

## **Work in Progress: Effects of Out-of-School STEM Activities on Sixth Grade Students: A Systematic Literature Review**

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Nicole is an undergraduate engineering student at Texas A&M University who is interested in promoting inclusivity in Engineering at the middle school, high school, and graduate levels.

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Aamir received his master's degree in Mathematics Education from University of Texas at Dallas and is currently a fourth-year doctoral student at Texas A&M university. Aamir Fidai served as a mathematics teacher and varsity tennis coach in Dallas ISD for 10 years. During his tenure at Pinkston high school in West Dallas, he became an advocate for the cause of access and inclusion in STEM education for all students. He founded the first STEM club in Dallas ISD and encouraged his students who were mostly from underprivileged families to aim for college education and careers in STEM fields.

Aamir's research interests include equity in STEM education and infusion of open source hardware and software in STEM classrooms through Internet of Things (IoT) Technology. Aamir is also interested in expanding the academic research opportunity to undergraduate students in in-service teachers in K-12. Aamir is an Aggie Research Leader and is active in mentoring undergraduate research scholars. Aamir has presented his research both at regional (SERA, TAMU LAUNCH) and at international (FIE, AERA) educational research conferences. Aamir has three published conference proceedings and is currently working on several research projects dealing with technology and equity in STEM classrooms.

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# **WIP: Effects of Out-of-School STEM Activities on Sixth Grade**

## **Students: A Systematic Literature Review**

### **Introduction**

There is a need for innovative teaching and learning practices in middle school STEM classrooms. The middle grades are an educational period during which adolescents go through significant biological, cognitive, and socio-emotional changes [9]. In this work in progress systematic review of literature, we focused on 6th grade as it is a critical transition year between lower education and higher education. During this developmental period students begin to develop career aspirations, and furthermore, it is easier for students to establish positive attitudes towards STEM at this age. Poor academic performance in the middle grades can lead to student's having low self-esteem, a lack of motivation, and absenteeism [12]. To combat these trends, it is imperative that effort be channeled towards improving middle school STEM education using innovative teaching and learning practices.

Informal and out of school STEM (IOS STEM) Education activities use innovative and unorthodox approaches to teaching and learning practices. IOS STEM activities are typically much more flexible and personal to the students. Literature shows that these activities can improve student's self-efficacy and interest them in STEM professions [18]. Students consider IOS STEM programs to be more fun than classroom activities, which could make them more productive and eager in their desire to learn. Additionally, IOS STEM programs that incorporate Inquiry based approaches to learning, which is a learning style that emphasizes the student's role in the learning process, have been found to improve critical and creative thinking skills. [22]. Lastly, IOS STEM activities have also been shown to improve attendance rates and to better the social skills of adolescent students [22].

### **Background**

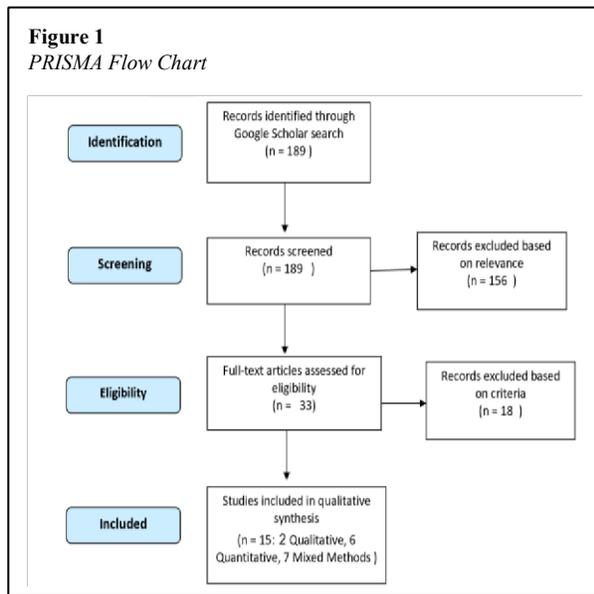
Growing recognition of the importance of STEM education has resulted in an increase of scholarly research regarding STEM education in recent years. It is becoming more important to understand how, and if, adolescent student perceptions, interests and attitudes predict long-term STEM persistence. Perceptions are mental impressions that yield great influence over an individual's self-identity and their interpretation of the world. STEM identity development goes hand in hand with students' ultimate decisions about participating in the STEM education pipeline [8]. Research indicates that students from minority and underrepresented student groups perceive that they do not belong in STEM classrooms because they fail to relate to the professionals in the STEM field [7]. During middle school grades, students may form incorrect perceptions of STEM professionals due to lack of exposure to professionals that 'look' like them [5][6]. Students explore career choices based on their interests in future careers. Sadly, the middle school students have shown a lack of interest in STEM careers in the recent years [24]. This lack of interest in STEM fields is even higher for female students [4]. Early exposure can help improve students' interest in STEM career pathways [3]. In addition to interests, middle

