

# Enhancing Collaborative Skills of Learners Through STEAM

**Mohini Tripathi**

Post Doctoral fellow, ICSSR

M.Sc., M.Ed., and Ph.D. in Education

E-mail ID: [mohini25tripathi@gmail.com](mailto:mohini25tripathi@gmail.com)

**Abstract** STEAM (Science, Technology, Engineering, Arts, and Mathematics) is an emerging educational approach focusing on the development of the creative thinking, problem solving, collaborative, and other life skills of the learners. To foster and strengthen national development and innovations, STEAM-based schools and curricula are showing up. This is an approach to integrating Art into STEM. In spite of the increasing interest in STEAM universally, research on the approaches to evaluate collaborative skills is still lacking. The proposed study is an effort to know the effect of the STEAM Learning Approach on the Collaborative Skills of the learners. Quasi-Experimental Design has been used on two intact sections of 40 learners of class VII. Mean, Standard Deviation, and Critical ratio (t) were calculated. It can be concluded that STEAM Learning Approach does enhance the Collaborative Skills of learners.

**Keywords:** STEM, STEAM, Collaborative Skills

## 1. Introduction

STEAM is the integration of Science, Technology Engineering, Art, and Mathematics disciplines. In the words of Spector (2015), it can be explained as “the inclusion of Arts and Humanities in STEM education” (p. 5). STEAM education can be viewed as a medium of solving problems by developing creative and collaborative skills. The idea of STEAM education as proposed by Stroud & Baines (2019) was to promote productive engagement of the learners in issues and problems associated with Science, Mathematics, and related curricular areas. STEM learners experience an enhancement of creativity, broadened perspectives, and discover their unknown strengths when they learn through art-making. Schools are facing challenges to keep up with the expectations of learners and so they started bending towards their need for discovery-based, flexible, multidisciplinary, experiential learning through STEAM. This approach to learning helps to flourish the life skills like creativity, cooperation, communication, rationality, flexibility, self-reliance, etc. in learners to prepare them for global competition. Quigley & Herro (2016) says that one of the main goals of STEAM is to make learners use their creativity, critical thinking through innovation, effective communication, collaboration, and ultimately new knowledge to solve authentic problems (p. 410). They further proposed that STEAM can be used in project-based learning. It is so because in this approach Science, Technology, Engineering, Arts/Humanities, and Mathematics can be used as per required in the situation to develop creativity, collaborative problem-solving skill, designing, inquiry approaches, using multiple paths, etc. (as cited in Herro et al. 2017, p. 2 ).

## 2. From STEM to STEAM

Today in the age of technological overdoses, kids learn to figure out ‘how to learn’. Budnyk (2019) expressed that the 21st century is set apart by phenomenal innovative progression and requests for a profoundly gifted labor force. Technological advancement today can't be maintained and progressed without abilities, like teamwork, collaborative skills, innovativeness, global awareness, financial literacy, critical thinking, and so on. Liao (2016) found that STEAM, in which the "A" stands for the Arts and Humanities, is becoming more popular as a result of a decline in the number of people selecting STEM as a profession both in the United States and globally (p. 44;). To oblige the requests of the present era, how learners were ready for the future must be reexamined and STEM training needed to be redesigned. The literature revealed that STEM subjects alone would not assist and uphold the advancements that the 21st century needs. Hence, the expansion of "workmanship" to go from STEM to STEAM was firmly supported by

Maeda (2013). Herro et al. (2017) urged that STEM must be reconceptualized into STEAM, where "A" addresses expressions, in its underlying finding demonstrating that STEAM-based educational programs expand the inspiration, commitment, and powerful disciplinary learning in STEM zones. STEM educators advocate that creativity and design are apparent in teaching tools and presentations in effective STEM programmes. Ernst and Clark (2007) state that STEAM values both (Arts and STEM), while STEAM effortlessly includes design, computer graphics, visual and performing art as expression, or even creative problem solving abilities while seeking answers, STEM places a greater emphasis on math and science. (Gettings, 2016; Jolly, 2014; Liao, 2016; Miller and Knezek, 2013). Herro & Quigley (2017) Because STEAM is so new, there is no study on it, and it lacks conceptual understanding, which contributes to the conflicts between STEM and STEAM. However, methods for teaching STEAM include some abilities that could be developed, such as problem solving, collaboration, and creativity in a real-world application. In this backdrop, STEAM education continues to increase.

