KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

The Importance of Representing STEM Professional Role Models Through Multimedia Instructions

Riris Marito Tamba*, Chia-Ling

Department of Education and Human Potentials Development, National Dong Hwa University, Republic of China (Taiwan)

ORCID
Riris Marito Tamba: https://orcid.org/0000-0003-0736-4379
Chia-Ling Chiang: https://orcid.org/0000-0003-0736-4379

Abstract.
The first part of this paper discusses that STEM education does not have clearly defined fields, unlike discipline-based educational programs such as science education, which do have clearly defined areas. In order to overcome the complexity and ambiguity of different STEM and STEM education perspectives, it is necessary to understand the status and trajectory of STEM education research. Also, the authors suggest that stereotypes about STEM professionals can be minimized by using several faces associated with learners, as role models in presenting information about the career options available to STEM professionals in order to reduce stereotypes. As learners learn STEM, they can recognize their potential and their sense of self as well as their STEM connections. Additionally, by exposing students to various professions through multimedia learning, the distance between role models and learners may be closed, thus appealing to their interests and encouraging them to pursue careers that they are interested in the future.

Keywords: STEM, professional role models, multimedia instructions

Corresponding Author: Riris Marito Tamba; email: 810988118@gms.ndhu.edu.tw

Published: 3 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

Gender disparity in Indonesia still exists, and the example of the gender gap has wider appeared at the institutional career level. In [1], the number of females enrolled and graduated from primary through diploma, bachelor, professional, and the specialists' levels were more than males. In contrast, men have outperformed women in the number of master's, doctoral, and university careers. The representation of female lecturers was significantly less and lesser when it came to leadership positions and STEM-related majors' jobs in the university. Women face challenges when it comes to sustaining careers in STEM fields [2], including negative stereotypes, threats, and implicit bias holding a fixed mindset. The connection between the lack of STEM role models to the reinforcement of stereotypes in STEM subjects, which, in turn, have adverse psychological and academic effects on students, including lower performance, lower interest in STEM, as well as feelings of not belonging to STEM fields [3]. Minorities (i.e., women and non-white men) experience more negative outcomes in STEM, which can negatively impact their interest in pursuing STEM careers in the future.

This study aims to have STEM professional exposure as a local career role model that may influence middle school female students' efficacy and engagement in science, technology, engineering, and mathematics (STEM) at Kisaran, North Sumatra. Students at middle and high schools will be surveyed using the Student Attitude Toward STEM Survey, the Student Engagement Instrument (SEI), and semi-structured interviews to understand how the career role model learning design impacts students' retention in STEM and engagement in STEM learning. The following questions are explored in this study:

1. can STEM professionals help boost middle school female students' perceptions of self-efficacy in STEM?
2. In middle school, can STEM professionals empower female students to become more engaged in STEM activities by developing the cognitive skills required for sustainability, such as teamwork, perseverance, resilience, creativity, and motivation to learn?

1.1. What is STEM, STEMist -- Overview of STEM Education

In the U.S., two historical events have contributed to the development of a reform-driven education system. Firstly, the arrival of the post- Russian satellite Sputnik (1957) revolutionized educational curriculum research. The satellite Sputnik proved that the U.S workforce of scientists, technology experts, engineers, and mathematicians (called STEMist) to compete in the global market was lagging. For a country to maintain and upgrade its economic, social, and political power, the reform highlighted the importance of scientific disciplines as structures and understanding of how scientific inquiry works to produce STEM-capable workers who are well-trained in STEM literacy and skills [4].

Since then, the K-12 science education curriculum introduced 'science for all' to promote understanding natural, social, economic, and psychological phenomena through observation and scientific explanation as STEM skills and literacy. Secondly, to encourage students' interest in the STEM field as their profession of choice, it must monitor the quality assurance of educational innovations. Low-quality assured would pass the political and economic power to more competitive and well-prepared countries. The Trends in International Mathematics and Science Study [5] indicates that Japanese students fared better than Americans, and 'STEM for all' refers to engineers being less likely to graduate from universities in the United States than in China [6]. Considering these two situations, the importance of global competition in ensuring reasonable quality assurance in producing well-trained graduates of STEM or related fields is evident.