School students' attitudes towards STEM education play a significant role in their academic performance as well [2]. Student's attitudes towards science are one of the biggest factors affecting students' science achievements [1]). Students' negative attitudes towards STEM subjects have detrimental effects on their STEM career choices [18]. Improving student's perceptions towards STEM subjects and careers can greatly improve the chances of their participation in the STEM pipeline.

## Methodology

### Research Question

In this systematic literature review, we investigated the following research question: *What are the effects of informal STEM activities on sixth grade students' perceptions, attitudes, and interests towards STEM fields?* There is a lack of literature which targets specifically sixth grade students and the overlap of their perceptions, interests, and attitudes regarding STEM.



### Search Strategy

The search was executed in Google Scholar. The search terms were constructed by using Boolean logic. We conducted our literature search in google scholar using the key words: "After school", "STEM", "Learning Outcomes" OR "Academic Outcomes", "Experimental" OR "Quasi Experimental", "6th Grade", "Pre Test" OR "Post Test" OR "Pre-Test" OR "Post-Test". We chose google scholar because it provides links and pointers to artifacts from a diverse range of publication outlets (e.g., peer-reviewed journal articles, conference proceedings, books, dissertations, and masters theses).

### Inclusion/Exclusion Criteria

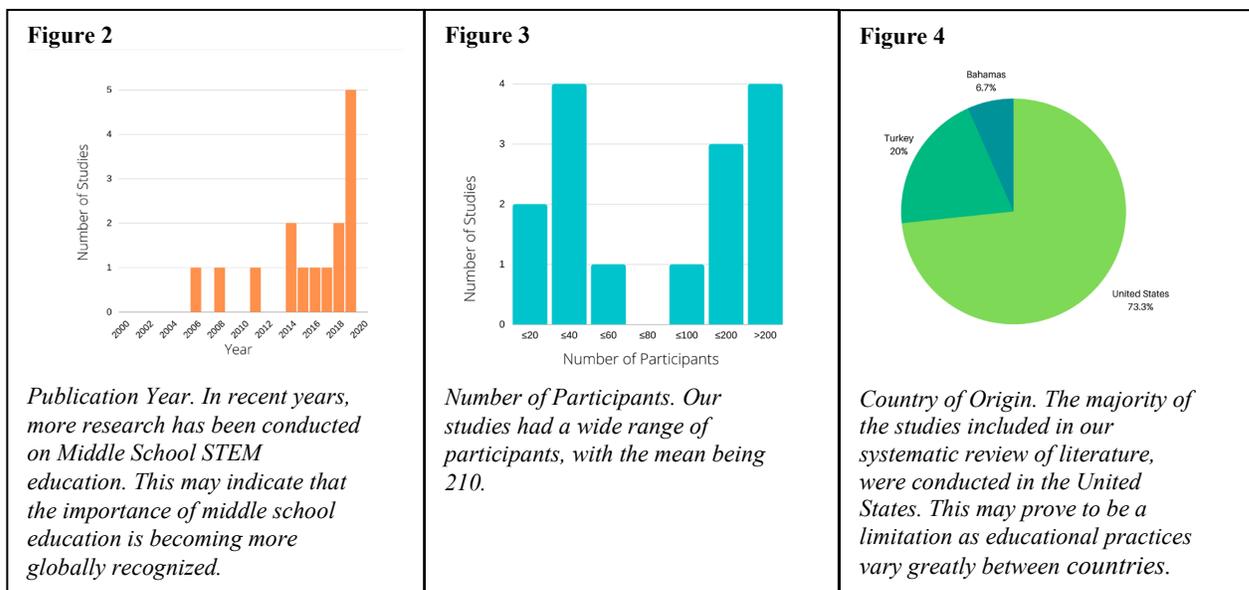
We only selected the studies that: were published between 2000 and 2020; written in the English language; provided data on 6th grade students; focused on STEM concepts; were conducted outside of school time; were published in Peer Reviewed Journals; appeared in conference proceedings or were committee approved Masters' or Doctoral theses; and were focused on the sixth grade students' perceptions, attitudes, and interests towards STEM.