### **3. Collaborative Skills**

Worldwide interest in STEAM education is developing in the area of education and parallelly many visionary reports are also being proposed which are in favor of this approach. But there is shockingly little examination of the efficacy of instructional methodologies. Moreover, Platz (2007) says that there is little research on deciding and estimating fundamental 21st-century abilities like collaboration, creative thinking, innovativeness, communication, etc which are crucial for success in STEAM activities. Roschelle and Teasley (1995), says that Collaboration is nothing but a harmonized, and corresponding activities which is the result of a persistent attempt to construct a knowledge, solution and conception of a problem (p. 70). Collaborative skills include ways in which learners work together in exploration, planning, creation, and analysis to connect and build knowledge (Herro & Quigley 2017). There is a developing interest in the appraisal of abilities related to collaboration, especially in problem solving situations, which is a basic segment of STEAM instructions in an assortment of settings such as school, work environment, and society. Graesser et al. (2017) proposed that collaborative skills benefits problem solving in the way that collaboration deals with the expense of a more practical division of work, the union of courses of action from a group of individuals with varying points of view, knowledge, and experience, and improved quality of solution by the group members. STEAM upholds the advancement of learner's intellectual abilities (abstracting, analyzing, applying, categorizing, forming, understanding, perceiving, modeling, synthesizing, and asking), interactional abilities (communication and collaborative skills), and innovative abilities (planning, designing, play, performing, displaying, and interfacing thoughts). Kim & Park (2012) explains that advancement, innovation of thoughts and items, and thought arrangements are upgraded by, and developed through imaginative learning. The communication skills include ways in which teachers develop the learner's ability to brainstorm, communicate evidence (disseminate, present, respond, and explain), construct explanations, engage in argumentation, etc. Research suggests that learners are better equipped to apply their knowledge in various contexts and have a longer-lasting recall of the content and also they can communicate efficiently in a wide range of methods.

### **4. Rationale of the study**

For this study, international and national studies have been taken into account. Herro, Quigley, Andrews, and Delacruz (2017) proposed STEAM education as an approach to solving relevant problems by the means of evolving creative and collaborative skills to enhance their inclination and involvement in these areas. Lafont & Casey (2012) proposed that it is also a constructivist-inspired approach that believes students can interact with one another to construct their knowledge and improve their interpersonal skills. Further, in research Marra, Steege, Tsai, and Tang (2016) found statistically significant relationships between individual student contributions in collaborative work and learning outcomes. Hadinugrahaningsih, Rahmawati, and Ridwan (2017) in their study found that learner's 21<sup>st</sup> century skills i.e. creative thinking skills, critical thinking skills, collaborative, problem solving, leadership, literacy skills etc. were developed. According to Song, Park, and Park (2020), the intricacy of the challenges we confront is frequently beyond the capacity of one bright individual, so collaborative problem-solving skills have grown more crucial in recent years. Collaborative problem-solving has been expanding global consideration because much of the complex work in the modern world is performed by teams (Costantino, Kellam, Cramond & Crowder, 2010; Graesser et al., 2017; Graesser et al., 2018). Therefore it is needed to research how the STEAM learning approach helps enhance the collaborative

skills of learners.

## 5. Objective and Hypothesis

Research on the STEAM approach to learning is still being explored at international levels but these areas need to be explored in the Indian educational system also. Therefore the research question which needs to be answered is- Does the STEAM Learning Approach influence the Collaborative Skills of learners at the Elementary Level? So the objective of this research is- To study the effect of STEAM Learning Approach on Collaborative Skills with respect to it's dimensions (i.e. Peer Interaction, Positive Communication, Inquiry Rich/Multiple Paths, and Transdisciplinary Thinking) at the Elementary Level. To achieve this objective research hypothesis was formulated as- There is an effect of STEAM through Group Work Learning Approach on Collaborative Skills with respect to it's dimensions (i.e. Peer Interaction, Positive Communication, Inquiry Rich/Multiple Paths, and Transdisciplinary Thinking) at the Elementary Level. As we cannot test the research hypothesis statistically, therefore the null hypothesis was formulated as: There is no effect of STEAM Learning Approach on Collaborative Skills with respect to it's dimensions (i.e. Peer Interaction, Positive Communication, Inquiry Rich/Multiple Paths, and Transdisciplinary Thinking) at the Elementary Level. To achieve the objective of this study an intervention programme based on STEAM Learning Approach for class VII in Science was prepared.

