable music devices, everyone now seems to remember Apple's iPod product. In 2016, Apple sold more than a billion iPhones, accounting for a fifth of the global market share. That's because iPhone users are loyal and appreciate the brand's cutting-edge innovation, distinctive design, and attention to detail. Steve Jobs was a huge advocate for the movement of STEAM education, thanks to his experience working at Pixar. He once said: *"It's in Apple's DNA that technology alone is not enough - that it's technology married with liberal arts, married with the humanities, that yields us the result that makes our hearts sing."*

Science and art go hand in hand in modern life, it is easy to see that science has changed our creative fields with advanced but common technology, insights and ideas. The novelty of artists that impact scientific progress with unlimited creative ideas Today with technology is getting faster, smaller and more complex. The sciences have begun to rely more on the arts than ever before for innovative ideas and solutions, as well as aesthetic demands for products. Science would be very dry without the harmony of art.

Through the above examples to show us that long-term exposure to the arts has helped students to form aesthetic competencies and that STEAM helps to orient the application of that competence in practical products to Increasing the ability to "beautify" products is a correct and necessary method for future innovators and creators.

3. CONCLUSION

The STEM education base is very special in helping us to be more efficient or increase speed in all given processes, but it is not good at developing curiosity or imagination, arousing creation. Art teaches us empathy, improves interpersonal interactions, and fosters multidimensional thinking. Science, technology, engineering and math are the most fundamental subjects to teach and focus on, but to prepare students for innovation, we need to focus on what creative thinking brings to life. Just focusing on STEM as a tool

to fill high-tech job vacancies and boost innovation is not enough. Art has become more than a recreational activity for students at school and offers more career opportunities than simply nurturing talents for future professional musicians and artists. The power of the arts may be exactly what we are looking for, for students when they come to school, being equipped with knowledge of science, technology, engineering and math is extremely important but not enough. Because imagination, creativity, and how students interact with each other in social relationships, how they confidently solve problems, intuitive thinking, and aesthetic orientation are equally important. Former RISD (Target Group to Integrate Art and Design with Art Education efforts, 2013) President - Maeda said, *"I believe art and design is poised to transform our economy in the 21st century just as science and technology did in the last"*. And Maeda told: *"Careers in STEM are no longer rigid and limited by technical ability; Creativity and social aptitude are equally important traits for STEM professionals"*[11]. According to Richard Sherwood, president of American Education Group: *"The STEAM program succeeds in its ability to inspire students. They don't even realize that they are absorbing a large amount of knowledge thanks to their fascination with each activity of the class, becoming a technology engineer, researcher."*

The arts are the factors that promote the development of the mind and help the creativity to flourish. Art also deserves to be placed with the sciences in terms of importance and necessity. Adding an A - Art, turning STEM into STEAM has contributed to calling for a worthy place for an element that has not been given due attention in many education reform discussions. Inspiration is always an important factor for children to find their passion and develop their potential through art, which is the right path.

Based on the above perspectives, art is proven to be an important component of STEAM, by way of creativity, freedom and flexibility of art has helped us to create the impossible, expanding the way to help students become well-rounded citizens of the 21st century. The arts provide openness to learning, opportunities to express themselves in fields, and broaden horizons and thinking. Thus, it is necessary to consider the arts to have an indispensable role in modern education.

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