### Data Analysis

We achieved interrater reliability by having at least two people code each article and discuss their findings. We coded the results of each article for the implications on the students' perceptions, attitudes, and interests in STEM. We also analyzed each article for the variables of setting, length of study, population, grade levels, and country. To ensure accuracy of the coding, the coders analyzed the first 2 articles together. In Table 1 we present the summary of our preliminary findings.

## Results

We present the preliminary findings of our systematic literature review in Figure 2, 3, 4, and 5.



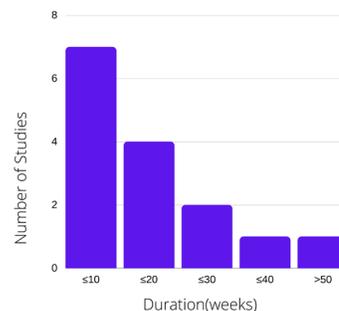
### Interests

Only one study, conducted by Gallegos [21], suggests that IOS STEM activities may have a negative effect on student STEM interest. The participants in Gallegos' study scored lower in the Career Interest Survey Post Test than they did in the Pre Test. The survey asked the participants to, on a scale of one to five, indicate how much they agree with statements, such as "I am interested in careers that use science" and "I like my science class". In this study, the IOS activity consisted of a virtual avatar incorporated into a video game to deliver biology lessons [21]. Other studies included in the systematic review on literature found that (1) increased exposure to IOS programs and activities can help students strengthen their interests, (2) IOS activities have the potential to foster student interest in STEM fields, (3) IOS activities have a positive effect on participant STEM awareness, and that (4) high STEM interest rates can help maintain student engagement in school [17][16][24][12].

### Perceptions

The studies included in this review seem to indicate that IOS Stem activities have the potential to change the perceptions that students have of their own self-efficacy and the perceptions that students have of the STEM field [18][15][10]. One of the IOS Programs which noted positive perceptions in the participants centered their curriculum around leadership values. The study alludes that collaborative based IOS programs may help students develop social and cognitive skills, as well as a desire to bring about positive change [15]. Another study found through

### Figure 5



*Study duration. The mean duration of the studies is approximately 18 weeks. However, when the outlier (108 weeks) is excluded, the mean duration is 11.928 weeks.*

statistical analysis that students who perceived science as being ‘always fun’ were more willing to consider careers in STEM [10].

### **Attitudes**

A study conducted by Weese [14] found through an attitude survey that student’s confidence levels dropped from Pre Test to Post Test. Weese attributes this to students feeling overconfident in their abilities prior to participating in the IOS activity [14]. The remainder of the studies strongly imply that IOS activities improve student attitudes [23][19][11]. One study found that as a result of an IOS program, girls had stronger attitudes towards gender equity [23]. This goes hand in hand with the notion that IOS activities having a positive effect on perceived belonging.

### **Discussion**

As this study is a work in progress, it is intended that a broader literature search be done to ensure that the findings are representative of most studies. Furthermore, we intend to classify the articles into two groups: (1) articles that identify a positive correlation between IOS STEM activities and the perceptions, interests, and attitudes of 6<sup>th</sup> grade students and (2) articles that identify a negative correlation between IOS STEM activities and the perceptions, interests, and attitudes of 6<sup>th</sup> grade students. We would like to find common factors within each group. As for the reviewed literature, a common theme that emerged is that the participants were described to be having fun when they were engaged in IOS STEM activities. The majority of the findings also suggest that IOS STEM activities help to improve student’s perceptions, interests, and attitudes towards STEM fields. We believe it would be beneficial if future research attempt to measure and quantify the levels of fun that students experience during Informal and Formal Stem education, to see if middle school students find Informal educational activities to be more fun than the traditional in-school curriculum.

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