## 6. Method of the Study

The proposed study is Quantitative research. Non-Equivalent Control Group Design of Quasi-Experimental Design was used. Non-Equivalent Control Group Design involves one experimental group and one control group. The experimental group was taught by STEAM Learning Approach while the control group was taught by the traditional method. The data was collected from rubrics for Collaborative Skills in STEAM Activities known as '**Co-Measure**' constructed by Herro, Quingley, Andrews, and Delacruz in 2017. For this research, Government Middle School, Delha, Gaya, Bihar was chosen conveniently. All the students of class seventh i.e. two intact sections were taken in which one section was assigned as an experimental group and another as a control group randomly for the collection of data. The intervention programme based on STEAM Learning Approach was developed for class VII STEAM integrated projects based on day to day problems for which students found the solution. Based on these solutions students made their projects, checked the workability of these projects and at last gave their presentation. The proposed research's objective is to check the collaborative skills of learners in STEAM Learning Approach. For this purpose the instrument used is Co-Measure rubrics which are a 1-3 Likert scale based on four dimensions namely Peer Interaction, Positive Communication, Multiple Inquiry, and Transdisciplinary Approach (Herro, Quigley, Andrews, and Delacruz, 2017). The attributes by (Herro, Quigley, Andrews, and Delacruz, 2017, p-8) that define these dimensions are mentioned in the Table 1 given below.

| S.N | Dimensions                     | Attributes                                                                                                                                                                                            |
|-----|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.  | Peer Interaction               | Monitors tasks and checks for understanding with peers.<br>Negotiates roles and divides work to complete tasks.<br>Provides peer feedback, assistance and redirection.                                |
| 2.  | Positive Communication         | Respects others ideas and compromises.<br>Uses socially appropriate language and behaviour.<br>Listens and takes turns.                                                                               |
| 3.  | Inquiry Rich/<br>Multiple Path | Develops appropriate questions and methods towards solving the problem.<br>Verifies information and sources to support inquiry.                                                                       |
| 4.  | Transdisciplinary Approach     | Discusses and approaches problem solving incorporating multiple disciplines.<br>Share connections to research or relevant knowledge.<br>Negotiates relevant methods or materials to solve the problem |

|  |  |                                                         |
|--|--|---------------------------------------------------------|
|  |  | posed.<br>Uses tools collaboratively to approach tasks. |
|--|--|---------------------------------------------------------|

**Table 1: Attributes defining Dimensions in Co-Measures**

The data was analysed by taking the average of dimensions and the description given in rubrics is mentioned in Table 2 below.

| S.N | Description | Average Range |
|-----|-------------|---------------|
| 1.  | Need Work   | 0-1.0         |
| 2.  | Acceptable  | 1.1-2.0       |
| 3.  | Proficient  | 2.1-3.0       |

**Table 2 Description of Average Range of Dimensions in Co-Measures**

## 7. Result and Discussion

The result of this research is based on the three STEAM projects assign to one section while the other section was taught the same science topics which were involved in three projects through traditional method. The experimental section was divided into groups. In the first project the problem was given to students that due to Covid-19 the economic condition of the families deteriorated therefore children are facing problems in purchasing toys. The students came to the solution of making toys with waste products and cheap materials. Each group made different toys. The toys of all groups collectively shown in Figure 1 given below.



**Figure 1: Toys made by different groups of students from waste products and cheap materials**

After collecting data from the sample, it was analyzed through Mean, Standard Deviation, and the Critical ratio (t). The analysed data is given in the tabulated form in Table 3. With reference to Objective and Null Hypothesis (H0), it was found that with  $df = 77$  the calculated value of  $t$  is 14.03 which is greater than the table value (1.99) at 0.05 level of significance. So the test statistic  $t$  is significant at 0.05 level. Hence the null hypothesis is rejected and the research hypothesis is accepted. This can be easily understood from the Figure 2 where the clear comparison between traditional approach and STEAM approach of learning is shown with the help of Bar chart.