In the late 1990s, the National Science Foundation (NSF) merged engineering and technology with Science and Mathematics, forming SMET (Science, Mathematics, Engineering, and Technology) for K-12 and undergraduate students [7] and replacing it in the early 2000s with STEM due to acronym choice [8]. According to NSF, scientific and technological literacy in STEM education is the primary pathway in producing 'STEMist'—categorizing STEM occupations. Its definitions of STEM are broader, including core sciences like physics, chemistry, and mathematics, and behavior and social sciences such as political sciences and economics. However, some U.S. agencies (e.g., the Department of Homeland Security and U.S. Immigration and Customs Enforcement) have narrowed STEM definition by excluding social sciences and focusing on the core sciences [9].

The career opportunities in STEM occupations seem to increase from 2012-to 2022 and predicted they will grow faster than any other career choices in 2030 in the United States [10]. In the United Kingdom, the demand for high- level STEM skills have increased. Nevertheless, STEM education challenges are fewer young adults who were degree holders of 'core STEM' (chemical sciences, biological sciences, physical/environmental sciences, engineering, mathematical sciences and computing, and technology and architecture) are willing to pursue core STEM occupations. The U.K. Commission for Employment and Skills [11] suggested the new definition of STEM role as emerging sectors and technologies is mostly missing from the list. This new STEM employment is different from traditional employment in manufacturing. The gap between supply and demand of STEM workforce even widens under other groups of ages, gender, and social and cultural backgrounds of the students. Lack of representation amongst groups for a particular profession will affect the interest in those professions. Promoting role models is one of the powerful strategies to fight against negative stereotypes and attitudes among groups or even toward STEM topics, fields, and disciplines [12, 13].

It would be more beneficial to form a comprehensive epistemic definition that incorporates sources, strategies, and practices from across fields, rather than having content-specific meanings that are too static [14]. The new definition of STEM is knowledge-building practices in STEM professionals investigating, modeling, communicating, and explaining the nature and designed world. Research in STEM education can be as discipline-based education of STEM combinations such as Science education, technology education, engineering education, and technology education, or the combinations of disciplines as multidisciplinary, interdisciplinary, or transdisciplinary. It is essential to introduce STEM as the integration of discipline lines where it cannot be separated from social studies, art, and humanities as assembles of practices built from many knowledge concepts are shared [8].

Based on the Social Cognitive Theory introduced by [15], the indication of having a solid self-efficacy appears when someone believes they can perform a specific task. Self-efficacy will determine how confident someone is in completing their goal or task. A person's level of motivation to accomplish a goal or task is determined by their level of self-efficacy [16]. Individuals' sense of self-efficacy contributes to their resilience to adversity [17]. The ability to develop strength for rigorous learning is perseverance, the ability to try again after a failure. [18] call this grit. Self-efficacy enables a learner to challenge STEM challenges in a confident manner. Instead of viewing the experience as a failure and a signal to retreat from the unfamiliar or uncomfortable, they will see learning setbacks as an opportunity to learn and press on a new path.

According to [15], self-efficacy can be built by four factors: 1) mastery experiences, 2) physical and emotional states, 3) social modeling, and 4) social persuasion. Success can lead to increased self-efficacy or in reverse. Still, it is critical to note that achieving success through low effort (compared to high action) can lead to rapid results, making failure more discouraging [19]. This argument relates to the importance of having a growth mindset rather than a fixed one. In addition, one's emotional and physical states may bias what would otherwise be an accurate judgment. For example, if someone is anxious or unwell on the examination, they may fail. Despite the high level of skill, their self-efficacy may decrease. This study will see if presenting role models will help students see their challenges in a STEM subject as part of the learning process with a growth mindset.