| t-Test              |                |             |
|---------------------|----------------|-------------|
| Teaching Approach   | STEAM Approach | Traditional |
| Mean                | 16.77          | 7.4         |
| Standard Deviation  | 3.21           | 2.74        |
| Observations(N)     | 40             | 40          |
| Df                  | 77             |             |
| t Stat              | 14.03          |             |
| P(T<=t) two-tail    | 0              |             |
| t Critical two-tail | 1.991254363    |             |

Table 3: Critical Ratio (t) Table for scoring Collaborative Skills

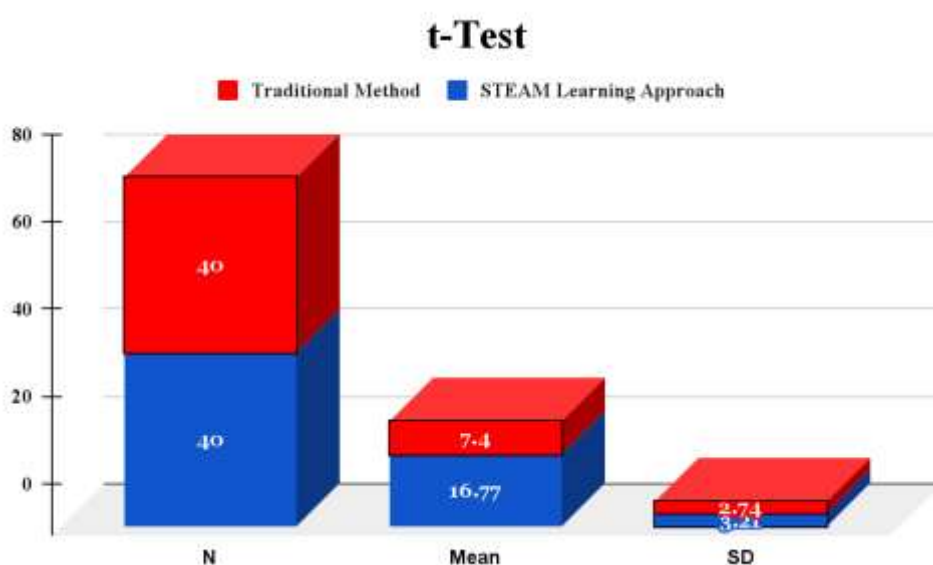


Figure 2: Comparison of STEAM Learning Approach and Traditional Method

To know in detail the data was then analysed dimension wise. The data were analysed by summed score dimensions wise for each student, using scale as mentioned in scoring key i.e, 0=need work, 1=acceptable, and 2=proficient, with ranges (0-2, 3-4, 5-6), while transdisciplinary approach has four attributes so the range 0-2, 3-5, 6-8 was used. For example, a student scores 1, 0, 1 summed to 2 for all the three attributes of the peer interaction dimension would come under “need work” range for that dimension.

Dimension wise the number of students scoring at each proficiency indicator were converted to a percentage. Table and description of analysis for each dimension is mentioned in detail as follow:

#### a) Dimension- Peer Interaction

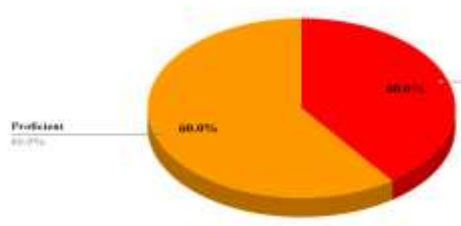
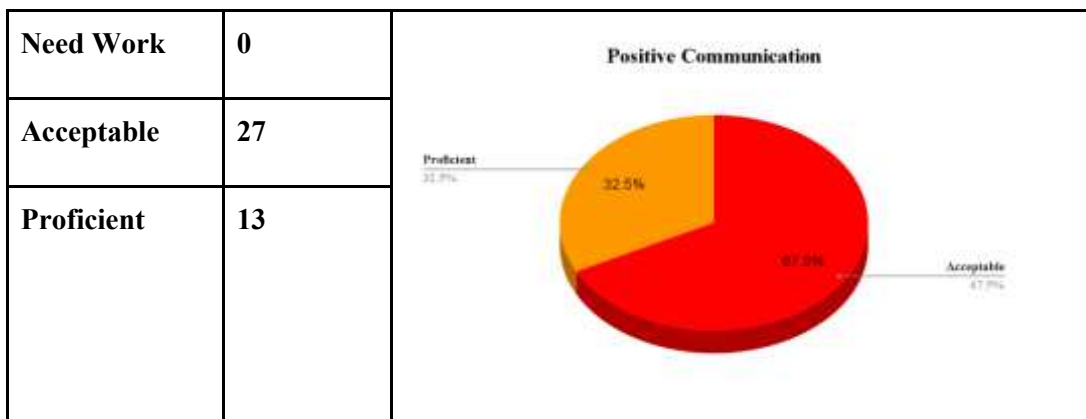
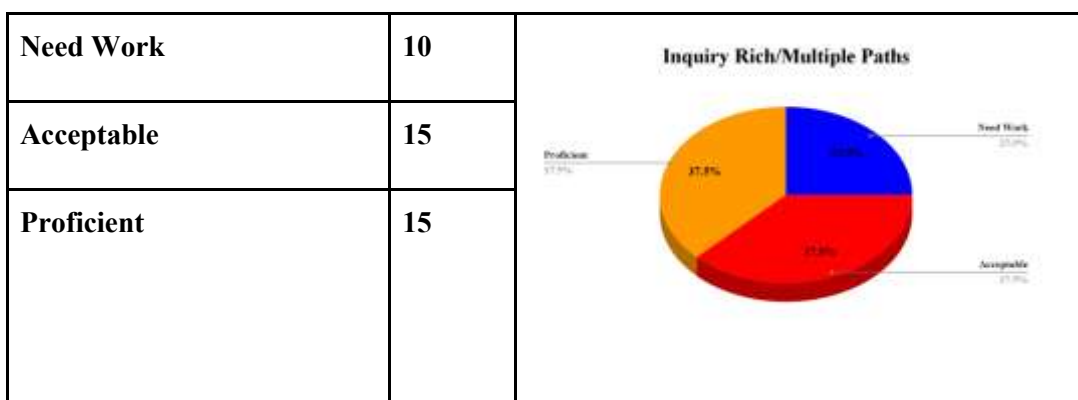
|            |    |                                                                                                                                                 |
|------------|----|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Need Work  | 0  | <p style="text-align: center;"><b>Peer Interaction</b></p>  |
| Acceptable | 16 |                                                                                                                                                 |
| Proficient | 24 |                                                                                                                                                 |

**Table 4-Table for Collaborative Skills for Dimension- Peer Interaction**

Out of 40 students 16 (40%) students scored in the “acceptable” range, while 24 (60%) students scored in the “proficient” range. This result shows that students improve their social dimension of Peer Interaction.

**b) Dimension- Positive Communication**

**Table 5-Table for Collaborative Skills for Dimension- Positive Communication**

The result shows that students improve their social dimension of Positive Communication as the majority of the students, i.e. 27(67.50%) out of 40 scored in the “acceptable” range, while 13(32.50%) students scored in the “proficient” range.

**c) Dimension- Inquiry Rich/Multiple Paths**

**Table 6-Table for Collaborative Skills for Dimension- Inquiry Rich/Multiple Paths**

Out of 40, 10(25%) students scored in the “need work” range, while 15-15(37.50%) students scored in the “acceptable” range and the “proficient” range. The result shows that there is room for improvement of students in spite of an increase in the dimension of the Inquiry Rich/Multiple Path.

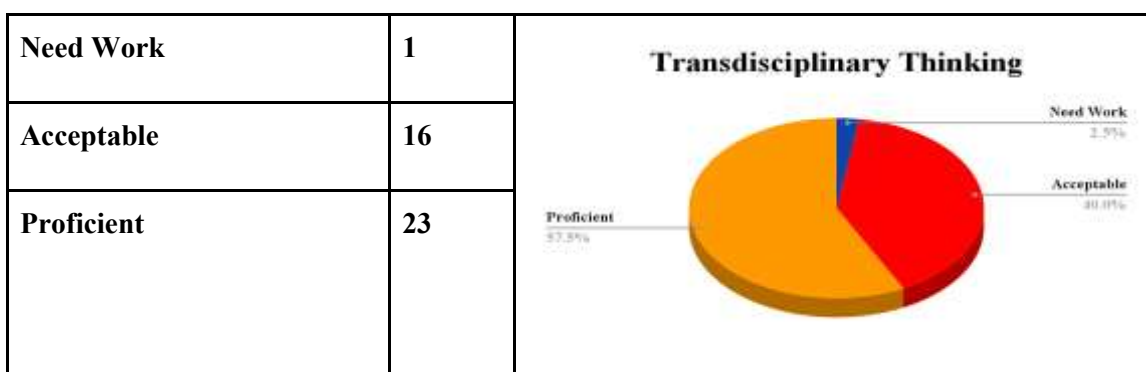
**d) Dimension-Transdisciplinary Thinking**