1.2. The rationale: The importance of role model building through multimedia instruction

Connected to the trend of science teaching research mentioned above, many efforts to reboot the interest in STEM learning led to an interest in those careers. It enabled students to have more positive attitudes toward entering those professions directly or indirectly in studies. Some studies introduced different teaching approaches for improving students' abilities and conceptual understanding mastery and concepts (Bloom, 1968), problem-based solving (Schmidt, 1983), scientific literacy (American Association for the Advancement of Science, 1993), critical thinking (Dewey, 1910; Aikin, 1942; Ennis, 1962), even comparative studies of different teaching methods. Other studies focused on textbook analysis to innovate the interactive textbook and classroom interaction analysis.

However, adequate role models brought into the classroom interaction are rarely explored [3]. Science, mathematics, and technology teachers are STEM educators working in STEM education and, at the same time, the closer role model as the image of STEMist occupation that students see in the classroom.

Most common stereotypes about STEMist or related experts often characterized as male-dominated, western people, white skin, has independent and robust personalities, masculine, and willing to work as a researcher in laboratories or universities, which sometimes a student simply tricky to identify themselves as STEM learners and STEM fields as their professional choices. Gladstone and Chimpian (2021) state that effective role models will differ for various learners. In other words, which role model to which students need to be considered. There are three key features that are dependent. Firstly, perceived competency; if a performer model can succeed on a particular task, learners may also believe they can grow on a similar or related job, affecting students' efficacy—secondly, the perceived similarity between the models and learners in characteristic or background in status. The last is perceived attainability, regardless of similarity with the models, but if the task seems unattainable for learners to succeed. The learners will be demotivated. The idea of motivating student by presenting the models need to consider perceiving the role model to be "like learners" as more profound on a psychological level. [20] describes a survey in 2004 of over 1,000 scientists and engineers found that nearly half (52%) had been influenced by a visit to the work of a scientist or engineer, and almost a quarter (23%) had been influenced by a scientist or an engineer visiting their school (p.14). This study believes that providing students with the opportunity to have ten to fifteen STEMist in their classroom would impact the students' career choices. Through STEM role model encounters, some barriers can be eliminated, as follows:

1. Positive role models can reduce negative stereotypes, threats, and implicit bias by allowing students to see themselves in the profession.
2. Having a role model will help students see their challenges as part of the learning process with a growth mindset.

The study is planned to share ideas with the school in Kisaran, North Sumatera, about creating an opportunity to meet the STEMist role models in the classroom. The target audience will be students and teachers in the school. Ten to fifteen different faces of local STEM professionals will be at the planned STEM meeting and given a chance to share for 5 minutes. Hope from the literature study is that this role model of presentation to students and teachers would help to minimize the challenge of STEM education. Students will see if this plan will affect their attitude toward science and students' perceptions of self-efficacy in STEM. For teachers as a mediator to introduce this direct access to role models in the classroom and at the same time recognition of themselves be one of the students' roles models. Based on the reflection on how to engage ten to fifteen local STEM role models to give their time to speak to the students, it would be essential to convince them of the Indonesian STEM career trajectory and STEM education situation, along with my personal experiences about why they are needed for middle-level students. Several examples of the negative impact of poor role models that students need to be seen daily in the media, television, and the internet. Shared personal narratives about lack of STEM role model exposure also take some percentage of individual decision making.

Nevertheless, role model interaction through mediated video will represent their different images and faces. Thus, this study acknowledges the importance of bridging high school learners to the STEMist and related workers. Furthermore, providing young students with practical experiences with professionals in specific careers may strengthen interest in those careers and enable students to have more positive attitudes toward entering those professions. During the Coronavirus period, the number of face-to-face teachers and student interactions reduces and lowers student learning effectiveness. The condition has been forced quickly into an online classroom. This situation would benefit if the teacher upgraded the teaching into a multimedia mediated classroom, bringing new online strategies. Furthermore, considering that preparation of professional interview experts needed more behind the class, which somehow helped in time-matching between the class schedule and convenience of experts' availability.

Multimedia learning is necessary to foster the learners' cognitive process in instructional design as more attractive and emotional to learners' enjoyment and connected to the experts as the interviewee [21]. The research participant will be filling out the S-STEM and ESI survey on a five-point Likert scale (Strongly Disagree to Agree Strongly). The constructs will be developed as a survey for middle school students. They will be intended to measure the students' attitudes toward science, changes in students' efficacy in STEM subjects, learning skills, and booster interest in STEM careers job. Aside, semi-structured interviews will be conducted to understand how the career role model learning design impacts students' retention in STEM and engagement in STEM learning.

The [22] explored that, generally speaking, students would want to interact with STEM professions that they can relate to effectively. The similarity gives a sense of being connected to a STEM role model and attaining a STEM career. For example, the engineer shares that they came from a farm family or local indigenous would give more confidence to the similar background status of the student by saying, "If this role model can do it to be an engineer, I shall be the one too."

References

[1] Tamba RM, Chiang CL. "Gender disparity in north Sumatera higher education and challenges of young Indonesian women in science and STEM education.," In: International Joint Conference on Science and Engineering 2021 (IJCSE 2021. pp. 635–641. Atlantis Press (2021).

[2] Williams JC. "The 5 biases pushing women out of STEM.," Harvard Business Review. vol. 24, no. March, p. 2015.

[3] Cherchiglia LL. The creation of STEM role models: An exploratory study on the design of mentoring characters for a STEM gaming website. Michigan State University; 2019.

[4] Victoria SG. STEM education in Victoria. Victorian Government; 2022.

[5] N.C. NCES. Trends in International Mathematics and Science Study. TIMSS; 2019.

[6] Lynch SJ, Peters-Burton E, Ford M. Building STEM opportunities for all. Educ Leadersh. 2015;72(4):54–60.

[7] Zia LL. The NSF national science, mathematics, engineering, and technology education digital library program. Commun ACM. 2001;44(5):83.

[8] Sanders M. Integrative STEM education: primer. Technol Teach. 2009;68(4):20–6.

[9] Gonzalez HB, Kuenzi JJ. Science, Technology, Engineering, and Mathematics (STEM) education: A primer. Washington (DC): Congressional Research Service, Library of

Congress; 2012.

[10] U.S.B. Labor Statistics, “Employment in STEM occupations,” (2021).

[11] U.K. “Commission for Employment and Skills,” (2015).

[12] Karaca M, Bektas O. The relationship between perceived role models and self-regulation in science. Int J Educ Res. 2021;110:101884.

[13] Guenaga M, Eguíluz A, Garaizar P, Mimenza A. “The impact of female role models leading a group mentoring program to promote STEM vocations among young girls.,” Sustainability. vol. 14, no. 3, p. 2022. https://doi.org/10.3390/su14031420.

[14] Moon J, Singer SR. Bringing STEM into focus. Educ Week. 2012;31(19):32.

[15] Bandura A. Human agency in social cognitive theory. Am Psychol. 1989 Sep;44(9):1175–84.

[16] Bandura A, Locke EA. Negative self-efficacy and goal effects revisited. J Appl Psychol. 2003 Feb;88(1):87–99.

[17] Martin AJ, Marsh HW. Academic resilience and its psychological and educational correlates: A construct validity approach. Psychol Sch. 2006;43(3):267–81.

[18] Grohman MG, Ivcevic Z, Silvia P, Kaufman SB. The role of passion and persistence in creativity. Psychol Aesthet Creat Arts. 2017;11(4):376–85.

[19] Bandura A. An agentic perspective on positive psychology the science of human flourishing. New York: Ed. Praege; 2007.

[20] Martin V. Leading change in health and social care. Routledge; 2020.

[21] Mayer RE. Using multimedia for e-learning. J Comput Assist Learn. 2017;33(5):403–23.

[22] Gladstone JR, Cimpian A. Which role models are effective for which students? A systematic review and four recommendations for maximizing the effectiveness of role models in STEM. Int J STEM Educ. 2021;8(1):59.