**Table 7-Table for Collaborative Skills for Dimension- Transdisciplinary Thinking**

The result shows that there is an enhancement of the dimension Transdisciplinary Thinking as a majority of students 23(57.50%) out of 40 scored in “proficient” range, 16(40%) students scored in “acceptable” range and only one (2.50%) student scored in “need Work” range.

Hence, it can be said that the difference in treatment (teaching method) is an influencing factor for Collaborative Skills. Thus it can be concluded that there is a significant difference between the mean scores of Collaborative Skills of the learners learned by traditional method and learners learned by STEAM Learning Approach. It was found that the learners learned by STEAM Learning Approach scores high in Collaborative skills measurement. Therefore it establishes that STEAM Learning Approach enhances Collaborative skills of learners.

**8. Conclusion**

Recently, a multidisciplinary approach to education in the form of STEAM has aroused global interest. To keep pace with the demanding present times, nations are reforming and exploring new education approaches in the form of STEAM to enable their learners with 21st-century skills where collaborative, critical, and creative thinking play a significant role. STEAM education is viewed as an advanced learning procedure that will reshape Indian education. Unless the STEAM education is not integrated as a policy level into the school curriculum, the teachers may not have a legitimate reason to implement STEAM lessons. From the findings of the study, it can be concluded that STEAM Learning Approach helps enhance Collaborative skills of learners which is one of the life skills that is very important for facing global challenges. However, research in the field of STEAM is in the early phase, hence there is no research available regarding STEAM effect on Collaborative Skills.

**9. References**

- Budnyk, O. (2019). Theoretical Principles of Using Steam-Technologies in the Preparation of the Teacher of the New Ukrainian School. *Journal of Vasyl Stefanyk Precarpathian National University*, 5(1), 23-30. <https://doi.org/10.15330/jpnu.5.1.23-30>
- Costantino, T., Kellam, N., Cramond, B., & Crowder, I. (2010, March). An interdisciplinary design studio: How can art and engineering collaborate to increase students' creativity? *Art Education*, 63(2), 49-53. 10.1080/00043125.2010.11519062
- Ernst, J., & Clark, A. (2007). Scientific and technical visualization in technology education. *Technology Teacher*, 66(8), 16-20.
- Gettings, M. (2016). Putting It All Together: STEAM, PBL, Scientific Method, and the Studio Habits of Mind, *Art Education*, 69(4), 10-11. <https://doi.org/10.1080/00043125.2016.1176472>
- Graesser, A. C., Dowell, N. M., & Clewley, D. (2017). Assessing Collaborative Problem Solving Through Conversational Agents. In A. A. von Davier, M. Zhu, & P. C. Kyllonen (Eds.), *Innovative Assessment of Collaboration. Methodology of Educational Measurement and Assessment* (pp. 65-80). Springer. [https://doi.org/10.1007/978-3-319-33261-1\\_5](https://doi.org/10.1007/978-3-319-33261-1_5)
- Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., & Foltz, P. W. (2018, November 1). Advancing the Science of Collaborative Problem Solving. *Psychological Science in the Public Interest*, 19(2), 59-92. 10.1177/1529100618808244
- Hadinugrahaningsih, T., Rahmawati, Y., & Ridwan, A. (2017). Developing 21st Century Skills in Chemistry Classrooms: Opportunities and Challenges of STEAM Integration. *AIP Conference Proceedings*, 1868 Article 030008. <https://doi.org/10.1063/1.4995107>
- Herro, D., & Quigley, C. (2016). Exploring teachers' perceptions of STEAM teaching through professional development: Implications for teacher educators. *Professional Development in Education*, 43(3), 416-438. <https://doi.org/10.1080/19415257.2016.1205507>
- Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: developing an assessment for student collaboration in STEAM activities. *International Journal of STEM Education*, 4(26). DOI: 10.1186/s40594-017-0094-z
- Maeda, J. (2013, March). STEM + Art = STEAM. *The STEAM Journal*, 1(1). 10.5642/steam.201301.34

- Jolly, A. (2014). *STEM vs. STEAM: Do the arts belong*. Education Week. Retrieved December 30, 2019, from <https://www.edweek.org/teaching-learning/opinion-stem-vs-steam-do-the-arts-belong/2014/11>
- Kim, Y., & Park, N. (2012). The Effect of STEAM Education on Elementary School Student's Creativity Improvement. In T. Kim, A. Stoica, W. Fang, T. Vasilakos, J. G. Villalba, K. P. Arnett, & M. K. Khan (Eds.), *Computer Applications for Security, Control and System Engineering* (Vol. 339, pp. 115-121). Springer, Berlin, Heidelberg. [https://doi.org/10.1007/978-3-642-35264-5\\_16](https://doi.org/10.1007/978-3-642-35264-5_16)
- Lafont, L., & Casey, A. (2012). Cooperative learning and tutoring in sports and physical activities. In B. Dyson (Ed.), *Cooperative learning in physical education: A research based approach* (1st ed., pp. 136-149). Routledge. 9781138023673
- Liao, C. (2016). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEAM education. *Art Education*, 69(6), 44-49. <https://doi.org/10.1080/00043125.2016.1224873>
- Marra, R. M., Steege, L., Chia-Lin Tsai, C.-L., & Tang, N.-E. (2016). Beyond "group work": an integrated approach to support collaboration in engineering education. *International Journal of STEM Education*, 3(17). 10.1186/s40594-016-0050-3
- Miller, J., & Knezek, G. (2013). STEAM for Student Engagement. In R. Mc Bride & M. Searson (Eds.), *Proceedings of SITE 2013-Society for Information Technology & Teacher Education International Conference* (pp. 3288-3289). New Orleans, Louisiana, United States. Association for the Advancement of Computing in Education (AACE). Retrieved February 10, 2019 from <https://www.learntechlib.org/primary/p/48602/>.
- Platz, J. (2007). *How do you turn STEM into STEAM? Add the Arts!* Ohio Alliance for Arts Education. Retrieved December 1, 2019 from <https://oaae.net/2007/10/01/how-do-you-turn-stem-into-steam-add-the-arts/>
- Quigley, C., & Herro, D. (2016). "Finding the Joy in the Unknown": Implementation of STEAM Teaching Practices in Middle School Science and Math Classrooms. *Journal of Science Education and Technology*, 25(3), 410-426. <https://doi.org/10.1007/s10956-016-9602-z>
- Roschelle, J., & Teasley, S. D. (1995). The Construction of Shared Knowledge in Collaborative Problem Solving. In C. O'Malley (Ed.), *Computer Supported Collaborative Learning* (Vol. 128, pp. 69-97). Springer, Berlin, Heidelberg. [https://doi.org/10.1007/978-3-642-85098-1\\_5](https://doi.org/10.1007/978-3-642-85098-1_5)
- Song, M. H., Park, J. A., & Park, J. (2020). Measuring Collaborative Problem Solving Capability in Creative Problem Solving Situation. *Companion of the 2020 ACM International Conference*, 103-106. <https://doi.org/10.1145/3323994.3369884>
- Spector, J. M. (2015). Education, Training, Competencies, Curricula and Technology. In X. Ge, D. Ifenthaler, & J. M. Spector (Eds.), *Emerging Technologies for STEAM Education: Full STEAM Ahead* (pp. 3-14). Springer, Cham. [https://doi.org/10.1007/978-3-319-02573-5\\_1](https://doi.org/10.1007/978-3-319-02573-5_1)
- Stroud, A., & Baines, L. (2019). Inquiry, Investigative Processes, Art, and Writing in STEAM. In: Khine, M.S., Areepattamannil, S. (Eds) *STEAM Education: Theory and Practice* (pp. 1-18). Springer, Cham. [https://doi.org/10.1007/978-3-030-04003-1\\_1](https://doi.org/10.1007/978-3-030-04003-1_1)

## Acknowledgment

This study is a part of research work for the Doctor of Philosophy. A big thanks to Cassie Quigley and Danielle Herro for sending the tool named Co-Measures and permitting me to use it. I am thankful to the Principal of Government Middle School, Delha for giving me permission to do this experimental study and collecting the required data for this study.